APPROACH FOR MODELLING KNOWLEDGE MANAGEMENT SOLUTIONS WITHIN THE PRODUCT DEVELOPMENT PROCESS USING THE 'KNOWLEDGE MODELING AND DESCRIPTION LANGUAGE'

Laukemann, Alexander; Binz, Hansgeorg; Roth, Daniel
University of Stuttgart, Germany

Abstract

In the research field of knowledge-based product development, a huge number of knowledge management solutions is available and enjoys high attention in the entrepreneurial environment. In contrast to whole knowledge-intensive business processes, which are partially modelled by means of a modelling language, the importance of a modelled knowledge management solution is not considered yet. A modelled knowledge management solution by means of the Knowledge Modeling and Description Language (KMDL) offers high potential for supporting the product development process. This paper describes an approach for developing product-development-process-specific knowledge management solution models by using KMDL. As a frame of reference, the generic procedure model in KMDL projects, which KMDL provides, has been adapted and optimised. The derived approach is described with several process steps. Finally, the presented approach is critically discussed and the paper ends with a brief conclusion as well as an outlook for subsequent research activities.

Keywords: Organisation of product development, Process modelling, Knowledge management, Design process

Contact:
Alexander Laukemann
University of Stuttgart
Institute for engineering design and industrial design
Germany
alexander.laukemann@iktd.uni-stuttgart.de

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1 INTRODUCTION

Since Nonaka and Takeuchi (1995) explained the transformation of tacit knowledge into explicit knowledge in an entrepreneurial environment and since Probst (2010) continued by presenting several key activities of knowledge management, a large number of knowledge management methods and knowledge management tools have been provided. It is widely acknowledged that a general knowledge management method or knowledge management tool which is universally applicable through every business process is non-existent. However, some of these approaches and concepts currently enjoy high attention in research and industry. Due to the lack of direct practical applicability, most of the knowledge management methods or knowledge management tools are not accepted and do not enter general use. A huge potential is offered by an approach focused only on knowledge-intensive business processes. Eppler (1999) examined all business processes within an entrepreneurial environment and determined two criteria to classify business processes with regard to knowledge management: process complexity and knowledge intensity. The complexity of the examined processes can be identified by a set of attributes such as, for example, the amount of process steps or the dynamic of a process. Besides the process complexity, a knowledge intensity of a business process can also be described. To define the knowledge intensity of a business process, Eppler (1999) provides several characteristics such as, for example, contingency (weak contingency if process activities are defined) or decision scope (strong decision scope if participants of the process have several possibilities) of a process. Four process classes are the result of the classification of business processes by using the criteria knowledge intensity and process complexity (Eppler, 1999):

1. Low process complexity combined with weaker knowledge intensity (class 1)
2. High process complexity with weaker knowledge intensity (class 2)
3. High process complexity with higher knowledge intensity (class 3)
4. Low process complexity with higher knowledge intensity (class 4)

Class 3 in particular, with its high process complexity and high knowledge intensity, offers the potential to be supported by knowledge management solutions. One business process that is representative of class 3 is the knowledge-intensive and complex process of product development (see Figure 1).

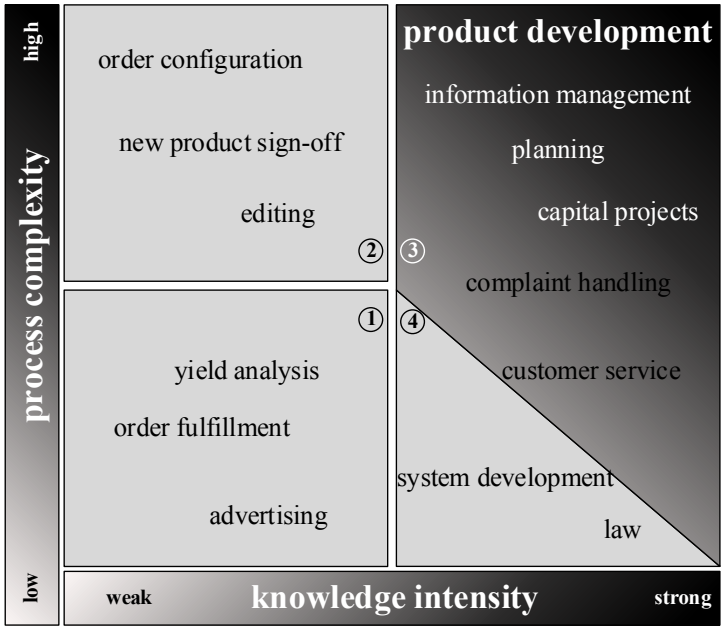

Figure 1. Classification of business processes with regard to process complexity and knowledge intensity (adapted from Eppler, 1999)

As mentioned before, knowledge management challenges within product development can be faced by several knowledge management solutions. The term 'knowledge management solution' has various different meanings in academic literature. Knowledge management solutions are used as a term for

every knowledge management method or knowledge management tool, which can be used to face a knowledge management challenge, in the understanding of the authors. For the business process 'product development', a huge number of different knowledge management solutions are available. In almost every stage of the product development process, there is a set of particular methods or tools available. Most of them are not known as specific knowledge management solutions but pursue the same goal. The major reason why knowledge management solutions should be used in all stages of the product development process is that the results of the application of these solutions are structured and relevant information plus process-specific knowledge. Within the product development process, there are several methods and tools which are widely used to assist particular process steps such as, for example, Failure Mode and Effects Analysis (FMEA) to identify and prevent malfunctions in an early stage of the product development process or the creativity technique 'brainstorming', which supports gathering ideas contributed by its members to find a conclusion for a specific product development issue.

