A view-based approach to modeling product semantics in design chains

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Abstract To reduce “time-to-market”, semantics of a product must be synchronized in a design chain, because inconsistencies during collaborative product development cause an unnecessary waste of time. To guarantee semantic synchronization, all enterprises should co-operate and maintain semantics whenever they are updated. In this paper, a V2-model is proposed to share product semantics during collaborative product development through view-based semantic synchronization. The V2-model has two kinds of model layers for semantic synchronization: a view-independent model (VIM) layer and a view-specific model (VSM) layer. Semantics in the VIM is the well-structured semantics shared among all enterprises and thus are published across the collaborative design chain. On the other hand, semantics in the VSM is the inconsistent semantics for product information that occurs during the early design stage, when different enterprises may have differing views about product concepts that are constructs of semantics. The inconsistencies between the different views can be solved by a decision and sharing (DnS) process and V2-model. The DnS process transforms the concepts in the VSM to the concepts in the VIM by utilizing topic maps-based scoping and merging functions. The proposed V2-model has been successfully applied to the design process of a washing machine model.

Keywords Collaborative product development · Design chain · Semantic synchronization · Topic maps · View

1 Introduction

Today’s enterprises are subject to tremendous business competition. To cope with this, enterprises should integrate value chains such as supply chains and design chains [1]. And these chains should support collaboration between enterprises in order to minimize time-to-market that is the key success factor, especially in new product development [2, 3]. To effectively collaborate, the enterprises should share semantics since semantic confusion leads to time consuming work [1].

The function of the design chain during the new product development is very important because more than two-thirds of all product lifecycle cost is determined during the conceptual design process [4]. Hence, the enterprises in the design chain must be capable of collaborating agilely, changing the design according to emerging requirements while minimizing “time-to-market”. A semantic model to support this is required since semantics must be shared among all enterprises whenever it is updated. Figure 1 shows an example of a design chain in product development. Because of time delay in sharing semantics between enterprises, the enterprises in the design chain have different time lags to design. As the time lag increases, the enterprises have less time to design their artifacts. To compensate this limitation, semantic synchronization is needed to get the right information from other enterprises. Semantic synchronization means that artifacts of product development are shared between all enterprises related to...
the product at the same time and inconsistency among enterprises is not allowed. To guarantee semantic synchronization, firstly the model for product semantics should represent evolving semantics that are continuously created and modified in product development. Secondly, all enterprises in the design chain should support fast semantic sharing. That means that all enterprises co-operate and maintain the product semantics, whenever it is updated, without inconsistency.

To represent product semantics, Pouchard et al. [5] proposed the process specification language (PSL). However they did not consider evolving semantics in a product development. To represent evolving semantics, C-VISTA [6] introduced the basic concept and the v-oriented concept. The v-oriented concept is the basic concept with views. C-VISTA defined special inter-relations (inter-associations) between v-oriented concepts such as “equivalence”, “inclusion”, and “exclusion”. However they did not consider fast semantic sharing.

In this paper, we propose a V2-model that supports agile collaboration through semantic synchronization by introducing the view concept for representing evolving semantics and sharing semantics consistently and fast. To avoid semantic inconsistency, the V2-model has two model layers: a view-independent model (VIM) layer and a view-specific model (VSM) layer. The VIM has consistent semantics. It is well-structured among all enterprises and the semantics is published to them throughout the collaborative design chain. On the other hand, the VSM layer represents evolving semantics and contains semantics for product development that are inconsistent between enterprises during the early design stage. Because of this inconsistency, it is impossible to share semantics between enterprises. Inconsistency in the VSM is solved by a decision and sharing (DnS) process that supports fast semantic sharing. Topic maps are used as a modeling language for semantics, since they are web-based language that has merging operations which are similar to semantic sharing processes. Extended topics such as B-topics and S-topics are used to resolve the inconsistencies in a semantic model. The proposed V2-model has been successfully applied to the design process of a washing machine model.

The layout of this paper is as follows. The proposed V2-model is described in Section 2. Topic map representation for the V2-model is introduced in Section 3. The V2-model for the washing machine is implemented in Section 4. Then we conclude the paper with some remarks.