# SEMANTICS AND VIRTUAL ENGINEERING IN SMART MANAGEMENT SUPPORT

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## 1. Introduction

There are several computerized tools that support different stages of the Product Life Cycle (PLC), these tools provide a good, yet open to improvement way to handle the large amount of data produced while at the same time, they reduce the potential information and even knowledge loss. The supporting computerized tools for a Product Life Cycle Management (PLM) are called Virtual Engineering Tools (VET) and the supporting applications are called Virtual Engineering Applications (VEA). It is then common to categorize a VEA by a series of its embedded VET.
It is problematic to assure that the computer programs (VEA) used in every stage of the product life cycle management (or even in the same stage but from different vendors) are able to share information not to mention extrinsic knowledge, which accounts for another potential danger of information and knowledge loss. Being that Semantics is an important steering technology for the Web, we believe that the intensive use and embedding of Semantic-Based Technologies in VEA, could be a plausible solution to overcome some of the reported problems in [MB06, MB07]. In this position paper, we will explore the use of Semantic-Based Technologies and the improvements that they introduce in VEA, which can be summarized as follows:

- Improved information and knowledge management
- Enhancements in the search, knowledge and information sharing processes.
- Use of the intrinsic knowledge embedded in the elements being described
- Empowerment of the VEA through better use of his knowledge and embedding of such knowledge in a structured and explicit conceptualization.

## 2. Conceptual Basis

The ideas and technologies that support the Semantic Web provide an interesting platform to support the Virtual Engineering Applications. This can aid in the development, use and re-use of knowledge from a networked environment in which the information is meaningfully distributed. According to McCorkle the underlying question that must be answered today is:

> *"How will information be integrated in a manner that will allow commercial and proprietary software tools to remain separate while also being integrated so that the end user can control and query these tools with little to no knowledge of the tools implementation or inner-working details?"* [MB06]

The answer to this question will depend largely on the ability to implement open interfaces and schemes that can evolve over time as well as open source toolkits that enable development teams to collaborate at a high level. The enhancement of VEA by Knowledge-oriented (or Knowledge

supported) technologies has been arguably tangentially reached by some independent efforts. In [MB07], a discussion about potential applications of the Semantic Web to explore the above question is given, presenting some specific capabilities that should be fulfilled by semantically oriented Virtual Engineering Tools. Huang [HB05] presents a decision support platform for the interactive design that integrates mathematical optimizations with human interactions based on VET. In this approach, the designer's interaction causes the optimization process to dynamically change by adding, deleting, and modifying objectives, constraints, and other parameters that govern processes. As an illustration, a coal pipe design case was used to demonstrate the platform's capabilities. Huang's case study demonstrated that adding user interaction into the design process has the potential to improve design efficiency and quality. Kuntz's [KCC+98] research was focused on the application of computational simulation models used in other branches of engineering to project planning, the authors propose a model, called the Virtual Design Team (VDT), that represents the structure and capabilities of organizational entities, such as teams (called actors in the model), activities, and both direct and coordination work. The model links the organization chart and the activity diagram of projects, and can be used to predict the effect of different organizational structures or of the use of different project constraints. In this respect, the proposed method outperforms planning tools based on the Critical Path Method, as it explicitly incorporates the necessary communication and coordination among the actors assigned to different project activities. As mentioned previously, some research into the topic has been carried out, however, at the present time, the scientific community has not reached consensus in how to extend Virtual Engineering Tools with Semantics.
The basic idea would be to provide means for maintaining the semantic load (e.g. gathered knowledge) in every step of the PLC (see fig.1), embedding such knowledge in the VEA and their set of VET. In order to do that, considerations on the user, the domain (using for example engineering standards) and a mechanism for fast query retrieval is needed.

