Intelligent Assistance for a Task-oriented Requirements Management

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***Abstract*-Requirement specifications for complex products are hard to handle due to their high amount of number and interrelations. Thereby, requirements represent the legally binding basis for the product development. In this paper we present a concept for a task-oriented filtering and provision of requirement specifications to support the engineer in his information management. The approach is based on a semantically enhanced categorization of requirements to prepare a computer interpretable information basis. The selection of processed requirements and their monitoring with respect to changes will be implemented by means of information agents. The associated agent schema and exemplary system architecture is provided. The approach enables an optimized processing of requirements which backs an efficient product development.**

I. INTRODUCTION

It is essential for the manufacturing industry to bring new products in short time at low costs and of high quality onto the market. This implies that a company has to act efficiently and flexibly if it wants to survive in the global market. Innovations represent the unique selling point in competition [1]. Innovative solutions are primarily realized by the extended application of electronics and software in automotive or aerospace industry. This is associated with an increased product complexity, which is characterized by the type, diversity and number of elements and relations, as well as the dynamics of the system [2]. The development of innovative products is linked with the integration of different processes and domains. The control, management and implementation of such an integrated product development is one of the challenges that have to be tackled nowadays.

It is commonly known, that the product development is primarily responsible for the determination of a product's total costs. Thereby, requirements represent the legally binding basis for the development tasks. A requirement is an expression of a perceived need that something be accomplished or realized [3]. This definition by Gabb et al. includes the demands and wishes a desired product has to fulfill, as well as the constraints regarding e.g. system environment, services or personnel entities.

Three abstract user profiles can be identified that are concerned with requirements. The *developer* is the recipient of a requirement. He is directly responsible for the problem solving and component design with reference to the stated requirements. The *system analyst* is responsible for the general requirements engineering and system design in the early product development phases up to the start of production. He is engaged in the extensive elicitation, analysis, negotiation and documentation of qualitative requirements, as well as the fundamental system conception. The *stakeholder* characterizes a person with a not explicitly defined involvement along the product development. This can be a supplier participating in the requirements elicitation and negotiation process, or a person in charge with access to the requirements specification to support his tasks (e.g. marketing).

The design process can be characterized as follows. It is definitely personal, based on creativity, and dynamic. The agreement on requirements and problem-solving solutions is marked by negotiations and compromises. The engineers' tasks are based on their individual knowledge by interpretation of available and acquired information. Several systematic approaches to engineering design have been proposed (among others [4], [5], [6], [7]). Despite the variances, general tasks are common to all these approaches:

- Requirement specification and planning
- Search and development of solutions
- Selection and optimization of variants

Requirements have a relevance in all these tasks. After determination, their fulfillment and adaptation have to be considered continuously [8]. The procurement of information changes its focus in the course of the development cycle [9]. It is mainly problem-oriented in the beginning (What has to be created?), and alters to solution-oriented to the end (Does my solution fulfill all demands?). The aforementioned user profiles are also characterized by different informational needs. Additionally, the view on information is influenced by the respective task, e.g. regarding the level of detail.

The statement of requirements represents a problem regarding their qualitative documentation, especially in matters of clearness and analysis. Nowadays, the specification of requirements results still predominantly in a natural language based format. Model-based or graphic approaches are not widely distributed yet in the manufacturing domain. The application of text is linked with problems of e.g. incompleteness, inconsistency or ambiguity [10]. This restricts also a computer-based processing. Additionally, the increasing product complexity affects the number of requirements and the level of interrelations. This has an aggravating influence on their processability.

The identification of relevant requirements has a positive influence on the quality of the generated results [11]. Nevertheless, the complexity of the requirements document raises the need for a specific support, as a manual analysis and processing is extremely time-consuming respectively hard to real-

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ize. This is supported by the psychological point of view. The human ability to handle a great amount of information is limited, which leads to an incomplete or reduced consideration [12]. Requirements of high quality and the opportunity of their goal-oriented processing will meet the problem of information overload and support the necessary systematic proceedings [13].

