The Role of Process-oriented Enterprise Modeling in Designing Process-oriented Knowledge Management Systems

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Abstract

Process-oriented knowledge management systems (KMS) are aimed to provide employees task-relevant knowledge in the company's operational processes. Thus, process orientation can be regarded as a broad concept in the creation of an architectural framework for KMS. The subsequent question here is whether, and to what extent, process-oriented enterprise modeling, a key method of process orientation, can serve as a basis in the design and utilization of KMS.

After first presenting utilization benefits of a process-oriented approach, the following study will discuss the contribution of process-oriented enterprise modeling for the tasks involved during the conception and the operation of the systems. In particular, the study will present a systematic framework to look at modeling activities for business process management and knowledge management. The framework is used to show in what direction classic modeling activities need to be developed in order to meet the particular demands in modeling knowledge-intensive processes that are supported by KMS.

Process-oriented KMS

To begin with, a classification scheme already in use for knowledge management projects is applied for classifying knowledge management systems (KMS). A distinction is made between knowledge management employing a portal strategy, knowledge management using community services, and knowledge management with a continuous connection to information in the work process (see Sippach et al. 1999). While portal-oriented strategies are aimed at integrating pre-existing data bases and bringing them together via a standard user interface (portal), the emphasis in community-oriented strategies is to manage communities that stress the importance on the collection, commenting, discussion, and evaluation of business-relevant information. In contrast to portal- and community-oriented KMS, process-oriented KMS seek to provide employees with task-relevant knowledge within the business processes that are operating in the company. This means that an employee receives precisely the knowledge he/she needs for his/her task in the business process.

Knowledge is seen here from a constructionist perspective. Knowledge is (re)constructed by the subject with the help of information and the information's context. Context is determined, among other things, as in the case of the central points emphasized here, by tasks, objectives, roles, etc. in the business processes. For the term "process," cf. for example, (Becker and Vossen 1996). For the distinction between processes, cf. (Hess 1999).

Of course, mixed forms also exist such as portal-oriented KMS that provide access to process-related knowledge. Here the classification, which is only one of many that are possible (cf. Lehner et al. 1998), is intended more to describe and clarify various approaches and methods when implementing a KMS than it is to clearly classify KM architectures.

Process-oriented KMS not only acquire and provide external knowledge, they are also supposed to contribute actively to so-called knowledge processes that regulate the flow of knowledge between various knowledge-intensive operative business processes. Thus process-oriented KMS also directly support processes carried out within knowledge management activities.

The following types of processes are considered as knowledge intensive and can be supported by process-oriented KMS (cf. Allweyer 1998):

- *Knowledge intensive operative business processes*: this type of process uses knowledge in order to create the process output as well as for handling the process itself.
- *Knowledge processes:* they support the flow of knowledge between business units and processes as well as the creation and collection of knowledge. This can be processes supporting the collection, processing and storing of information as an outcome of conventional business processes. This means that process-oriented KMS supporting knowledge processes are directly involved in knowledge management activities.
- *Knowledge processes* can in turn be subdivided in *(knowledge) management processes* and in *specific knowledge processes.* Both play different roles in the context of controlling and managing the organizational

knowledge base. This differentiation is based on a distinction made by Probst, who mentioned two principles important for the arrangement of the components within his knowledge life cycle. The external cycle consists of goal settings, implementations and measuring knowledge. It builds on the traditional management process. An internal cycle of specific knowledge processes like knowledge identification, knowledge presentation and knowledge distribution links these processes and defines a relation between them (cf. Probst et al. 1998).

Typically, the main component to guide process-oriented KMS is a navigation structure derived from process descriptions. This structure links process elements, for example process parts, tasks, roles, information- or business-objects or process outputs, to various knowledge elements. These can be links to documents concerned with project descriptions, with lessons learned, or with task instructions, or they can provide access to other knowledge systems such as expert systems, business intelligence solutions, or research data bases. Links to communication channels such as e-mail or news forums also allow for direct contact to knowledge sources and groups (cf. fig. 1).

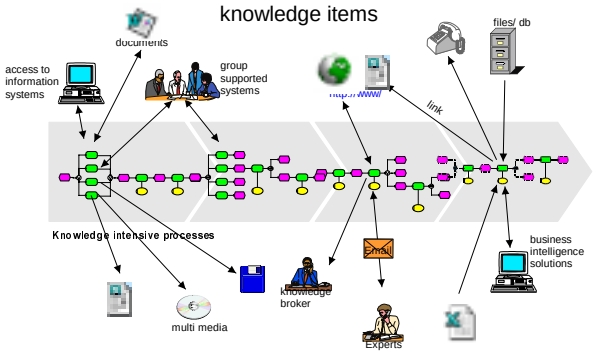

Fig. 1: Process-oriented navigation in knowledge sources.

