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Information sharing and exchange in the context of product lifecycle management: Role of standards

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Abstract

This paper introduces a model of the information flows in Product Life cycle Management (PLM), serving as the basis for understanding the role of standards in PLM support systems. Support of PLM requires a set of complementary and interoperable standards that cover the full range of aspects of the products' life cycle. The paper identifies a typology of standards relevant to PLM support that addresses the hierarchy of existing and evolving standards and their usage and identifies a suite of standards supporting the exchange of product, process, operations and supply chain information. A case study illustrating the use of PLM standards in a large organization is presented. The potential role of harmonization among PLM support standards is described and a proposal is made for using open standards and open source models for this important activity.
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1. Introduction

The full product life cycle involves many complex processes and employs numerous computer-based applications/systems. As a management paradigm, Product Life cycle Management (PLM) is a strategic approach to creating and managing a company's product-related intellectual capital, from the product's initial conception to the product's retirement. The PLM concept is gaining acceptance primarily because of the emergence of the networked firm and the networked economy, in contrast to the market- or hierarchy-based organizations that typically use a transactions cost model as the cornerstone for the choice of organizational structure [1].

PLM support entails the modeling, capturing, manipulating, exchanging and using of information in all product life cycle decision-making processes, across all application domains. Currently, the lack of explicit semantics and contexts in the information content to be shared across PLM applications is a major problem. Making data semantics explicit, context-aware, and sharable among product life cycle applications is a major challenge. For an adaptable organization to function, an information infrastructure that supports well-defined information exchange processes among the participants is critical.

The paper covers the role of standards for information sharing and exchange within the context of PLM in the most generic sense. Two caveats are in order. First, the presentation is not intended to be comprehensive across all industries employing PLM; the concepts and illustrative

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standards covered arise largely from our experience in the discrete electromechanical manufacturing domain. Second, the paper does not deal in any way with knowledge sharing across the processes occurring in the product life cycle and managed by PLM; this is a new concept still very far from considerations of standardization.

The paper is organized as follows. Section 2 presents current approaches to PLM support. Section 3 develops a model of communication between producers and consumers of information and extends the model to the PLM context. Section 4 presents a typology of standards, divided into four levels. Section 5 evaluates the current status of PLM support standards. Section 6 presents an illustrative case study of standards relevant to the US Army's product data management. Section 7 addresses some challenges in standards harmonization for PLM. Finally, Section 8 presents the conclusions from this study.

2. Current approaches to PLM support

The information technology (IT) industry that provides PLM support systems is currently vertically integrated. An industry review shows that the current availability of support tools is partial and incomplete [2]. Some technology providers cover several areas, while there are areas that are poorly covered or not covered at all by any technology provider.

Currently only a few IT companies with vertically integrated toolsets provide facilities that are even partially integrated. Relying on a single technology provider to cover all areas of PLM support would not provide the kind of process innovation, functionality and information compatibility needed by PLM users. The lack of interoperability across tools and the barriers to entry for software developers that could provide a plug and play approach to PLM support are real impediments to the wide-scale adoption of PLM.

From the users' point of view, the challenge remains in understanding how PLM can be approached with the existing technologies used by a company. Companies that have invested in PDM, ERP or other engineering solutions (often complex and disparate) prefer to expand these solutions to solve their PLM support problems.

In an extended enterprise context, PLM support needs to connect the product design and analysis processes to the production and supply chain processes, including: product data management (PDM), component supplier management (CSM), enterprise resource planning (ERP), manufacturing execution systems (MES), customer relationship management (CRM), supply and planning management (SPM), and others that will undoubtedly follow. The benefits of PLM will be realized only when these disparate systems are horizontally integrated.

3. Models of communication for enhancing PLM support

3.1. A model of communication between producers and consumers of information

Before addressing the PLM-specific case, we first present a general model of information exchange between producers and consumers (whether human or computer). We will use this model to make the case that supporting PLM is akin to supporting a composition of information exchanges across time, space and multiple disciplines.

Communication between producers and consumers of information requires exchanges that convey the content of the information through a language. A model of communication proposed by Flower et al. accommodates the semantics of the exchange [3]. In this model, the exchange between receiver and sender[7] is dependent on the understanding of the mental model of the receiver by the sender, who has to transform his/her mental model to that of the receiver. Both mental models are contextualized by awareness, familiarity and other personal experiences. The objective of the sender is to ensure that he/she communicates to the mental model of the receiver. When the mental models of the receiver and the sender are matched, what is communicated takes on a standardized form of exchange. This form of standardized exchange behavior within a specified set of conventions is called a *protocol*. The language of a protocol has form (syntax), function (scope) and the ability to convey as unambiguously as possible an interpretation (semantics) when transferred from one participant to the other.

In describing the role of protocols in computing, Galloway states that a language with a set of conventions governs the set of possible interpretations (behaviors) within a heterogeneous environment [4]. In this sense a language of exchange is a technique for achieving voluntary regulation within an environment with many contingencies. Given the nature of communication in a networked world, protocols (specialized and standardized languages) are a means for distributed management that allows for control to exist within a heterogeneous environment [4].

Exchanges between producers and consumers of information require the creation and use of a common linguistic world with multiple languages that serve as a means for efficient exchange of content [5,6]. When the common linguistic worlds are not the same, the possibilities of misinterpretation and consequently the actions implied by the interpretation (behavior) are mismatched.

Two aspects of languages used in protocols are a language's expressiveness and processible expressiveness.

Expressiveness of a language is not related to the level of abstraction/detail it uses in describing the domain of interest. Highly expressive languages are best suited for use within a well demarcated domain. Mathematics has served this purpose in many disciplines. Mathematics is a means of expressing the physical world with a certain amount of precision and parsimony [7]. While mathematics as a meta-language has transcended disciplines, mathematical forms used and interpreted in a domain adhere to the disciplinary vocabulary integral to the linguistic world of discourse (also known as common ground or domain of discourse) of the domain. Similarly, the visual language of geometry

[7] Receiver and senders can be consumers or producers depending on the direction of exchange.