Since Davenport and Short (1990) explored the relationship between information technology and business process redesign in detail, business process management and the modelling of business processes gained increasing importance in industry and science. A myriad of business process management systems have therefore been developed which mainly pursue the objective of coordinating the activities involved in business processes. A model of the knowledge-intensive process with a modelling language supports the identification of the potentials of knowledge management solutions within the product development process (Laukemann, 2014). The Knowledge Modelling and Description Language (KMDL) is able to indicate the information flows, knowledge transformations and personal knowledge of a business process. One major advantage of KMDL is that, contrary to the other process modelling approaches like ARIS (Scheer, 1991), INCOME (Remus, 2002) or PROMOTE (Hinkelmann, 2003), it is able to distinguish between tacit knowledge and explicit information (Gronau, 2004). KMDL is not just a modelling language to visualise knowledge-intensive business processes, but rather a set of special analysis tools. Important aspects of KMDL are the different process perspectives that can be modelled and also the detailed approach for implementing KMDL. The implementation of KMDL occurs by means of the generic procedure model in KMDL projects (see Section 3, Figure 2). This generic procedure model is designed to support an entire business process and includes several process steps which support comprehensive process analysis. Pogorzelska (2009) gives a detailed description of the latest version (2.2) of KMDL. Furthermore, Bahrs (2005) provides a pattern-based analysis of knowledge-intensive business processes and shows how different process patterns may be used to redesign processes into improved processes. However, an approach focused mainly on modelling knowledge management solutions within the product development process has not been considered yet and will comprise the content of this paper. In the next section, the problem statement and goals of this paper will be presented.

2 PROBLEM STATEMENT AND GOALS

The problem is that there is currently only one generic procedure model in KMDL projects, which can be subdivided into partial analysis procedures. But the particular challenges of knowledge management solutions within the product development process in the context of process modelling have not been considered yet. The generic procedure model in KMDL projects may be used as a kind of framework for the modelling of knowledge management solutions. This framework lacks explicit process steps to support KMDL modelling with regard to knowledge management solutions in the context of the product development.

The research question is as follows: *"Which steps of the procedure in KMDL projects are relevant and which need to be extended to support the modelling of knowledge management solutions within the product development process?"*

As stated before, the existing generic procedure model in KMDL projects (see Section 3, Figure 2) may be used as a frame of reference for modelling knowledge management solutions of the product development process by means of KMDL. The major part of this paper comprises the presentation of characteristic process steps, which are necessary to generate a process model of a knowledge management solution. Additionally, the result of each process step shall be represented separately. This paper is directed at knowledge engineers and mechanical engineers who are familiar with modelling languages and process-oriented knowledge management. The approach presented here

might help to clarify the connection between process-oriented knowledge management and knowledge management solutions, which are described with a modelling language.
Based on the problem statement, Section 3 presents the state of the art in terms of KMDL in general and selected knowledge management solutions related to the product development process. Moreover, the necessity of an approach for modelling knowledge management solutions will be elaborated upon. Section 4, as the main portion of the paper, deals with the method of how knowledge management solutions may be modelled with KMDL. The obtained results, visualised as a KMDL model, are discussed in Section 5. The paper ends with an overall conclusion and an outlook (see Section 6).

3 STATE OF THE ART

In the research field of knowledge-based product development, a variety of process modelling approaches is well known. Gronau (2004) investigated several approaches and discovered that each modelling method does not separate tacit knowledge from explicit information. With regard to Nonaka and Takeuchi (1995), this distinction is an elementary requirement for knowledge creation. Former business process modelling methods were developed to structure control and data flows. When knowledge management enjoyed high attention in research and industry for the first time, traditional methods for business process management were merely extended with notations from knowledge management. These and other deficiencies were the reason why KMDL was developed. The semi-formal modelling language has been continuously developed from version 1.0 to the latest version: 2.2. The language consists of a clearly defined set of symbols and a given syntax (Pogorzelska, 2009). KMDL 2.2 provides three different views to describe an entire knowledge-intensive business process. The process view gives a rough overview of all steps of the process. The activity view focuses on detailed and relevant tasks within each process step. This view is very important for further analyses with regard to knowledge intensity or the distribution of process knowledge in general. The communication view is the latest one of the view concept. This view takes into account how the communication between different knowledge carriers is organised. Along with the view concept, KMDL provides numerous objects of each view to describe the investigated business process in a graphic manner. Particularly worthy of emphasis are the objects of the activity view, which facilitate the modelling of a flow of information and a process of knowledge creation. Therefore, the activity view provides the information object, knowledge object, conversion, requirement and personal objects such as the person, team or undefined person. However, for this paper, the generic procedure model in KMDL projects (see Figure 2) is more important.