The immediate support of processes by IT-solutions controlling the workflow in a narrow sense has not been described in this figure. Systems like intelligent workflow applications or groupware systems can provide real-time information about the actual context of a process (cf. e.g. Reimer et al. 1998, Wargitsch et al. 1998). This means that they contribute in many ways to process-oriented KMS.

A successful improvement of knowledge intensive processes has a stronger relationship to the flow of knowledge and information than to the workflow (cf. Davenport et al. 1996). This means that existing knowledge which is not generally available or accessible within business processes may be of great importance. As a consequence process-oriented KMS should also focus on the design and maintenance of the organizational knowledge base and the connected flows of knowledge in order to link them to knowledge intensive processes during run-time.

Thus, process-oriented KMS identify, filter, manage, and organize process-relevant knowledge in order to provide it in the processes.

At first glance these systems seem to be no more than document or content management systems with some intelligent functions added. This is not quite true because there are some attributes qualifying them as KMS. First of all they realize and document specific knowledge processes (e.g. processes for identification, collection, distribution, sharing and storing of knowledge and processes for managing and improving the structure and content of the knowledge base). Secondly there is a link between the components of a business process (role, activity, resource) and process-related knowledge items. And last but not least the use of KMS stimulates process orientation and thus supports continuous process improvement and organizational learning.

In the following, we show the advantages of a process-oriented approach for KMS before we proceed to the central point, the contribution of process modeling to system design.

Potentials and Benefits of a Process-oriented Approach

- *Value chain orientation:* The process orientation corresponds to the value chain. Knowledge that contributes to value added activities is successfully linked to the business process. Thus, knowledge can be offered to an employee in a much more targeted way. At the same time, however, an information overload can be avoided, since only information relevant to the value added activity is filtered and made available. Additionally knowledge management activities directly support selected knowledge intensive processes. The process view is an important and integrative factor.
- *Context relevance:* The second benefit of process-orientation is that processes can provide part of the context that is important for the interpretation and construction of process-relevant knowledge. Especially knowledge that emerges or is created in a process should be stored together with its process context. That includes knowledge about processes that is to be stored together with the process of creation and use. Here, the broadness of the process context can be variably defined. It stretches from information on individual activities and partial processes to information about connections extending over more than one process and needs to be linkable to the information required by a particular person or specific role. This is important because every employee possesses a different level of prior context knowledge and therefore needs a certain amount of extra context information.

- *Improvement in knowledge processing:* Next to the advantages resulting from a company's analysis of its own business processes, such as making tasks clearer and promoting an integrative view, this can also be the starting point for a more targeted improvement in the processing of knowledge in these activities. Thus both the knowledge used in the processes and the knowledge about processes become clearer and more transparent. Knowledge about processes thereby becomes an integral part of a company's knowledge base.
- *Support for process-oriented knowledge management:* Knowledge management is included in process-oriented considerations. Processes such as management processes that guide and monitor the flow of information, or even specific knowledge processes responsible for the exchange of information between processes, can be implemented and established organizationally (for example, by creating a position as process owner). An example for a typical knowledge process would be a publishing process in the corporate intranet. Different roles (e.g. responsibility for a topic, author, webmaster) and tasks are combined to a specific and integrated process. The design of knowledge processes like this can be supported by systematic modeling activities. A big problem in knowledge management is also the transparency about costs and benefits. Practicable approaches to knowledge controlling could profit from a process-oriented approach.
- *Navigation and design components of KMS:* In the design of KMS, processes can be the starting point for the conception of a navigation structure that, next to general retrieval possibilities, navigation within categories (subjects that are process-related or span more than one process) (cf. Bach et al. 1999), also permit navigation that follows processes as they run. Other information from processes can also be used to specify KMS more precisely. In addition to the aforementioned navigation structure, process-oriented knowledge maps and knowledge structure diagrams can be broadly sketched out.

The Role of Process-oriented Enterprise Modeling

In order to link activities in business processes to the knowledge necessary to carry them out, the precise understanding of these processes is required. As a method for knowledge explication business process modeling (BPM) provides models that may be employed in a variety of ways in the design of KMS.

