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Model-based support of the conceptual design in distributed product development

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Abstract

Distributed product development presents a particular challenge to the knowledge management in small and medium-sized companies. Barriers for information exchange arise from the separation of organisational units, separation of projects and separation of the development process. However, to make reliable decisions in the early phases of the development, information must be provided to designers gathering requirements and elaborating the product concept. In this paper, a methodical approach is presented, which aims on a better integration of information in value-added networks. The principal core of the approach is an information model, combining partial models of requirements, system components and suppliers. Introducing this with a web-based tool, a step towards better decisions in development could be made.

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Keywords: product lifecycle, information and knowledge management; collaborative design; systems architecting; conceptual design

1. Introduction

Todays significance of distributed product development has brought a new emphasis to an efficient knowledge management. Thus, for many companies it has become necessary to perform the development process across multiple geographic locations in mostly independently operating departments or companies. Consequently, especially small and medium-sized enterprises (SME) often participate in OEM centered value-added networks. In this way, they are able to focus their special competences in collaboration. Such networks, for instance, can be found in the development of mechatronic products, which integrate components of the mechanical and electrical engineering and information technology. An example for a network of a system developer is shown in Fig. 1.1.

Each company assumes a specific role in these networks, whereas the degrees of cooperation differs widely: Companies could collaborate as producers of single components, while others cooperate as dependable partners in design and production. Especially with mere producers knowledge exchange is very limited. Even though, both system developer and supplier could benefit from closer cooperation [2].

1.1. Barriers for Knowledge

Apart from the designers creativity, one key factor for successful product development is the available knowledge as basis for decisions [1]. However, this knowledge is often not sufficiently available when it is needed for decision-making, but rather exists in later stages of the process. For example, during conceptual design, decisions on needed functions or suitable solution principles are made as a basis for the product to be developed. The knowledge about different options for product implementation is not available as the manufacturer gets involved only later in the process. Thus, the concept engineer has to make assumptions. As it turns out later, these decisions might be incorrect or non-optimal, expensive and time-consuming iterations are needed.

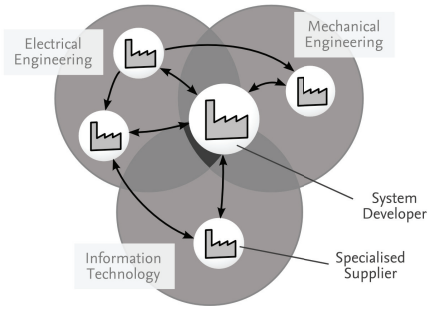

Fig. 1. Interdisciplinary collaboration network with a system developer and specialised suppliers.

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Besides this temporal discrepancy of knowledge availability, boundary conditions as independently acting organisational units or functional separation of project processing complicate the knowledge exchange between knowledge carriers. These barriers promote the emergence of so-called islands of knowledge during the design process [5].

1.2. Objective

In many cases, even in SME applicable methods and tools are missing to handle and communicate product and process information across geographical distances and different disciplines efficiently. The methodical approach presented in this paper aims to facilitate a profitable cooperation with suppliers due to an enhanced exchange of knowledge. As basis, an information model is described, enhancing an easy sharing of information in distributed product development.

1.3. Structure

In following chapter 2, the barriers for knowledge in distributed product development are analysed and general challenges of information exchange are identified. On this basis, in chapter 3 the problems of an efficient knowledge management are clarified, before the idea of the methodical approach is presented in chapter 4. Thereafter, the information model as its core element is described in detail in chapter 5. The paper ends with a conclusion and an outlook.

2. Knowledge in distributed product development

Knowledge is the competence of individuals in dealing with complexity. Thus, the success in complex product development with many different options to choose is mainly based on knowledge [3]. However, as knowledge is bound to individuals in the form of tacit knowledge, a direct exchange is not possible [4]. Rather, a resource is needed, which could be extracted by knowledge carriers and from which other person could generate knowledge. This resource is information [5].

2.1. Knowledge in the Process of Product Creation

A knowledge-based product development aims on the provision and combination of knowledge at earliest possible decision points. Thus, decisions in the early phases of the process determine most of the costs, whereas they are caused only later. However, the knowledge necessary for decision-making is often non-sufficient available at the time needed within the process [6].

Especially in distributed product development, this temporal discrepancy is difficult to overcome. Available knowledge in early phases is mainly based on experience of single persons. However, reliable information is hold by departments or companies, that are only later involved in the process. For example, knowledge regarding manufacturing limitations could only be considered by the company that will later participate as a supplier of a subsystem. Often, this supplier is not even defined and will be chosen later. The decision could only be made on basis of estimations founded on the experience of a specific person, but not expert.

2.2. Islands of knowledge in distributed product development

Besides the temporal discrepancy, as an extra dimension, the organisation is added to the challenges in distributed product development to bring knowledge together. Barriers between organisation units prevent combination of knowledge. As a third dimension the inaccurate connections between current projects and experience from other projects hinders the access to existing knowledge.

These three dimensions process, organisation and projects creating barriers between interrelated knowledge, are represented in Fig. 2.

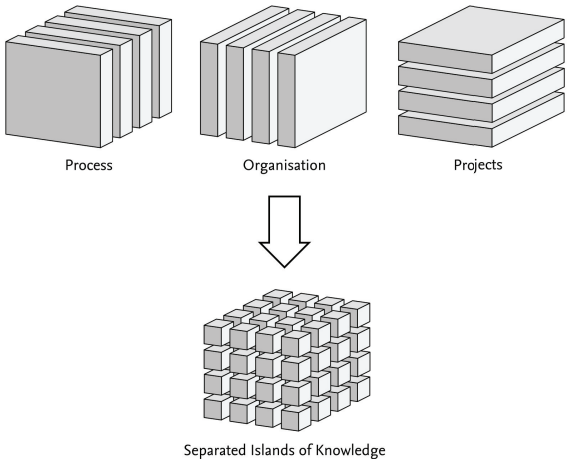

Fig. 2. Dimensions of separation causing islands of knowledge (see also [7])

These dimensions of knowledge separation are the barriers to be overcome for an efficient knowledge management.

2.3. Information pathologies

In the process of knowledge exchange, problems could occur, that effect a lack of information needed for decision-making. Four types of avoidable mistakes could cause these so-called information pathologies [8]: information that is not produced at all, is not acquired, is not or incorrectly transmitted and information that is misunderstood or not put to use.

In interdisciplinary collaborative product development, many information pathologies could be identified, which cause non-optimal decisions. Assuming that all required information exists at any time of the process, following main problems were identified in current research:

1. **Production**: Information does not exist at all, because it is not produced by individual persons (as knowledge carriers). Especially the innovative strength of SME often depends on individual persons and their tacit knowledge, that is not directly transmittable and long-term storable.
2. **Acquisition**: Information is not acquired, i.e. information exists, but the decision-maker does not know, that it could be acquired. In distributed development, this could be caused by complex organisational structures with various departments and companies, but also by separated project