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MODEL-DRIVEN APPROACH FOR PRODUCT INFORMATION MANAGEMENT

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Abstract:

Nowadays, product information is being a key issue for traceability and quality management but also for state of the art technologies such as intelligent product technologies. From this statement, product information design and management is becoming one of the most important steps in order to control the quality of services and products that aims at customer satisfaction. However, no real method exists to build the exhaustive representation of products throughout their production cycle. In this paper, a product oriented-system modelling approach is proposed, based on an adaptation of the Zachman framework, in order to provide a complete method for product representation through modelling the system that produces it. This modelling approach aims at covering all aspects related to product information and its management. Moreover, a model driven methodology is proposed in order to enable application models synchronisation for product oriented-systems interoperability.

Keywords:

Product information management; product traceability; Enterprise integration; manufacturing systems; Zachman Framework;

1. INTRODUCTION

The objective of this paper is to propose a model-driven approach for modelling product information, along its lifecycle, ensuring the completeness of such model with regard to the various networked enterprises applications that will interoperate with it. Our aim is to simplify the modelling of different aspects of the product (information and material) by considering the aggregation of information about the product and the conceptual view all applications may have about it [1]. The first assumption of our work is a necessary synchronous modelling of product material views and product informational views. Indeed, in a manufacturing environment, information and material flows are often considered separately. Throughout its lifecycle, the product evolves in a dual way, a physical product that is subject of physical processes, and an informational product that combines all information collected about product states during its lifecycle and product information needed for production control, quality assessment and traceability management [2].

During the last decade, the concept of digital-physical product [3] or « Intelligent Product » has been widely used in manufacturing systems field. This concept is often used to indicate a product equipped with a specific technology that enables it to develop certain capacities. Indeed, according to [4] an intelligent product possesses all or some of the following features.

1. A unique identity,
2. The capacity of communication with its environment,
3. The capacity to retain or store data about itself,
4. The capacity of using a language to display its features, requirements, etc.,

5. The capacity of participating in or making decisions relevant to its own destiny.

Using these features, [4] categorise product intelligence into two levels:

Level 1: information oriented intelligence that enables the product to be conscious of its status, and to be able to communicate about it. This level of intelligence is ensured by the first three features of the previous list.

Level 2: In this case the product is supposed able to influence and control operations related to its manufacturing. This level of intelligence is said to be decision oriented. To achieve this level of intelligence the product should ensure all features of the list below.

In this context, the biggest problem is not the one related to technology used to implement the intelligent product. Indeed, technologies like AutolD, UPnP or RFID enable identification and information embedding on the product itself, technologies related to multi agent systems are a mean to make the product able to take decisions and to take control of its own destiny [5]. The real problem is how to decide what kind of information is mandatory on the product, what should be the knowledge of the product and what information should it retain. This critical choice will influence the ability of the intelligent product to take the right decisions using the right pieces of information.

In this paper, a product oriented-system modelling approach is proposed in order to build a complete method for specifying product information for product traceability. The product representation proposed aims at enabling a synchronous modelling of product material flows and product information flows in a given manufacturing environment. Indeed, in a manufacturing environment information and material flows are often considered separated, however each information exchange refers to a physical exchange and, conversely, material flows are always accompanied with some information, even if this information is minimalist. Through its lifecycle, the product evolves in a dual way, a physical product that is subject of physical processes, and an informational product that combines all information collected about the product during his lifecycle and needed for production control, quality assessment and traceability management.

2. A UNIFIED REPRESENTATION OF THE PRODUCT

In [2] we proposed a meta-model for the formalisation of product information. The proposed meta-model formalises some of the critical features that are mandatory in the representation of a product. To formalize our dual view of the product (information and material) we adapted the holon concept. Indeed for product representation, a holon can be seen as the aggregation including the material part of the product and all information related to the product in enterprise information systems. In our application, a holon represents an aggregation of an information part and a physical part of a product.

A holon is an identifiable part of a system that has a unique identity, yet is made up of subordinate parts and in turn is part of a larger whole. A holon has two main features: autonomy and cooperation. In the manufacturing context, a Holonic Manufacturing System [6] is an autonomous and co-operative building block of a system for transforming, transporting, storing and/or validating information and physical objects [7]. In this context, several adaptations of the holon concept for the product have been proposed in literature [8, 9].

In the following, we introduce some of the important features for product representation in our meta-model:

Product Structure: Manufacturing products are made by successive composition and transformation of raw or intermediary materials. We call product structure, or product

composition the tree structure whose nodes represent raw or intermediary materials used to make the product located at the root. Arcs of this tree structure represent composition relationship between different nodes. To take in account this notion of structure, our holon adaptation should consider the link of composition between objects [2].

Product features: The informational part of the holon should describe the set of features of a specific product, these features can be distinguished into two categories "*attributes*" and "*properties*":

- Attributes describe intrinsic features of the physical product. These features are substantial to the physical part of the product (example: weight, high, material).
- Properties describe pieces of information that are assigned to the product through design phases; each piece of information is of a specific domain and a specific use. (e.g. identifier, production date, etc.)

State of a product: During manufacturing phase, a product passes through several states that describe its history. The storage of the set of states of a specific product and the relation between them allow traceability management of this product [2, 10, 11]. The state of a holon is then specified using tuples (attribute, value) et (propriety, value). Each operation processed on a holon implies a state change.