The definition for process modeling preferred in this study not only focuses processes in the narrow sense of the term (i.e., control flow), but rather broadens it to include business resp. enterprise modeling, which includes other perspectives, such as data, functions, organizations, resources, strategies, and knowledge. Despite this we continue to use the term business process modeling even if the term process-oriented enterprise modeling would be the more correct one. One reason is the integrative function of business process models for different types of enterprise models. The other reason is that process models are useful instruments to visualize the value chain and therefore build a framework to support knowledge management activities.

In the following we will discuss the tasks of BPM during build and run time of a process-oriented KMS.

In the Design Phase

- *Navigation:* Process models can be integrated as central navigation structures within a KMS so that the assignment of knowledge to individual activities is made clear and employees receive the knowledge they require. Some commercial KMS already incorporate such a structure.
- *Context:* The idea behind is that information about the process provides part of the context information for the (re)construction of knowledge. This context information can refer to the sequence of process steps (process control), single components or goals. If the context information is stored together with the information itself it is easier to reconstruct details later. Process models allow the analysis which leads to the detection of knowledge resources that might be key candidates for capturing additional context information. An example might be a decision to be made in a publishing company about the acceptance of a manuscript. The whole process leading to the final decision will be documented. The relevant information can be captured real-time either by intelligent systems or by the use of checklists. The necessity of capturing context information in the case of a decision can already be seen in advance when modeling the checklists or the supporting IS. An example for such context information could be known profile information about the employees involved in the decision.
- *Visualization:* such context information could also be expanded to include other elements such as multimedia elements, visualization techniques or additional models. However too much context may be counterproductive (cf. Buckingham Shum 1998).
- *Process knowledge:* In addition, process models can be used to gather knowledge relevant to a process. With a process description an employee can analyze in an easier way what his knowledge needs and deficits are. Logically these information can be used to define and derive broad outlines of knowledge maps. Knowledge maps, however, are only useful if they are up to date. Therefore, a model of this information has to be expanded to include a dynamic component to update model knowledge.
  A typical example is the administration of employee profiles. First, a number of base profiles are centrally stored. Employees themselves can then start new profiles,

categorize and arrange them. The result is a highly dynamic profile administration system that updates itself, which would not be possible using static modeling methods.

- *Knowledge Processes:* On the basis of such an analysis, optimization measures along the lines of "Knowledge Process Reengineering" can be carried out more easily. Note that the concentration on knowledge intensive processes should mainly focus on the flow of knowledge instead of the workflow. Most business or information models neglect this demand (cf. Kock et al. 1997, Stader and Jarvis 1998). Furthermore knowledge flows are not only restricted to one process and can only be captured by special modeling techniques like knowledge flow analysis or communication analysis.
- *Push / Pull:* In course of the design of a knowledge process it has to be defined whether the knowledge will be distributed by a push- or a pull-strategy. Process-oriented KMS do not necessarily employ only pull strategies. Actually, a mix of push and pull strategies can help to keep process knowledge up to date and to supply employees in the processes with current information. For example, an employee who serves customers as a key account manager receives regularly information filtered according to his task from external information sources (push). In addition, out of the context of his assignment, he is offered proven search paths that he may use for possible searches (pull). Further research is necessary to get evidence which information about a process or part of a process, certain types of activities, events or roles is needed for push / pull design decisions.
- *Workflow modeling:* The analysis of process models can be a first step towards the definition of workflow models. During run time these models manage the workflow of knowledge intensive processes.

Some of these aspects are currently investigated at a semiconductor producer. Existing process models based on ISO 9001 are used to document the formation and use of knowledge of a product development process. Interviews with the people engaged in the process are carried out to gain this knowledge. The interviews result in role specific information and knowledge profiles which can be used for knowledge maps and knowledge diagrams. In a second step the results of an information and knowledge flow analysis contribute to the design of specific knowledge processes. This includes a modeling phase succeeded by the realization of this process which means defining personal responsibilities and supporting the actual process by information technologies (e.g. publishing or content management systems). Simultaneously new sources of knowledge are identified in order to meet the demands of the product development process. Among others an OLTP- and a data mining solution is about to be developed to visualize standard figures describing the quality of certain activities.