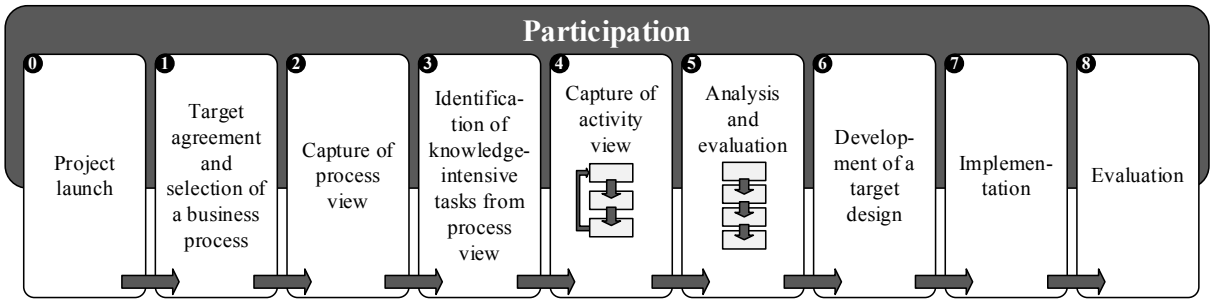

Figure 2. Procedure in KMDL projects (adapted from Pogorzelska, 2009)

The procedure involves nine different phases and starts with the project launch (step 0). The content of the first step comprises the definition of an organisational frame for the KMDL project. The goal of the second step is to identify relevant and knowledge-intensive business processes. The result of step two is a modelled process view at a higher level of granularity. Afterwards, the knowledge-intensive tasks of the investigated business process will be recognised in step three. With the obtained results of the previous steps, the activity view can be modelled based on an iterative process in step four of the KMDL procedural model. Step five includes the process model; the analysis will be performed by taking previously obtained results into account. The final steps deal with organisational issues such as, for example, how the project partner will implement necessary changes in their organisational structure and processes.

As stated in Section 1, the product development process is characterised by high knowledge intensity plus high process complexity in comparison to all other business processes (see Section 1, Figure1). The Verein Deutscher Ingenieure (1987) provides a generic and systematic approach to the design of technical products. This approach involves different stages, which should be processed step-by-step with the opportunity to iterate forwards and backwards between the stages. Each stage has a specific outcome, which includes obtained results. At a higher level of granularity, the stages may be assigned to four superior phases. The first phase is named 'Clarification of the task' and includes the definition of the problem as well as the determination of functions and their structure. In the second phase, 'The conceptual design', solution principles and their combination should be developed. After this, the principle solutions may be divided into realisable modules. The third phase, 'The embodiment design', deals with module structures which are obtained in the previous step. The major task of phase three is the layout development of key modules. As one of the results of the embodiment design, the key modules will be transferred into definitive layouts. Finally, the detail design phase prepares production and operation instructions for the further realisation (see Figure 3).

