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# KMDL – Capturing, Analysing and Improving Knowledge-Intensive Business Processes

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**Abstract:** Existing approaches in the area of knowledge-intensive processes focus on integrated knowledge and process management systems, the support of processes with KM systems, or the analysis of knowledge-intensive activities. For capturing knowledge-intensive business processes well known and established methods do not meet the requirements of a comprehensive and integrated approach of process-oriented knowledge management. These approaches are not able to visualise the decisions, actions and measures which are causing the sequence of the processes in an adequate manner. Parallel to conventional processes knowledge-intensive processes exist. These processes are based on conversions of knowledge within these processes. To fill these gaps in modelling knowledge-intensive business processes the Knowledge Modelling and Description Language (KMDL) got developed. The KMDL is able to represent the development, use, offer and demand of knowledge along business processes. Further it is possible to show the existing knowledge conversions which take place additionally to the normal business processes. The KMDL can be used to formalise knowledge-intensive processes with a focus on certain knowledge-specific characteristics and to identify process improvements in these processes. The KMDL modelling tool K-Modeler is introduced for a computer-aided modelling and analysing. The technical framework and the most important functionalities to support the analysis of the captured processes are introduced in the following contribution.

**Keywords:** process-oriented knowledge management, knowledge-intensive business processes, knowledge modeling description language, K-Modeler
**Categories:** D.3.3, H.3.1, H.3.3, H.4.3, H.5.2, I.2.6, I.2.4, I.3.6, I.5.2, I.6.3, I.6.4

## 1 Introduction

There are two main approaches to knowledge management distinguished in the literature [Mentzas, 03]. The process-centred approach treats KM as an interpersonal communication process. The product-centred approach on the other hand focuses on the artefacts for knowledge, i.e. the documents, their creation and reuse in corporate

computer-based systems. In the last few years the process-oriented knowledge management as integration of business process management and knowledge management has been established in the scientific and practical field.

The process-oriented knowledge management not only considers the business processes but uses the process-oriented view to describe the dynamic knowledge conversions between the process participants. Knowledge and business processes are connected directly; therefore the integrated consideration is indispensable.

Business processes can be modelled and analyzed extensively with well known and established methods. Further approaches exist that consider knowledge as a component of a company or an organization [Goesmann, 02], [Remus, 02b]. The simple mapping of static knowledge (typically in an explicit manner as information) does not fulfil the requirements of a comprehensive and integrated approach for process-oriented knowledge management. Only the coordination of business processes with the processes of knowledge processing guarantees an efficient knowledge flow [Remus, 02b]. The above mentioned problems and challenges have been the trigger for the development of the Knowledge Modelling and Description Language KMDL and the tool K-Modeler to model and analyze knowledge-intensive business processes.

### 1.1 Overview of the Contents

In this contribution, after introducing business process oriented knowledge management knowledge-intensive business processes are defined. In the following section the theoretical foundation of the KMDL, the differentiation of tacit and explicit knowledge and the knowledge conversion are described. These concepts are used to evaluate existing tools and methods for process-oriented knowledge management to point out the need for a new method to capture, model and analyse knowledge-intensive business processes.

The fourth section explains the KMDL object model. Each object is shortly described and the obligatory and optional attributes are presented. A practical example is used to create a better understanding of the modelling technique.

The fifth section gives an overview of the used KMDL procedural model. It consists of six phases which are explained. The second phase is divided into a sub-procedure to elicit correctly all required information.

The knowledge modelling tool K-Modeler and its main functionalities are depicted in the sixth section. First of all the integration of the tool into Eclipse is explained. Consecutively the modelling, the process analysis, the defined views on the model, the support of skill management applications and the XML data description are shortly described. The next section illustrates the practical benefits of KMDL by applying the language in practical projects. In one case the KMDL was used to improve the communication between the product development and the customer care. The last paragraph introduces the present and the future work of KMDL.

The following figure 1 shows the content of the contribution.