In the Operation Phase

- *Continuous process improvement (CPI):* It can be assumed that the use of process models as navigation components leads to a better understanding of both one's own as well as other processes. As a result, weak spots can be found in a process. With a CPI, these weak spots can be analyzed and corrected. Since process models themselves embody knowledge, this process knowledge also has to be kept updated. Implementation of a CPI is one way to accomplish this.
- *Run-time modeling:* Components of KMS themselves can contribute to the support of modeling activities. Here, KM-functions are used for dynamic modeling and for completion and updating of process knowledge. Process knowledge includes knowledge intensive workflows, knowledge maps, profiles, etc. The small control loop constructed between the modeling and the KMS serves as a dynamic system component that keeps the models updated.
- *Context update:* The relevance of process models in determining context has already been indicated. During the run time, the context information may have to be updated and expanded to include other elements (e.g., multimedia elements). Processes that are typically modeled on type level have to be updated during the run time with current process information in order to determine the context more precisely on the basis of current process data.

In all of the cases described above, the acquisition and documentation (modeling) of processes can be useful. However, there are difficulties and problems that should not be overlooked.

- *The identification and separation of processes:* The identification and separation of business processes often causes problems. Therefore, what must be investigated is which characteristics can help identify and distinguish knowledge-intensive processes? (see Eppler et al. 1999) Currently one of the authors works on this topic and tries to identify the main characteristics of knowledge intensive processes and put them down in a checklist. This checklist is intended to support the systematic analysis of a process and to serve as a starting point for „knowledge process reengineering“ activities.
- *Weakly structured processes:* Knowledge-intensive business processes are often poorly structured and are therefore at first difficult to model. Which modeling techniques can nevertheless be used to understand the processes? What are the limitations of modeling in this case? Several research institutes are working in this field. They try to use AI technologies for modeling and implement the result in workflow applications in order to support flexibility and organizational learning (see e.g. Reimer et al. 1998, Wargitsch 1998).

- *Process knowledge:* Process knowledge lies in the hands of the employees themselves and is difficult to be collected and maintained centrally. What methods or actions can be employed to ascertain this knowledge? Another difficulty arises from the fact that process knowledge is constantly changing and yet needs to be current. What methods can be used to keep process knowledge up to date?

This brief outline of the problems associated with modeling knowledge-intensive processes shows that classic business process modeling methods alone are not enough to give the "knowledge" factor in business process models the necessary consideration when designing KMS. For this reason we will now present a framework where different BPM and KM modeling methods and procedures can be classified that can lead to a meaningful expansion of modeling activities.

The Expansion of Modeling Activities

In order to put the expansions in a certain order, it is suggested to classify them, on the one hand, into the two dimensions, modeling time and modeling action and, on the other hand, into modeling scope, modeling methods, and modeling support. Fig. 3 shows modeling methods arranged in a matrix determined by the two dimensions, time and action. The modeling scope is visualized by the area of a circle. The figure attempts to show that, in order to consider the resource "knowledge," modeling increases in scope. As a result, classic modeling methods have to be expanded to include new concepts that in turn create new demands on support.

Note that the characteristics of modeling time, action and scope are strongly dependent on the modeling objectives. Consistent and valid requirements for IT solutions, like the specification of a KMS, require modeling methods that are different from those that are needed to promote understanding and new knowledge within the business (see fig. 2).

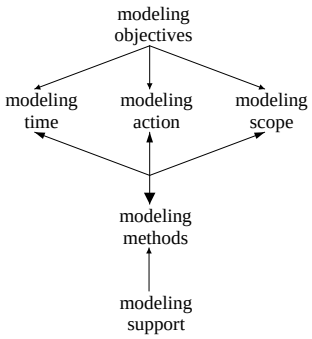

Fig. 2: modeling dependencies

In particular, the following aspects in modeling are to be considered.

- *Modeling time:* The modeling time indicates when to model. In the case of classic business process models, modeling is done first. At best, a dynamic component comes into play in a CPI (continuous process improvement). Due to the fact that many knowledge-intensive processes cannot be determined, a dynamic run-time modeling phase must be added. Build and run time thereby coincide. Methods to support this are incomplete modeling and late modeling.

- *Modeling action:* The classic business process models are often carried out centrally with the help of modeling experts. Yet, these experts usually do not possess the process knowledge of the functional departments. However, especially the individual employee's implicit knowledge about the many "little" processes, methods, and best practices should be documented and also made available to other employees (cf. Geib and Wagner 1997). Due to the individual aspect of the resource knowledge, it seems reasonable to introduce more decentralized or participatory modeling activities.

