Quality-Driven Design In Mechanical Engineering

Poster Abstract

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Introduction

Individuals who get in deeper contact with a product's lifecycle - engineers, maintenance crew, customers etc. - describe the same product from their specific point of view, in their own wording. Nevertheless all those specific views have one thing in common: The aggregated multidisciplinary product model behind.
This approach for solving this fundamental PLM topic makes usage of the emerging semantic web technologies. Based upon publicly available approved standards PLM objects of different domains - product, organisation, process etc. - are modelled against their dependencies including meta information to a semantically enriched network.
Completely modelled this network can represent structured lifecycle documentation usable for knowledge management applications. This work spots on "Quality-driven Design"and risk management-related methodologies along the product's lifecycle. The information transition from developers to quality managers is focussed on supporting the link of a product's structure or its bill of materials (BoM) to the functional model, potential failures and their causes as well as recommendations for prevention and testing measures. This reference implementation features those functionalities as a component of a future, yet to come semantic PLM environment.

Quality-Driven Design

The integration of multi-tier program management is the main driver behind current product and process development while enterprise applications are still at least one step back. Insufficient interfaces, on user as well as on application side, sustainably affect information exchange in terms of consistency and transparency in existing heterogeneous organisation, process and system environments in a negative way. Quality-driven design is handled today in a tool specific way comparing the component structures and classifications, checking the feature consistency performed frequently by the design engineer and in a quality specific view with quality assurance methods realised by quality engineers.
Product development tools e.g. in mechanical engineering are predominantly geometrical driven whereas a common view of requirements, functions and the geometry itself is not implemented. Even the geometry concept (e.g. Multi Model links, CATIA V5) is mostly proprietary and not easy to handle if a more general model inside a heterogeneous toolchain is required. Two basic methodologies have to be adapted and extended to create an interface for seamless interaction with quality assurance tools:

- Component based design process
  Todays strongly hierarchical geometrical components originated from drawing table concepts do not take account of functional and requirement-driven aspects of mechatronical products. Although State of the Art CAD tools provide technological and functional feature sets, the logic behind is not formalized at the level of a common lifecycle related product model but rather encapsulated between predefined behaviours of parametric associative features.
  >> From the drawing table to a virtual product model
- The Bill of Material
  Until now the leading structure element of product development processes is the BoM, which is limited in provision of dynamic product configuration or specific views on a product.
  >> From the "Simple" BoM to a semantic product structure

Both methodologies can interact and couple quality assurance tools with the help of ontologies providing risk management in early phases and consistent product modelling over the whole lifecycle.

Objectives

The formalisation of product and process models in mechanical engineering is of particular interest to meet the growing number of market-specific Product Liability Acts (EU, USA, Japan, etc.) and increasing market dynamics. Product developers are forced to make usage of preventive risk management methodologies, e.g. failure mode and effects analysis (FMEA). It enables quality managers to discover potential risks in advance, to methodically analyse, rate, prematurely eliminate respectively pinpoint them to avoid later malfunctions and their implications (mainly costs and amount of time spent).

The capabilities of ontologies, regarded from enterprise information technology point of view, enable exchange and re-use of domain knowledge (concepts, events, entities) due to its formalisation which eases domain-specific as well as inter-domain-specific communication and documentation due to a limited vocabulary of concepts to avoid misunderstanding between the involved stakeholders.

Developing The Ontology For Quality-Driven Design

In this specific case the Web Ontology Language (OWL DL), component of the semantic web, and Protégé ontology editor were chosen. The ontological implementation of risk management methodologies in developer's domains is focussed:

- Investigating the product's critical properties and critical process parameters
- Diminishing variability of quality related properties
- Performing quality-oriented analysis on the virtual product model (structural, functional)
- Performing quality-oriented analysis on the virtual process and virtual organization model
- Generic ontology on risk management methodologies for re-use in product development business
- Ontology as a single, replaceable component within a modular semantic PLM environment
- Supporting the end-users in doing their daily work consistently
- Supporting knowledge management processes, e.g. “lessons learned”, data mining, etc.

The whole concept in mind the above addressed semantic PLM environment leads to a permanent dynamic quality management due to simulating functional and structural parameter changes at every stage of the lifecycle particularly in the early phases and returns free space for creative and more individual engineering enabling further development on the way to quality-driven design.

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