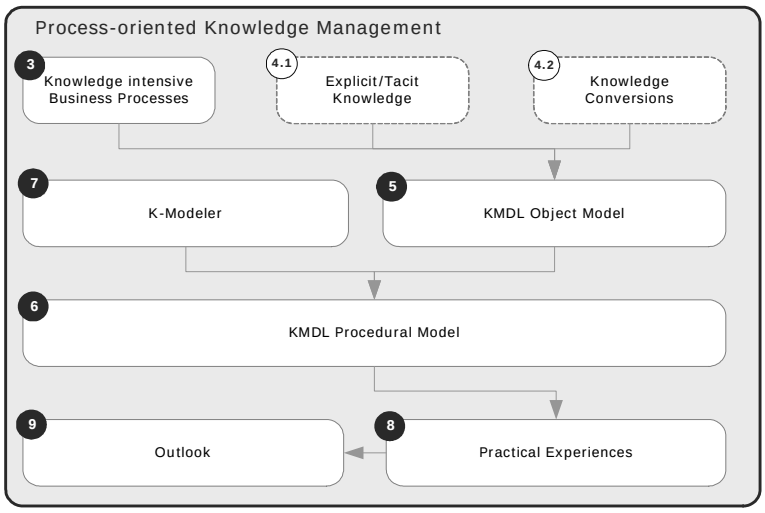


*Figure 1: Overview of the Contents of this Contribution*

## 2 Process-Oriented Knowledge Management

Abecker identifies a field of research, which utilizes the modelling of business processes to enable the derivation of knowledge management measures [Abecker, 02]. The three application scenarios "business processes as initial point for knowledge management", "knowledge management and process execution" and "business processes as subject of knowledge management" require some or all of the following project stages: Systems Design (consisting of Systems Planning, Analysis, and Implementation), Systems Usage, and Systems Evolution. To exactly classify different research approaches, it can be further segregated into three different layers. On the top layer, strategic business process-oriented knowledge management is a top-down perspective, which derives knowledge objectives from the long-term business objectives. The bottom layer deals with KM design based on communication analysis and diagnosis. It primarily deals with communication aspects of knowledge work and develops appropriate methods or tools. It is thus very hard to be separated from the middle layer, where Abecker allocates approaches of business process-oriented design, where methods and tools for business process analysis are extended to meet the new requirements of knowledge management. This middle layer is dealing with modelling methods derived from business process management and the modelling of existing processes to find potentials for improvement. A selection of the existing approaches BPO-KM, PROMOTE, and CommonKADS which belong to this category are introduced further in [Trier, 04]. The following short introduction of the three approaches is based on the result of this analysis.

The first selected approach is BPO-KM (in German: GPO-WM®). It proposes a method for a process-oriented analysis and design of knowledge management solutions [Heisig, 03]. Within this procedure of eight steps, the KM audit analyses the

fundamental conditions including the evaluation of existing IT systems, the analysis of the information- and knowledge culture, and the determination of the demand for information and knowledge. The main focus of this step is the identification of potentials for improvement of the existing utilisation of knowledge in the business context. The subsequent step analyses knowledge-intensive processes to identify strengths and weaknesses or possible improvements. Further the process- and task-related demand for knowledge is identified.

Another approach is the PROMOTE method, which integrates strategic planning with the evaluation of knowledge management and business process management [Hinkelmann, 03]. The intended scope of the approach covers the analysis, the modelling, and the execution of knowledge-intensive processes. It extends the more general method of business process management systems (BPMS) including strategic decision, reengineering and resource allocation, and workflow and performance evaluation [Hinkelmann, 03]. The additional KM related steps are creating awareness for enterprise knowledge, discover knowledge processes, create operational knowledge processes and organisational memory, and evaluate enterprise knowledge. Next to the process-oriented KM models introduced, the established knowledge engineering approach CommonKADS could influence a method for the capturing of knowledge-intensive business processes. Although its objective of constructing a program that can perform a difficult task adequately is completely different [Schreiber, 00], its process of knowledge acquisition can be regarded as similar, because knowledge acquisition includes the elicitation, collection, analysis, modelling, and validation of knowledge for knowledge engineering and knowledge management projects. The according knowledge acquisition (KA) techniques have been developed to help with the elicitation of knowledge from an expert.

## 3 Knowledge-Intensive Business Processes

Within process-oriented knowledge management the knowledge-intensive business process is the primary perspective [Remus, 02b]. Several attempts have been made in the literature to define knowledge-intensive business processes. Heisig points out the opportunity to schedule the knowledge demand and evaluates knowledge-intensity according to the existence of variability and exceptions [Heisig, 02]. Other sources define processes knowledge-intensive if an improvement with conventional methods of business reengineering is not or only partially possible [Remus, 02a]. Davenport recognizes the knowledge-intensity by the diversity and uncertainty of process input and output [Davenport, 95]. A process is knowledge-intensive if its value can only be created through the fulfilment of the knowledge requirements of the process participants. Several properties which are typical for knowledge-intensive business processes are introduced in the following list:

- In knowledge–intensive processes, knowledge contributes significantly to the values added within the process. Innovation and creativity play a major role in such processes [Eppler, 99]. People within the process have a large scope in the freedom of decision, they can decide autonomously.
- The event flow of knowledge-intensive business processes is not clear in advance, as it can evolve during the process [Davenport, 96].