On the bases of our holonic approach for product representation, we define a product oriented strategy for enterprise integration. Indeed, to cover all aspects of product information modelling, engineers generally use different modelling languages and constructs. On one hand, information models help to understand how manufacturing systems represent products properties. On another hand, behavioural models are also defined to control and to manage physical flows in the manufacturing environment. Nevertheless, ensuring consistency between different models from different abstraction levels is a key issue in product lifecycle management [12].

In the next section, we show how the holonic approach can be integrated together with other modelling approaches in order to offer a global model driven methodology for product information integration throughout different enterprise points of view.

3. A MODEL DRIVEN APPROACH

The objective of our holonic modelling approach is to facilitate the consideration the concept of a physical product and its interactions with its environment as a whole entity including product information and knowledge and physical material [2]. This unified representation is then translated for specific usage and specific applications. The need of transformations is due to the difference of concerns of applications and systems inside a given manufacturing environment. Indeed, while manufacturing oriented systems are interested in physical features of the product, business oriented systems are more interested in a service oriented representation of the product more related to informational aspects of the product. While well known MDA (Model Driven Architecture) [13] and its generalisation called MDE (Model Driven Engineering) [référence à MDE] propose a framework based on OMG¹ levels of abstractions, that shows different abstraction levels of a given system but under a unique point of view (i.e software development), a framework that combines various points of view of a given system linking manufacture views of a system at the "business to manufacturing"

¹ OMG : Object Management Group, <http://www.omg.org>

level. Our approach provides a methodology for product information design and collection, starting from the conceptual model of the product and the manufacturing processes that interact with it, until the definition of product information data models that can be used for product information management (product quality control, traceability or genealogy).

Our model-driven approach is derived from the Zachman framework [14] extending its use to take into account, not only information models but also models of manufacturing processes that interact with the product among its lifecycle [14, 15]. The Zachman Framework provides a formal and highly structured way of defining and representing an enterprise. It uses a two dimensional classification model based around the 6 basic communication interrogatives (What, How, Where, Who, When, and Why) intersecting 6 distinct model types which relate to stakeholder groups (Visionary, Owner, Designer, Builder, Implementer and Worker) to give a holistic view of the enterprise:

- How: process and functions performed in the enterprise.
- What: important data and objects of the enterprise.
- Who: human actors in the enterprise.
- Where: places, sites and locations where enterprise activity is performed.
- Why: motivations that lead business and manufacturing behaviour.
- When: events that launch activities in the enterprise.

Many works have been done in trying to map different enterprise architectures frameworks to the Zachman Framework [16, 17, 18, 19, 20], but these proposals try to compare themselves to Zachman while we propose to be complementary [21]. The perspective of our work is to contribute to a product oriented model-driven approach, based on the Zachman framework, which is being considered as an important departure from traditional techniques in such areas as software engineering, system engineering and data engineering.

Adapting our context from the Zachman framework original definitions, the product of a given enterprise belongs to the scope of the "What" column that describes objects that are important from the enterprise point of view. Enterprise applications and enterprise systems handle information about the product; each one of those systems has a specific representation of the product. Using retro-engineering techniques a precise logical representation of product view handled by each system can be produced. However, a generic representation of the product is needed at the conceptual enterprise model level to unify all logical views of the product and to enable then a unified product modelling approach.

In this context, we define that a product oriented process model is a conceptual model that aims on one hand at defining relations and exchanges and interactions between processes of a manufacturing environment; on the other hand it aims at specifying information related to a product during its lifecycle and its evolution through the set of processes involved in its manufacturing. Regarding this, a product oriented process model combines constructs defined in the holonic metamodel for product representation and constructs defined in standard process diagrams such as processes, activities, flows and messages. In a such model, in addition to the use of holons for product representation interactions between holons and processes represented in order to defined if a given piece information is relevant at for given process, relevancy depend on whether the process uses or produces this piece of information. Since this kind of models describes information schema related to products and in the same time processes and exchanges between them, it covers both the "What" and the "How" columns of the conceptual level of the Zachman grid. The Model driven approach leaded by the Zachman framework gives an exact idea about kinds of models and information that need to be provided at conceptual level in order to keep coherence between different representations in the different enterprise systems. At the logical level of the "What"

column, automatically generated UML class diagrams can be used to express informational models related to the product.

4. CONCLUSION

In this paper, a product oriented-system modelling approach has been proposed, in order to furnish a structured way to build a complete and consistent representation of products. The proposed representation is to be used as a repository for product information management. The product oriented modelling approach is based on a holon construct adapted for product modelling. In our approach the holon concept has been defined as the aggregation of a tangible physical part, and the informational part that corresponds. The main objective of the product oriented approach is to build a unique representation for the product in order to be used as a base for intelligent product design. This modelling is also a good base for traceability systems implementation. Indeed, a first application to the unique product representation is a centralized database storing product data, this database is a source for traceability data management. All enterprise applications that need information about product should connect this repository of data.

In our approach, the Zachman framework has been adapted to be used as a guideline that helps product information designers to fulfil the various and specific aspects of the product information by providing different views. These views are complementary but mandatory to cover product information spectrum. Our approach is defined by a sequence of artefacts in the Zachman framework; each artefact is represented by a specific cell in the Zachman matrix. The transition from one cell to one other is based on syntactic transformations or semantics mapping between models. The resulting methodology can be used for designing well-formed models for product traceability management. In order to validate our proposal, an implementation of the modelling methodology, based on the Zachman framework, has been integrated into a commercial business process and information modelling CASE tool named MEGA Suite². This implementation has been practically used to model an industrial case study for product information traceability.

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² MEGA Suite, MEGA International, <http://www.mega.com>

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