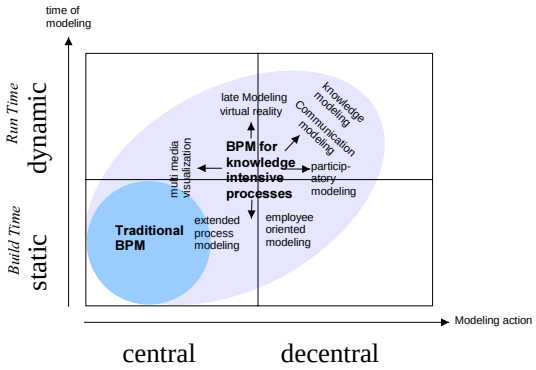

Fig. 3: The shift of modeling activities when using BPM for knowledge-intensive processes.

- *Modeling scope:* In the future, modeling also has to be able to capture and represent knowledge. For this purpose, the business process model has to be expanded to include methods for mapping and modeling knowledge. Here, it needs to be clarified to what extent methods from the field of artificial intelligence could be useful. Suggestions have already been made in the literature for recording process knowledge for knowledge management, for example, by producing knowledge maps (cf. Hagemeyer and Rolles 1998). Of course, these are rather static approaches. On the level of flows the recording and understanding of workflows is not enough. It has to be supported by the analysis of data-, information- and knowledge flows. Certainly the process view should be used for integration. The main purpose is not to loose the advantages of process orientation.

- *Modeling methods:* In order to fulfill the requirements with regard to modeling time, action and scope, classic methods for BPM have to be expanded to include the following methods: new model and object types expand classic approaches to include elements in knowledge processing (see Allweyer 1998). Workplace

or employee-oriented modeling methods (see Jarke and Kethers 1998) try to reproduce the knowledge or knowledge processes that the individual employee sees and uses at work each day. Methods and concepts for interactive modeling using multimedia elements, virtual reality, and visualization techniques will play a larger role in modeling business processes in the future (cf. e.g. IMPROVE 1999). The consideration of knowledge flows by modeling techniques seems to be most important. This can be done by information flow- or communication models because they create transparency about the flow of knowledge within and outside of business processes.

- *Modeling support:* Modeling needs to be supported by tools. Especially the new methods discussed above need to be adequately considered. The subject of reuse (process modules, process patterns, and reference models)[1] can also be useful when designing models.

Summary and Outlook

In this article, process-oriented KMS were singled out and presented as a particular class of KMS whose features justify their classification as "process-oriented." The special role of processes, both as "context suppliers" as well as navigation and design components for KMS, should be emphasized here once more. Process-oriented enterprise modeling was looked at in detail as a method for collecting information for processes and modeling these processes because it can be regarded as a central starting point for the design and utilization of KMS.

Of course, instruments for information- and knowledge modeling are without any use if the objective and the application field remain unclear. Depending on the objectives alternative methods and techniques can be taken into consideration. Possible areas of application of knowledge management are among others the improvement and design of knowledge intensive processes and the development of KMS.

For the optimization of processes a rough process overview may be sufficient. In the case of designing a KMS, a very detailed description of the processes is necessary. Nevertheless in the latter case a lot of questions remain unanswered. Should, for instance, process control be automated by an intelligent workflow concept? In that case the resulting models have to be extended by dynamic and adaptive components. For the concept development of a process-oriented KMS the corporate knowledge base and the knowledge flows play the main role. Process models extended by knowledge aspects should be supported by information flow and communication models.

However, the classical methods, techniques, and approaches to BPM for modeling knowledge-intensive processes are not sufficient and have to be expanded to include new aspects. Here, it can generally be observed that modeling activities for knowledge-intensive processes move from a central, static approach to a broader, more decentralized and dynamic one.

In order to present more detailed results and experiences with the modeling of process-oriented KMS further studies will be necessary. Next step of the ongoing research activities will be to use the modeling framework presented here to refine the modeling activities for different types of KMS.

1 *Process modules* are partial processes that can be reused for other processes. Here, the internal view of the process is transparent. Only the interfaces to other partial processes are externally visible. The *pattern* concept is based on the fact that application elements are frequently connected to one another in a similar fashion. These constantly recurring patterns can also be used for processes. *Reference models*, which describe processes or even partial processes on various levels, can be used as reference for modeling the same kinds of processes or partial processes, thereby greatly simplifying the modeling and guaranteeing quality.

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