The approach to enable a supported provision of only those requirements that are relevant for a specific task leads to the objective of a flexible, task-oriented requirements filtering. The user should be able to extract requirements from a database-driven requirements document by specification of a task-specific retrieval request. Additionally, the user should be notified on relevant changes in requirement specifications to always act on the latest status of requirements. This problem entails:

- Intelligent analysis and selection of requirements,
- Task-oriented editing and processing of requirements,
- Continuous, flexible requirements management,
- Change monitoring.

The remainder of this paper will describe the conceptual approach for the task-oriented requirements management by intelligent assistance regarding requirements filtering in detail, followed by the specification of the associated agent system, and conclude with the synopsis and evaluation of the proposed concept.

II. CONCEPT DEVELOPMENT

The functions that will be fostered by the introduced approach focus on the coverage and control of the complexity in requirements specifications, enable an efficient search and selection of requirements, and can be flexibly and continuously adopted by users during their variable tasks. Fundamentals to this method are a semantically enhanced categorization of requirements, information model integration, and the adoption of information agents for the task-oriented analysis, filtering, and monitoring of requirements.

With reference to Belkin and Croft, the problem of information filtering can be identified as the selection of information relevant for an individual user [14]. The qualification of information agents can be gathered from their definition. Klusch characterizes an information agent as an autonomous, computational software entity that has access to one or multiple, heterogeneous and geographically distributed information sources, and which pro-actively acquires, mediates, and maintains relevant information on behalf of users or other agents preferably just-in-time [15].

The basic skills of an information agent are divided in communication, collaboration, knowledge, and low-level tasks [16]. Communication can be accomplished with information systems including databases, agents or users. The interaction respectively collaboration with users or agents can be established on higher-level. Data, information or knowledge of different formats can be processed by the information agent, including ontological knowledge, metadata, profiles and natural language. Main tasks regarding the handling of information involve its retrieval, filtering, integration and visualization. The basic skills are interrelated and form the specific capability of an information agent.

The general applicability of information agents still asks for a task-specific configuration and determination regarding agent, environment, and information basis. As mentioned before, the processing of natural language by IT-systems is limited. This includes especially the identification of relevant information. It is necessary to cope with the vagueness and complexity of semantic relations of requirements. Therefore, an enhanced organization of requirements is necessary based on a formal specification mechanism, which can be achieved by a categorization of requirements, in accordance with Gabb [3].

It is mandatory that the semantic relationships will be covered by a defined schema. By mapping of requirements contexts, the efficiency regarding their IT-supported analysis will be improved significantly. The semantic allocation of data is of high complexity and within the focus of several actual research initiatives, e.g. the development of the Semantic Web[1] is of high importance in this area. Thereby, the integration of ontologies as formal specification mechanism has been considered. Gruber specified a commonly agreed definition, whereas an ontology is an explicit specification of a conceptualization [17]. An ontology extends the linguistic means of expression of a corresponding representation [18]. A basic product ontology refers mainly to classification systems [19]. Methods that are used by ontology integration approaches are e.g. text similarity, keyword extraction, structural analysis, and data interpretation and analysis [19].

The generation of a classification system for requirements solely realized per ontology requires immense efforts due to the existing complexity and diversity. A reduced system would limit the functionality and flexibility. Due to this fact, the integration to the standardized systems engineering reference model ISO 10303 STEP AP233 has been taken into account, pre-published as publicly available specification ISO/DRAFT-PAS 20542:2004(E) [20]. The following is within the scope of the AP233 model:

- Products with conformity to the concept of a system,
- System definition data and configuration control data pertaining to the design and the validation phases of a system's development,
- Requirements,
- Functional analysis data including functional behavior specifications,
- Physical architecture and synthesis data providing a high level view on the system under specification,
- Elements that are used to represent and trace requirements and functional allocation.

Fig. 1 shows a conceptual view of the AP233 system model in UML syntax, whereas every box represents a group of related entities. The central unit of functionality for requirements allows the integration of a classification system, besides the general representation of requirements, their interrelations and assignment to system specifications. The standard

[1] see http://www.w3.org/2001/sw/