- The participants in the process have different experiences and bring in knowledge from different domains at different levels of expertise [Heisig, 02].
- The life-time of knowledge involved in the process is often very short [Eppler, 99], it is outdated very fast. It is usually very time-intensive to build up this knowledge [Schwarz, 01].
- Knowledge-intensive business processes often do not follow structured working rules and often lack metrics for evaluating the success of the process [Davenport, 00].
- The IT-support for knowledge-intensive business processes is generally not very sophisticated because it strongly relies on socialization and informal exchange of knowledge [Hoffmann, 02].
- A knowledge-intensive process should be a core process of the company and it should produce or add new knowledge to the organization's knowledge base [Hamel, 90].
- Often the costs of knowledge-intensive processes are very high.

Looking at these criteria, we can classify various processes as knowledge-intensive. Just two examples are software development processes [Kidd, 94] or processes in public administration.

Common business processes are characterized by a predefined process structure and repeated tasks that are fulfilled basing on the underlying process model, which contains information, tasks and user roles. Knowledge-intensive business processes are only partially mapped by the process model due to unpredictable decisions or tasks guided by creativity. Typically knowledge flows and knowledge transfers between media and persons are necessary to achieve a successful process completion.

Identifying, modelling, analyzing and finally optimizing knowledge-intensive processes should be the long-term objective of a process-oriented knowledge management approach [Gronau, 04c]. Knowledge management and business processes are integrated and should be evaluated as a whole [Abecker, 02].

## 4 Theoretical Foundation of KMDL

This section introduces the theoretical concepts which are used to define the Knowledge Modeling and Description Language. The first paragraph outlines the tacit and explicit knowledge defined by Nonaka and Takeuchi. In the second paragraph the concept of knowledge conversion will be introduced. These concepts were used to analyze and evaluate existing tools for modelling and analyzing knowledge-intensive business processes. Finally the requirement of a new language specification is pointed out.

### 4.1 Tacit and explicit knowledge

The fundamentals of the process-oriented knowledge modelling language KMDL (Knowledge Modeling and Description Language) are influenced by the ideas of Nonaka and Takeuchi [Nonaka, 95]. In their book Nonaka and Takeuchi have build a

whole theory about knowledge and the creation of knowledge. This theory is based on the distinction between tacit and explicit knowledge.

The term tacit knowledge is based on the thoughts of Michael Polanyi [Polanyi, 58] which defined the idea of tacit knowledge as personal knowledge bound to humans. This type consists of mental models, beliefs and perspectives [Nonaka, 95]. It is partially unconscious and therefore difficult to be communicated and explained by the persons who possess it.

Explicit knowledge on the other hand is formal, codified, systematic, articulated in writing/numbers, easy to communicate, and shared [Hopfenbeck, 01]. This also means that it can be transmitted and stored for reuse by other people. Books, documents, data bases and graphs are just a few examples of this knowledge type.

### 4.2 Knowledge Conversion

From the business process perspective, the conversion of knowledge into other knowledge types plays a major role. The conversion between knowledge types is performed through interaction of tacit and explicit knowledge. In their book Nonaka and Takeuchi identified four types of knowledge conversion (see figure 2).

Internalization is the conversion of explicit knowledge into tacit knowledge. It is very closely related to learning-by-doing. Experiences made through socialization, externalization or combination are internalized and integrated into one's own knowledge framework. By this, they can become know-how or mental models and according to this, very important knowledge assets.

Externalization is the conversion from tacit to explicit knowledge. By using metaphors, analogies or models one can express his tacit knowledge in a manner which can be understood by others. It is the essence of tacit knowledge which can then be handed over in a written form, yet it can be very difficult to externalize tacit knowledge, often it is simply impossible.

Socialization is a conversion from tacit knowledge of one person to tacit knowledge of a different person. Often it is done by sharing experience: Just like apprentices of a craftsman learn their skills by observation, a knowledge-worker can learn his needed abilities through on-the-job training. The socialization does not even require speaking or writing a single word.