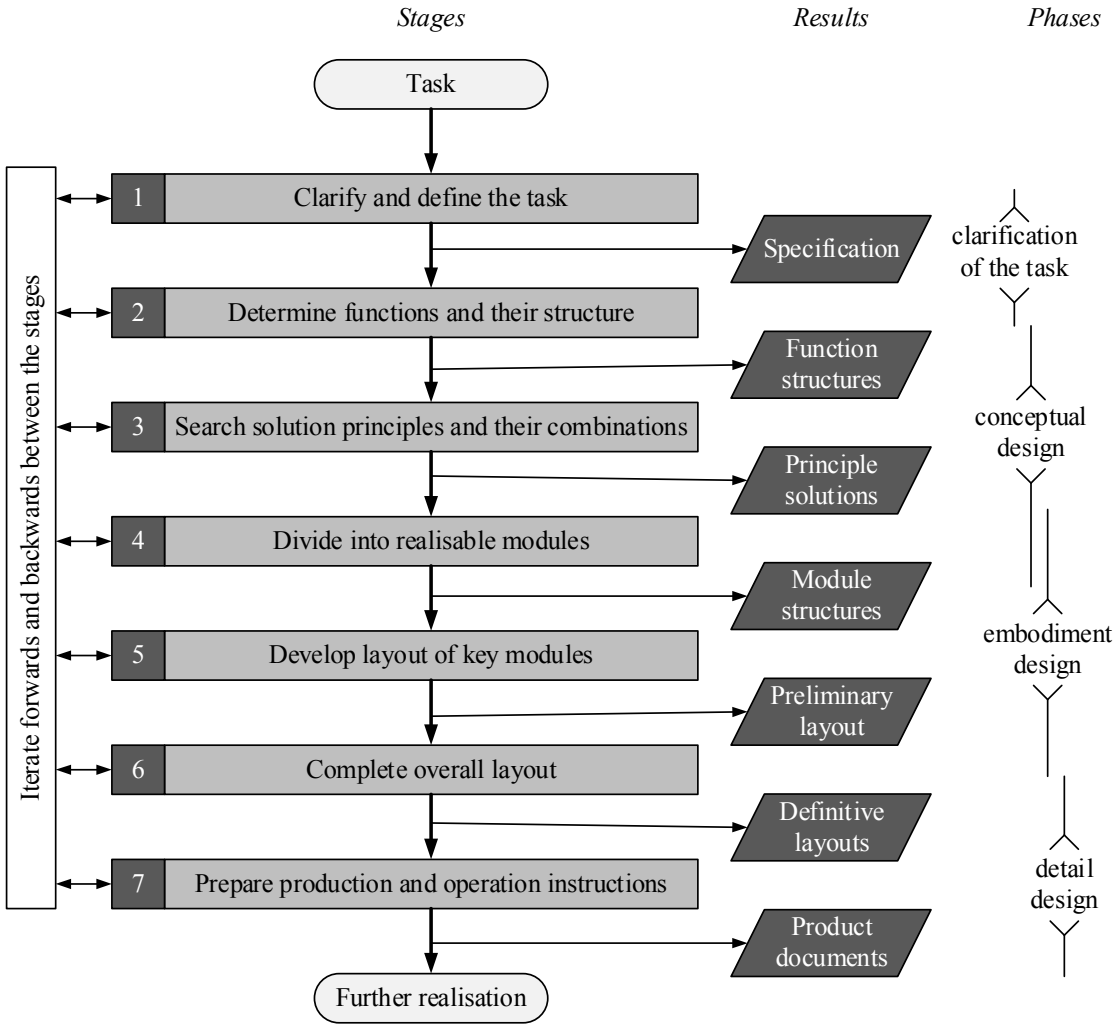

Figure 3. Guideline for mechanical engineers (adapted from Verein Deutscher Ingenieure, 1987)

For modelling information flows and processes of knowledge creation within the product development process with KMDL, a more detailed approach is necessary. Pahl and Beitz (1988) extended the generic model of the design process. Based on the superior phases, clarification of the task, conceptual design, embodiment design and detail design, Pahl and Beitz (1988) describe in detail the different activities and work instructions of each step. Furthermore, helpful methods and tools such as, for example, a guideline for developing a requirement list to clarify and define the task or to establish function structures for the conceptual design, are explained and support the application of the design

process. The connection between the generic model of the design process and the extensions by Pahl and Beitz (1988) is presented as an example in Figure 4.