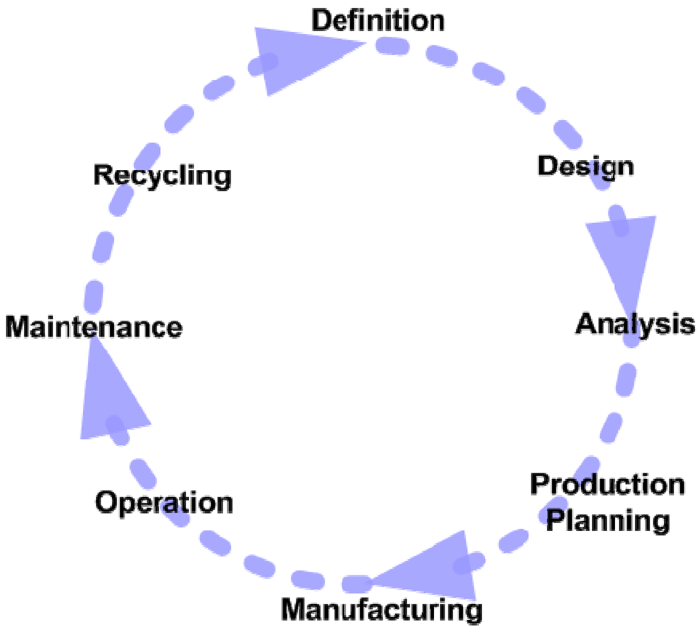


Figure. 1 PLM cycle

## 3. Strategies for the inclusion of semantics in Virtual Engineering to support smart management tasks.

As mentioned before, we propose that in order to fully take advantage of the knowledge created during every stage of the PLM for purposes like smart management, different aspects must be considered and embedded if possible in the VEA.

### 3.1. User modelling considerations [Tor09]:

For a good semantic model and from a domain perspective where the user takes an active role, the following aspects are decisive.

- **Consider User Roles in your User types:** Roles are not profiles, a simple profiling method is found not sufficient for nowadays applications as the Overlapping of characteristics can be wide, but degrees of knowledge on them could be narrow.
- **Consider implicit Semantics and explicit Semantics: Differentiation** between these two semantic degrees is commonly biased by contextual knowledge.
- **Consider the User Experience:** mechanisms like SOEKS are not only needed, but fundamental, as user experience must be considered in semantic models for decision support and especially in the Smart Management context [SA010].
- **Distinguish between high and low level Goals when modeling the User:** dividing Goals into high level and low level groups is a technique that helps in the understanding of the overall expectations of the User.

### 3.2. Domain modelling considerations [Tor09b]:

In a previous work we proposed a mechanism for the semantic model (of domain ontologies) based on engineering standards, benefits include:

- Consensus
- Avoidance of Semantic loss.
- Easiness of a new Domain modeling based on an existing Standards
- Permanent revisions and actualizations

Our mechanism is depicted in the following figure:

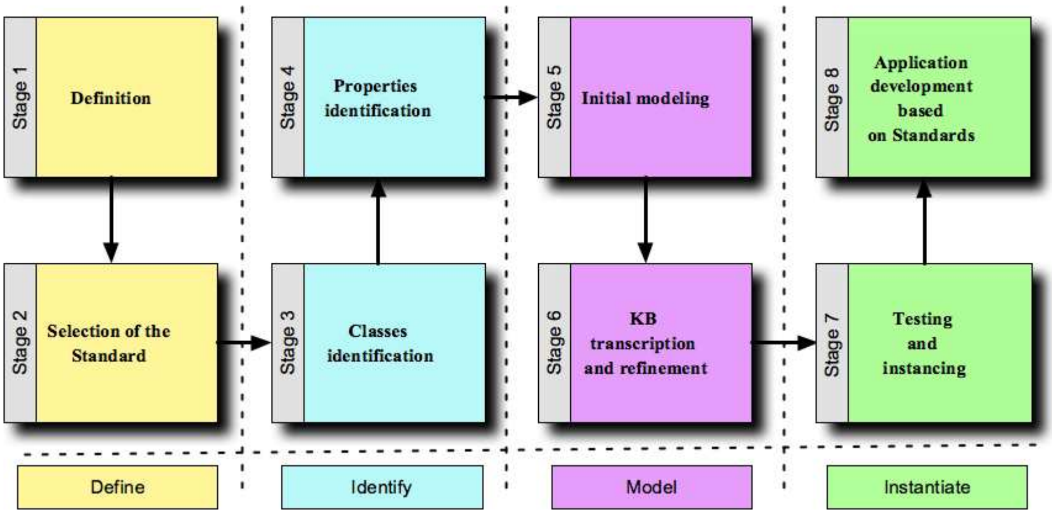


Figure. 2 Domain modelling based on standards

### 3.3. Fast query models [TSSP08]:

In a semantic based application, the knowledge contained can be quite vast. There are several ways to interrogate semantic models, however those APIs and strategies relay on querying the model every time. In order to perform better and fast interrogations, we developed the Reflexive Ontologies (RO). The following figure depicts the Ro concept.