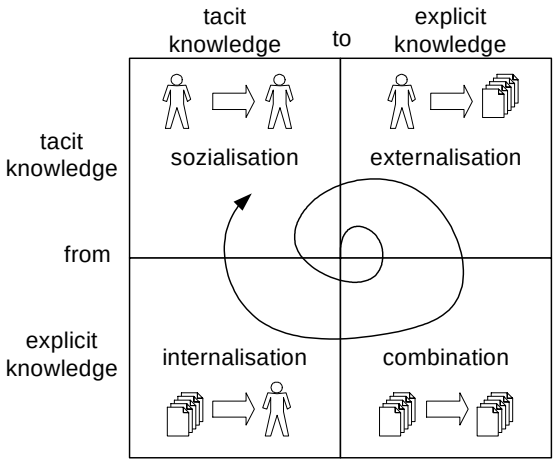


*Figure 2: Model of the Dynamics of Knowledge Creation*

Combination is the conversion from explicit to explicit knowledge. Different kinds of explicit knowledge can be combined through media like telephone, mail, word processing, further by reconfiguring, categorizing and adding new information and context to the knowledge.

According to the authors, the creation of organizational knowledge needs all types of knowledge conversion. To stimulate the process of knowledge creation in a company knowledge management plays an important role.

The model proposed by Nonaka and Takeuchi establishes a logical framework which can be used to take a look at tacit and explicit knowledge, the conversions between those kinds of knowledge and therefore the creation of knowledge and the conditions and requirements for conversion to happen. It will serve as the basic framework for modelling a dynamic process of knowledge creation within the authors' approach.

### 4.3 Critical evaluation of existing Knowledge Modelling Languages

Knowledge-intensive business processes are characterized by activities which change, which contain knowledge demands, which can not be planned easily, and which contain alternative results. Conventional process modelling approaches do not fulfil all requirements that have to be considered for modelling knowledge-intensive business processes [Remus, 02a].

Gronau [Gronau, 03] proposes a list of requirements that have to be fulfilled for modelling these knowledge-intensive business processes:

- Goal: Which goal is to be achieved by the model? Are there only documentation purposes or are a weak spot analysis and the definition of a new process necessary?
- Integration of process and knowledge modelling: There should be a unique approach that combines or integrates the process definition with the flow and transfer of knowledge.

- Tacit knowledge: Which definition and appreciation of knowledge is used by the model's approach? Is there a differentiation between explicit and tacit knowledge? Is it possible to express different levels of tacit knowledge [Snowden, 00]?
- Knowledge conversion: Are different mechanisms of knowledge conversion considered and expressed separately in the process model?
- Knowledge flow: Is there a differentiation between information flow and knowledge transfer?
- Offer and demand: Is it possible to show differences in the model between the supply of knowledge and its demand?
- Person-related knowledge: Is the modelling of knowledge restricted to organizational units or is it possible to show knowledge bound to persons?
- Comparison of intended and actual level of knowledge: Is it possible to compare the knowledge levels required for posts with the knowledge persons actually have?
- View representation: Is it possible to navigate through the models using different views, e.g. an organizational or a process flow view?
- Knowledge maps: Is it possible to generate knowledge maps from the results of modelling?

Based on these requirements common process modelling approaches like ARIS [Allweyer, 98], [Scheer, 98], Income [Remus, 02a] and PROMOTE [Karagiannis, 02] were evaluated.

The result of the analysis shows that all analyzed process modelling approaches do not separate tacit knowledge from explicit knowledge and that there are deficits in the conversion of the knowledge types and the person-related knowledge modelling of knowledge in the evaluated approaches.

Major disadvantages of two of the approaches described by can be illustrated by the following examples. In the ARIS approach the source of knowledge can not be related to the knowledge and therefore a statement about the interaction between tacit knowledge and explicit knowledge is not possible. The Income Process Designer does not support the modelling of knowledge flow and knowledge conversion.

The result of this evaluation leads to the formulation of requirements for the specification of a new description language [Gronau, 04].

## 5 KMDL Object Model

This section introduces the defined objects and their attributes of KMDL in the actual version 1.1. Furthermore a practical example for modelling with KMDL is described to support a better understanding of the defined objects.