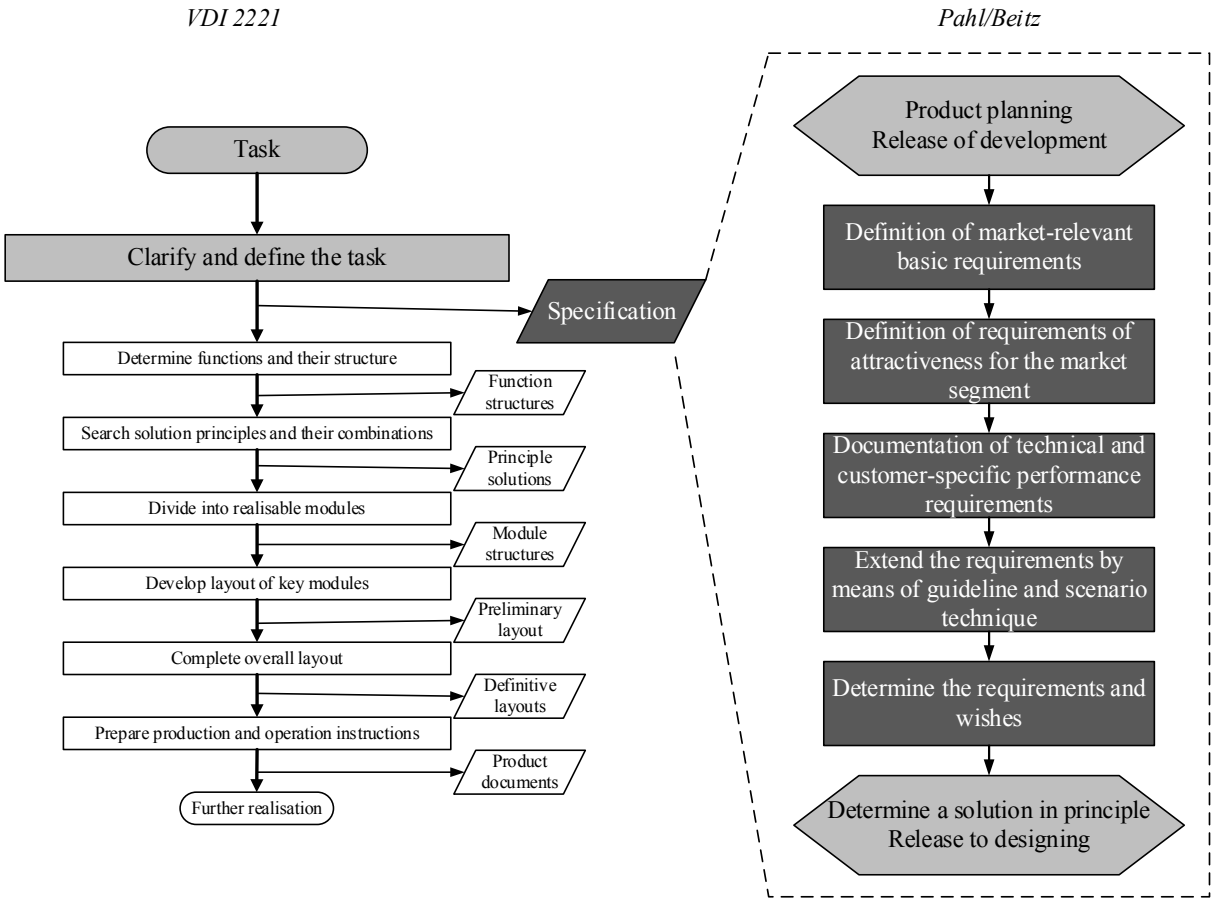

Figure 4. Connection between the generic model of the design process and the extensions by Pahl/Beitz

Within the product development process, a lot of methods and tools are used to support mechanical engineers. Especially in the early stage of a product development project, certain working results require a methodical procedure. The requirement list, the function structure, the morphological boxes or lists of design principles are some widely used methods and tools within the product development process across all manufacturing industries.
The following section describes a procedure to model knowledge management solutions within the product development process by means of KMDL. The investigated product development process is based on the generic model of the design process.

4 PROCEDURE TO MODEL KNOWLEDGE MANAGEMENT SOLUTIONS WITHIN THE PRODUCT DEVELOPMENT PROCESS BY MEANS OF KMDL

The presented generic procedure model in KMDL projects (see Figure 2) provides several steps for developing KMDL models of a knowledge-intensive business process. Knowledge management solutions represent knowledge-intensive methods or tools that support different steps of the product development process. To model product-development-specific knowledge management solutions by means of KMDL, the generic procedure model in KMDL projects has to be extended and described in more detail. In contrast to modelling a whole business process, the modelling of a knowledge management solution, certain process steps such as, for example, the selection of a business process (see Figure 2, step 1) or analysis and evaluation (see Figure 2, step 5) are not necessary and can be omitted.
Major parts of each KMDL model are the process and the activity view, which have to be described in more detail. For that reason, step 2 and step 4 of the generic procedure model in KMDL projects have to be adapted to develop a procedure to model product-development-specific knowledge management

solutions by means of KMDL. To follow the general instructions of process step 2 and step 4, special requirements concerning modelling of knowledge management solutions have to be considered (Pogorzelska, 2009). One reason for modelling product-development-specific knowledge management solutions is that the model should be used to support knowledge management challenges within the product development process. This aim has to take into account the requirement for the development of a knowledge management solution model. To meet this requirement, the process interfaces of the modelled product development process and the knowledge management solutions have to match precisely. Another requirement is that all relevant information for the knowledge management solution must be identified in the previous process steps.

The first step for modelling a product-development-specific knowledge management solution is to capture the process view. The process view contains different KMDL objects such as the task object, role, process interface, information system and different joint operators. The major KMDL object of this view is the task object, which describes a general stage of the knowledge management solution. The several task objects are connected through control flows. With the different KMDL objects, the process view may be captured in more detail. To identify all relevant stages of knowledge management solutions, the extensions of the generic model of the design process by Pahl and Beitz (1988) support the direct modelling of the process view (see Figure 5).