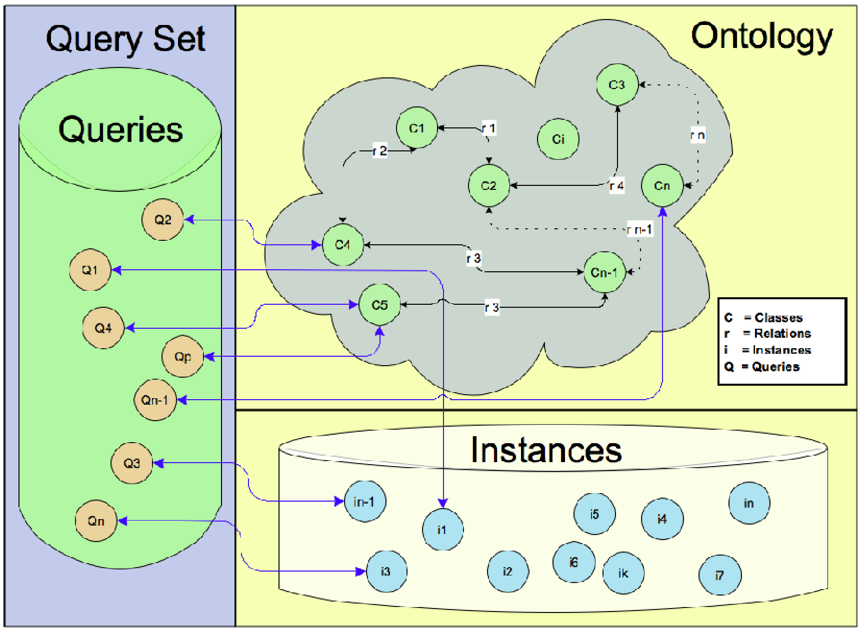


Figure. 3 The reflexive Ontologies

The next figure depicts an architecture for the embedment of semantics in the VEA that would aid the Smart Management of resources by maintaining the semantics in every stage of the PLM.