### 5.1 Knowledge and Information

Within KMDL the term knowledge is conceived as bound to persons. This kind of knowledge - tacit knowledge (see section 4.1) - is personal and cannot be transferred to a formal notation. It is anchored in the activities and skills of the knowledge carrier

and additionally in her/his ideals, values and experiences [Nonaka, 95]. In contrary explicit knowledge is easy to formalize.

To realize a clear distinction between tacit and explicit knowledge, the KMDL differentiates between knowledge and information objects. In KMDL the term knowledge object refers to the tacit knowledge and the term information refers to explicit knowledge. New knowledge and information objects are generated by converting existing elements within the process. This conversion is based on the interaction between knowledge and information objects. It has to be noted, that knowledge objects always refer to persons. In analogy to Nonaka/Takeuchi [Nonaka, 95] the KMDL distinguishes four kinds of knowledge conversions.

### 5.2 The Objects of KMDL V1.1

The KMDL provides an object library containing the basic objects “Information Object”, “Task”, “Role”, “Task Requirements”, “Person”, “Knowledge Object”, and “Knowledge Descriptor” [Gronau, 04a]. The connections of these objects are realised by using a directed information flow as an edge and the four kinds of knowledge conversion, as introduced in section 4.2. For all of these objects the attributes identifier, description, keywords, process description exist. Furthermore for each of the objects optional attributes are defined. Figure 3 shows the objects and their relations.

The capturing of processes is supported by the definition of aggregated objects. The process modeller has the possibility to define parts of the knowledge-intensive business process if required or not. The following aggregated objects are available: group, role aggregation and task aggregation as well as process interface.

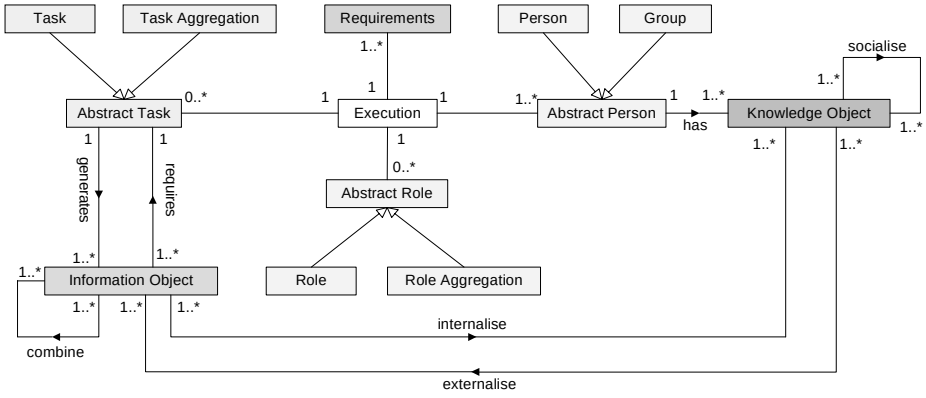


*Figure 3: Objects of the KMDL Data Model and their Relations*

The information object is next to the existing knowledge object the base for the creation of new knowledge objects. Information can be externalised in an easy manner. It is stored on electronic media or written down in documents. The creation of new information is done by externalisation or combination. One characteristic of

knowledge-intensive business processes is the processing of information. Within the KMDL the input and the output of tasks are represented by information objects. The specified optional attributes are location, medium, expiration date, and level (state of working progress).

Tasks are the basic framework for business process models. The sequence of the tasks determines the temporal structure of the process. A task is defined as an atomic transfer from input to output, represented as information objects.

Tasks are related to and are fulfilled by (job) positions. The organisational view of the information flow within the KMDL is workflow-oriented. Because of that the role is allocated to the task despite of the position.

Roles are taken by persons and have the knowledge objects of all persons assigned to them. By relating employees and tasks to a position, the functional and organisational structure of a company can be represented. The optional attributes are personal data and position. Persons are the owners of knowledge objects that are necessary to fulfil tasks. The knowledge objects of a person with the respective knowledge level should be equal to the requirements of the task the person has to execute.

Performing tasks describes requirements on the roles that are modelled as task requirements. The totality of task requirements defines the tacit knowledge that is necessary for a position working on a concrete task. More than one task requirement can be associated to a role, because normally more than one capability is necessary to accomplish the task. Here the knowledge descriptor and level (described within a competency matrix) are the available optional attributes.

A knowledge descriptor describes the borders and contents of a knowledge domain and defines partial domains if necessary. It is not codified knowledge. Task requirements and knowledge objects refer to a certain knowledge descriptor. The attributes of the task requirement and the knowledge object contain the required knowledge level within the considered domain. Because of the definition of the knowledge description the comparison of the desired task requirement with the available knowledge object is possible.