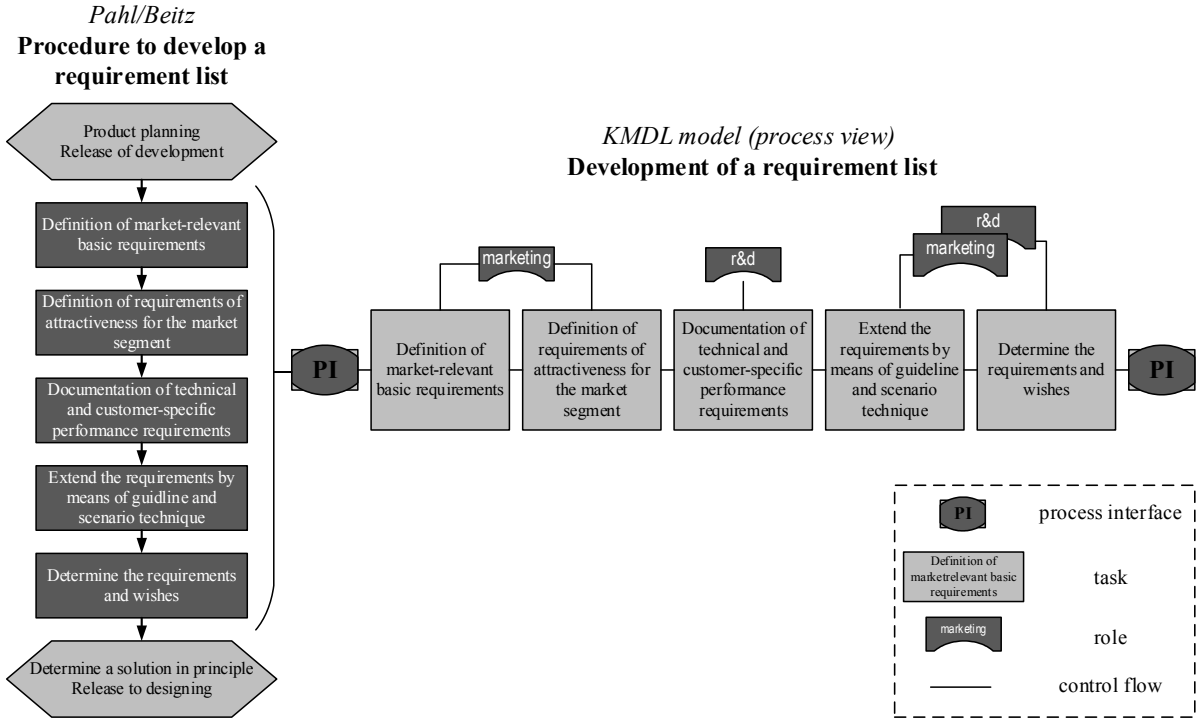

Figure 5. Connection between theoretical description of the procedure to develop a requirement list and the KMDL model (process view) of developing a requirement list

Based on the process view of the knowledge management solution, the more important activity view can be derived in the next step. Therefore, the KMDL objects of the activity view, such as conversion, information object, knowledge object, requirement and personal objects are needed to develop a KMDL activity view. If the instruction of the knowledge management solution includes a detailed process description, the superior KMDL objects of the process view may be identified without any problems, whereas the relevant KMDL objects of the activity view are difficult to detect. For this reason, the presented procedure recommends implementing a checklist to detect important KMDL objects for the activity view. This checklist is based upon the comprehensive description of specific objects of the activity view, which KMDL provides. The structure of the checklist is similar to a questionnaire of a structured interview and involves several questions to detect relevant KMDL objects (see Figure 6). The checklist is the major tool to identify and detect any necessary information for developing the activity view of the knowledge management solution. The reason for combining a checklist with parts of a structured interview is that the development of the activity view needs a certain minimum number of KMDL objects that have to be checked. Nevertheless, for a holistic

picture of the knowledge management solution, other investigation activities such as, for example, in-process research or knowledge management role-playing with participants of the investigated process should be considered in the same way.

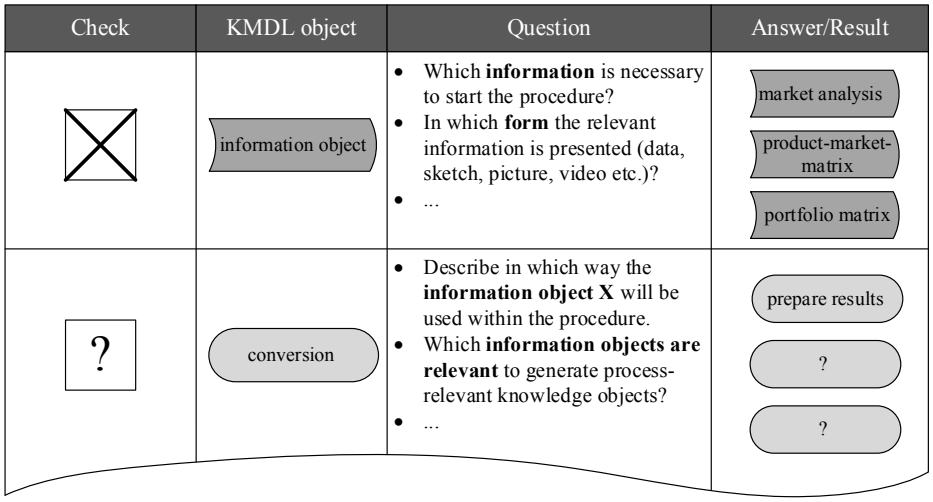

Figure 6. Extract from the checklist to detect relevant KMDL objects of the activity view

The presented checklist constitutes a guideline to identify and detect KMDL objects of a knowledge management solution. Figure 7 shows an overview of the procedure for how to develop the activity view.