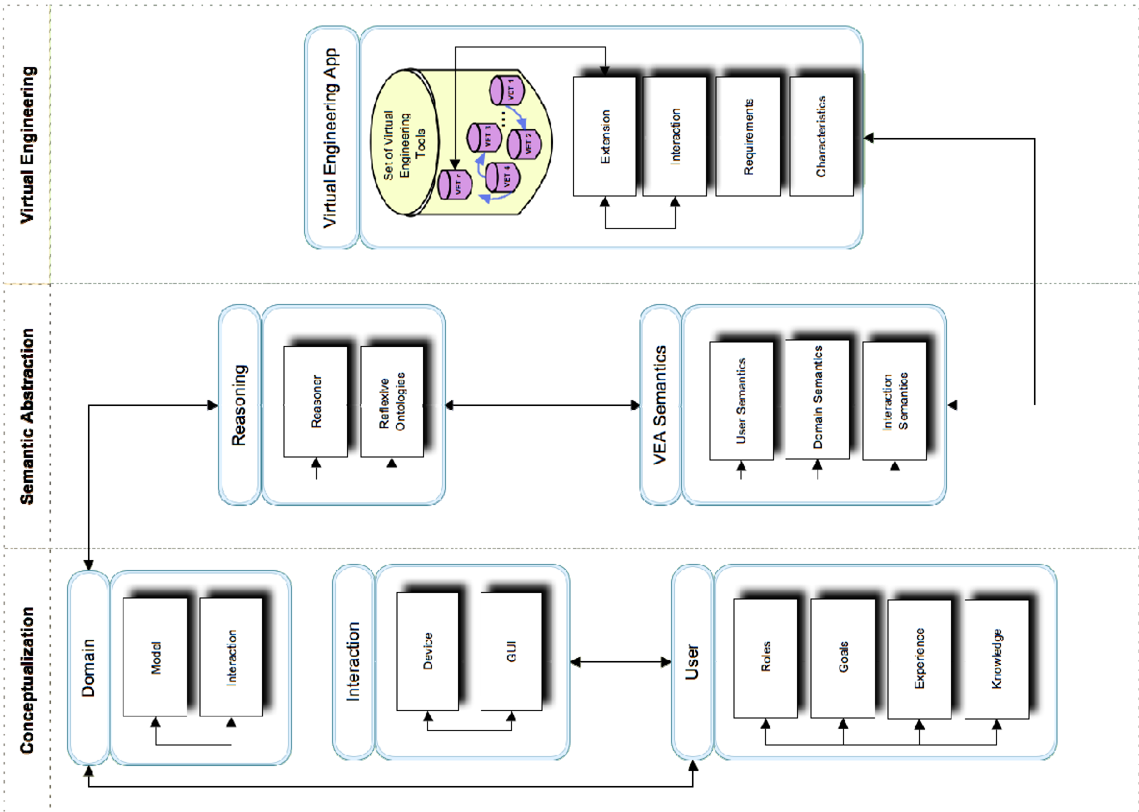


Figure. 4 An architecture for the semantic enhancement of VEA

## 4. Panel Discussion and Conclusions

We will discuss the problems related to the maintaining of semantic load and in general of knowledge between the different stages of the PLM and how these techniques indeed help in the smart management. We will address implementation issues like legacy systems integration and web based applications taking into account security and reliability of the knowledge produced.
Questions and answers can be also from the industry perspective as many of the presented and discussed techniques are indeed applied in real world applications running in managed environments in different types of industries.

The implications of knowledge embedded in engineer objects are not only an open issue from a technical perspective, but also an ethical discussion will arise in the next years as knowledge and experience from users will be transferred to intelligent objects providing foundations to the Internet of things paradigm.

## References


[HB05] Gengxun Huang and Kenneth Mark Bryden. Introducing virtual engineering technology into interactive design process with high-fidelity models. In *WSC '05: Proceedings of the 37th conference on Winter simulation*, pages 1958–1967. Winter Simulation Conference, 2005.

[KCC+98] John C. Kunz, Tore R. Christiansen, Geoff P. Cohen, Yan Jin, and Raymond E. Levitt. The virtual design team. *Commun. ACM*, 41(11):84–91, 1998.

[MB06] D. S McCorkle and K. M Bryden. Using the Semantic Web to Enable Integration with Virtual Engineering Tools. In Springer London, editor, Proceedings of the 1st International Virtual Manufacturing Workshop, March 2006.

[MB07] D. S. McCorkle and K. M. Bryden. Using the semantic web technologies in virtual engineering tools to create extensible interfaces. Virtual Real., 11(4):253–260, 2007.

[SA010] Sanin, C.: *Decisional DNA and the Smart Knowledge Management System: Knowledge Engineering and Knowledge Management applied to an Intelligent Platform.* LAP Lambert Academic Publishing, Germany 2010.

[Tor09] Toro, C., Graña, M., Posada, J., Sanin, C., Szczerbicki, E.: An Architecture for the Semantic Enhancement of Virtual Engineering. In: N. T. Nguyen, E. Szczerbicki (Eds.), *Studies in Computational Intelligence*, vol. 252, pp. 175-196, 2010.

[Tor09b] Toro, C., Graña, M., Posada, J., Sanin, C., Szczerbicki, E: *Domain Modeling Based on Engineering Standards* Knowledge-Based and Intelligent Information and Engineering Systems, pp. 95-102 Santiago, Chile, 2009

[TSSP08] Carlos Toro, Cesar Sanín, Edward Szczerbicki, and Jorge Posada. Reflexive Ontologies: Enhancing Ontologies with self-contained queries. *Cybernetics and Systems: An International Journal*, 39(1–19), 2008.