A knowledge object describes the knowledge of persons. Each knowledge object must have a reference to a knowledge descriptor for describing which part of a knowledge domain is covered in which quality. Every used and needed tacit capability is represented by a knowledge object. In the KMDL specification, the optional attributes for knowledge objects are knowledge descriptor, knowledge level (described within a competency matrix), frequency of access and topicality.

Additionally the different opportunities of knowledge conversion can be modelled with KMDL, so that the flow of knowledge between persons can be visualized. Knowledge flows in a process and the different kinds of knowledge conversion can be used in the model to retrieve information about the generation of new knowledge and possible weak spots.

KMDL also offers extended representation possibilities to grasp further characteristics [Gronau, 04b]. These can be transferred to other expressions of knowledge conversion.

- Frequency: The contact between two persons for the exchange of knowledge is possible once, often or permanent. The last possibility occurs especially during an imitation. The other cases can be explained with single or multiple telephone calls.
- Completeness: The completeness of the socialized knowledge has to be considered. Different or supplementary contents can be given in different contacts. In addition a complete transfer of the actual knowledge is possible in every contact.
- Number of participants: A conversion can take place with multiple participants. A talk given to three people is a single act of socialization. If this is modelled as three different relations between speaker and listener, it is meant that three different contacts with three different acts of socialization exist.
- Direction of conversion: A discussion, a brainstorming meeting or a personal suggestion of one of the participants implicates a multitude of knowledge flows. These are not directed. Every participant can be either sender or receiver. Otherwise the acts of socialization had to be represented on the level of single sentences. Such a degree of detail is not efficient and no real gain of information. Therefore a representation of expressions of knowledge flows is necessary, where the participants can be sender, receiver or both.

The conversion is represented as a node, with that all participants (knowledge or information objects) are linked. These relations are directed and show the status of the element as sender or receiver. The line style shows the frequency of participation while the completeness of the conversion is represented by the shape of the node symbol. The following figure 4 shows the defined edges and their properties.

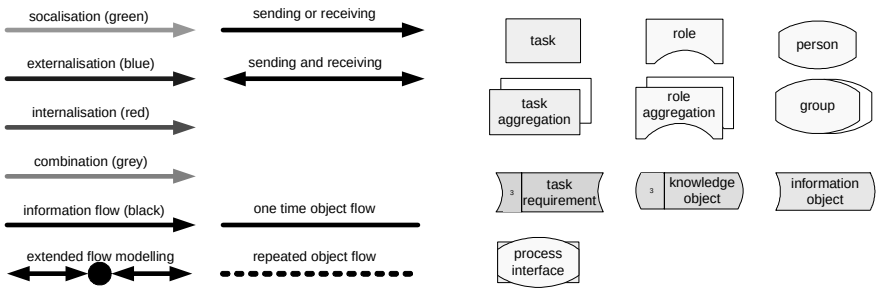


*Figure 4: Representation of Knowledge Conversion and Objects*

### 5.3 Practical Example

This paragraph describes the modelling of knowledge-intensive business processes with KMDL using a real world example. It consists of capturing processes in an international operating (small and medium sized enterprise) software company. The company's software development is based on standard products which can be adapted to customer requirements.

While using the software or when introducing a new software component the customer sometimes recognizes new requirements accordingly to the product. The company verifies these requirements. One possibility would be to realize these requirements as a customer specific feature of the software system. This is usually done when the new feature is specific to the customer's demands. When the company realizes that the solution is not customer specific and is demanded by several companies the requirements could be realized as a new feature in a new release of the software system or as an add on for the existing one. It could also be possible that the company is not interested in supporting the customer and does not realize the required features.

The process described below is part of the software development process that is carried out when integrating new features in the standard software product of the company (see figure 5). The whole process was acquired in the software company mentioned above.