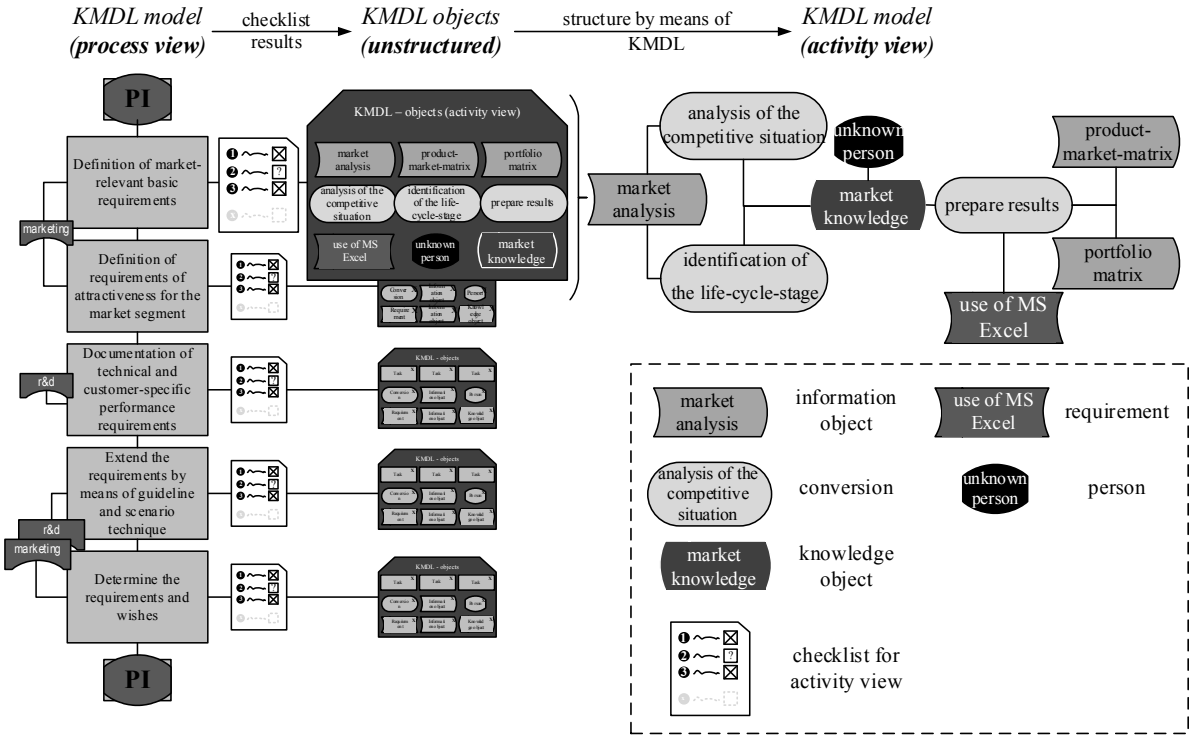

Figure 7. Interface between the application of checklists and the theoretical description of the procedure

With the working results of the presented procedure steps, the model of the process view and the more important activity view can be developed. The essential steps of the generic procedure model of KMDL projects to model knowledge management solutions by means of KMDL, capture of process view and capture of activity view, can be described more precisely (see Figure 8). Steps 2.1 and 2.2 explain the capture of the process view, which include the superior process steps. The process step 4.1 represents the major step of the procedure to model a knowledge management solution. Then, in step

4.2, the identified and detected KMDL objects of the activity view will be combined into different activity views. Finally, each activity view will be interconnected through process interfaces to compile one activity view, which is referenced to a process step of the process view (see Figure 8, step 4.3).

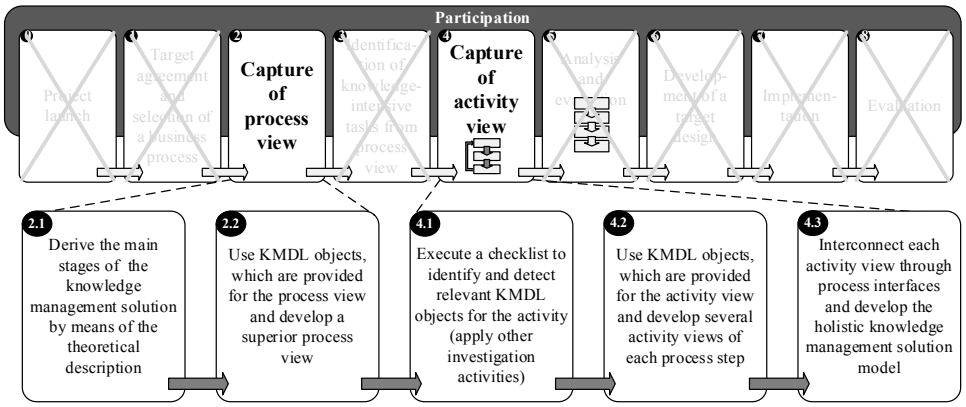

Figure 8. Relevant steps to model a knowledge management solution

The final result is a modelled knowledge management solution (see Figure 9), which can be applied for different purposes (see Section 6).