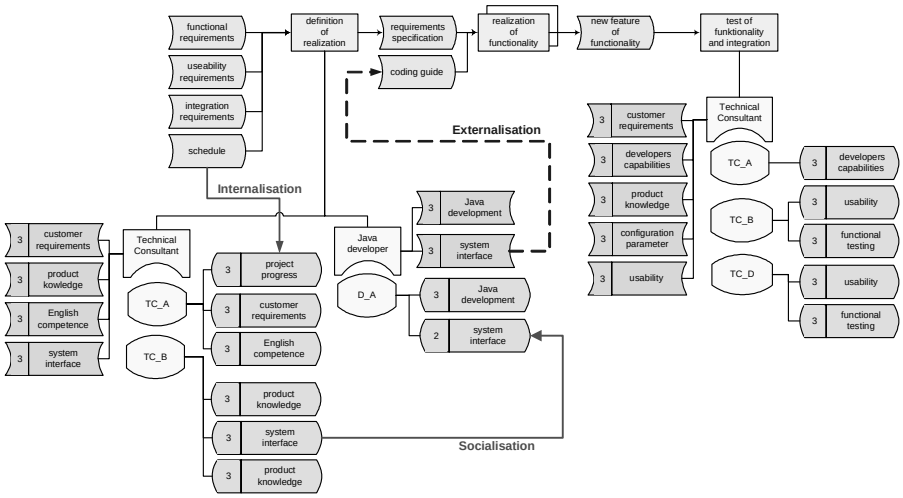


*Figure 5: Development of a new Feature in a Standard Software Product*

The integration of new functionality into the standard software product requires several activities. The identified activities here are functional definition for the realization, the actual realization of the new functionality and the test of the new implemented functionality and its integration in the software product. The "realization of functionality" is represented as task aggregation which simplifies the modelled process and focuses on the intended one. All other tasks are specified in more detail. As described above we just focus on a part of the whole process. This also means that tasks like "acquisition of customer requirements" are not included in this part of the model.

In order to carry out the task "definition of realization" the information objects "functional requirements", "schedule", "usability requirements" and "integration requirements" serve as input for the task and the information object "requirements

specification" is the resulting output information object which should specify all requirements in order to realize the new feature.

The two roles "Technical Consultant" and "Java developer" are required in order to carry out the task. The requirements for the role of the "Technical Consultant" are "customer requirements", "product knowledge", "English competence" and knowledge about the "system interfaces". As can be seen in the figure the person "TC_A" in the role of a "Technical Consultant" has knowledge about the customer requirements, knowledge about the software product itself and English competence. The person "TC_B" in the role of a "Technical Consultant" on the other hand has knowledge about the software product and knowledge about the system interfaces. Together the two persons satisfy the requirements of the task but both of them are required because each by oneself does not have the complete required knowledge. It can also be seen that the person "TC_A" has a monopoly in the knowledge of the customer requirements.

The second role required in order to carry out the task is the "Java developer". The role requires knowledge in Java development and about the system interfaces. As can be seen the person "D_A" in the role as "Java developer" satisfies the requirement "Java development". The required knowledge object "system interface" has to be gained by socializing the knowledge from the person "TC_B" who has the required knowledge.

There are two additional knowledge conversions identified and displayed in the modelled process. Through internalization of the project's schedule the person "TC_A" gains knowledge about the progress of the project. The person "D_A" defines or refines the coding guide which is an externalization of the knowledge about Java development.

## 6 Procedural Model

A detailed capturing and analysis of knowledge-intensive business processes are required to determine the potentials for improvement in the process. The Procedural Model ensures the correct elicitation of all data and information needed (see figure 6). The model consists of six phases. First of all, it is necessary to identify the knowledge-intensive processes. For this selection, a criteria catalogue can be utilized. It consists of up to thirty properties of knowledge-intensive business processes to support their definition. In the next phase, the capturing of the knowledge-intensive business process is executed. Here, the model offers a sub-procedure, which contains the six steps: definition of tasks associated to the process, identification of the information in- and output, assignment of the persons to the specific roles, executing the task, specification of the role requirements, and assignment of the knowledge objects to the accompanying person. The third phase models the process using the tool K-Modeler. Its practical application and benefits will be discussed later on. The results of the previous phase are required for the generation of a qualified concept, which could for example contain process improvements. The last phase of the model is the implementation phase, which is only used when Information Technologies are getting implemented. Participation is an inseparable element of the KMDL Procedural Model. During each phase the contribution of the participants is indispensable.