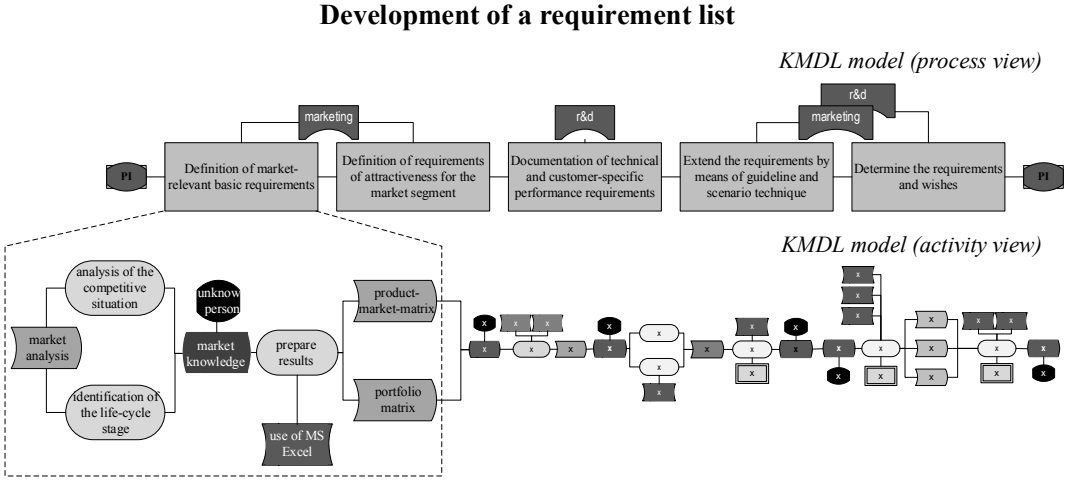

Figure 9. Exemplary KMDL-model of a knowledge management solution

5 DISCUSSION OF THE RESULTS

In this section, the presented results are critically discussed. A first critique has to be inferred from the selection of the underlying generic procedure model. On the contrary, a completely new approach should have been elaborated. The generic procedure model in KMDL projects maps the holistic procedure to analyse entire business processes. For this reason, the generic procedure model is used as a frame of reference. The process steps 2 and 4 have been identified as relevant for the adaptation of a procedure to model knowledge management solutions (see Figure 2 and Figure 8). A necessary requirement of the presented procedure is the availability of a detailed description of the knowledge management solution which is to be modelled. In this paper, the extensions by Pahl and Beitz (1988) of the generic model of the design process stand for the necessary detailed description. In Pahl and Beitz (1988) a huge number of tools, methods or procedures to support the product development process, is presented. But to model company-specific knowledge management solutions or special cases, more extensive information sources (e.g. lessons learned or reference books) have to be considered. The first two steps of the presented procedure to model knowledge management solutions within the product development process by means of KMDL describe the capture of the superior process view. This procedure does not constitute a crucial reform compared to the generic procedure model. Almost every knowledge management solution provides at least a short and superficial description of the use of the method, tool or approach, whereas the identification and detection of

separate tasks within process steps may be difficult. Effective examinations have to be conducted to gather all relevant information to model the more important KMDL activity views. The presented procedure recommends implementing checklists for identifying and detecting relevant KMDL objects from the activity view (see Figure 6 and Figure 7). For this, a critique has to be inferred from the decision of using checklists structured like a questionnaire to gather necessary information. In the research field of knowledge management, it is usual to implement questionnaires to collect relevant data. If certain requirements for developing a questionnaire and a purposeful response set are considered, the questionnaire is able to gather the right information (Porst, 2008). Finally, the last two steps of the presented procedure describe how the KMDL activity view can be developed and interconnected into a holistically modelled knowledge management solution. As with the initial modelling of the process view, this procedure does not constitute a crucial reform of modelling knowledge-intensive business processes by means of KMDL. Nevertheless, each process step is necessary to develop a knowledge management solution model. The product-development-specific checklists to gather the necessary information about the several tasks, in particular, have shown a great potential in preliminary investigations.

6 CONCLUSION AND OUTLOOK

As stated in Section 2, the current generic procedure model in KMDL projects does not consider in detail the individual challenges for modelling a knowledge management solution of the product development process. To fill this gap, the research question has been formulated. In this paper, a procedure is presented for modelling knowledge management solutions within the product development process by means of KMDL. Firstly, a brief overview about the state of the art concerning knowledge-based process modelling and the connection to the product development process has been described. Based on a generic procedure model in KMDL projects, a knowledge-management-solution-specific adaptation and optimisation has been executed. The presented procedure with its crucial reform by applying structured checklists has been described in detail. In the future, necessary checklists have to be optimised and evaluated in terms of application in industry. Another focus lies on the further purposes of the knowledge management solution models, which can be used to support the product development process. A high potential to improve product development processes is offered by the further analysis of the influence of knowledge management solution models.

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