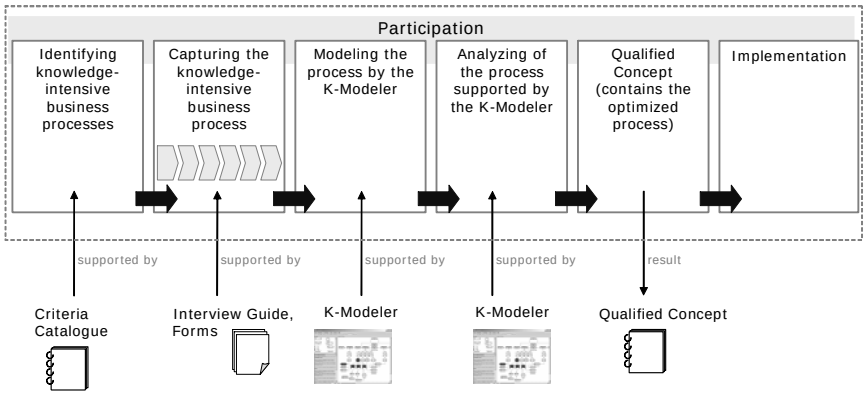


*Figure 6: KMDL Procedural Model*

A detailed capturing of the knowledge-intensive business process is a pre-condition for the analysis and evaluation of potentials within the process. The analysis of the process comprises the identification of knowledge-intensity, the process schemes and the process potential (weak spots).

As-is models illustrate the ownership, the demand, the development and the use of knowledge. Therefore it is possible to visualise the knowledge intensity as a kind of knowledge map of the whole process, of a process part or of single activities of the respective tasks. This procedure enables the classification of single tasks or the weighting of their relevance. The results are used for recommendations of technical and organisational improvements.

The comparison of as-is models of different instances from the same process is useful in order to generate universally valid sentences about process elements and element relations. Special knowledge based activities should be investigated to identify specific patterns. It is recommended to extend the existing reference processes with this information in order to support future participants of the process.

## 7 K-Modeler

Based on the KMDL approach described above, the KMDL modelling tool K-Modeler is under development. It allows to model knowledge-intensive business processes in an easy and intuitive manner as defined in KMDL. The K-Modeler also supports mechanisms to analyze the processes and generate reports from the model.

The K-Modeler is engineered using the graphical integration platform Eclipse [Eclipse, 04]. Eclipse has been developed to build integrated development environments (IDEs) and already comes with a variety of core services in order to easily integrate own IDEs with slight effort.

### 7.1 Integration into Eclipse

As mentioned above the K-Modeler will be integrated into Eclipse. Functionality is contributed to Eclipse in form of pluggable components, so called Eclipse plug-ins. The architecture and integration of the K-Modeler can be seen in figure 7.

Broadly seen the architecture can be divided in three parts, the graphical layer, the application layer and the persistence layer. The graphical layer includes all components that are visible on screen like an editor for editing the KMDL models, views to display properties and attributes and other aspects of the model and its objects. The application layer provides functionality for analyzing the model, for syntax checking, for report generation and other functionality that is processed in the background and not directly visible to the analyst. The persistence layer provides functionality to store the model persistent. The model is stored in a relational database management system (RDBMS). However the persistence layer will be implemented independently from the storage system which keeps a large degree of freedom in the choice of the storage system, which means that the RDBMS can be easily replaced by storage into XML files.

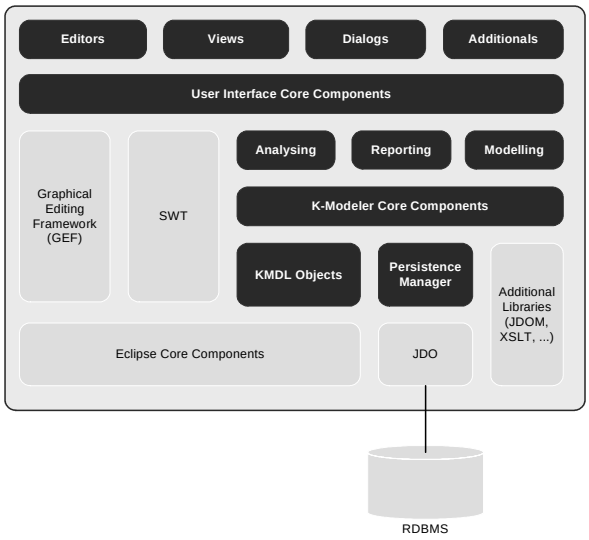


*Figure 7: Integration Architecture of the K-Modeler in Eclipse*

### 7.2 Functional Overview of the K-Modeler

In following section the basic functionalities of the K-Modeler is described. The first section explains of the modelling processes with the K-Modeler that is carried out. The next part deals with the process analysis that can be done with the K-Modeler. Then the actual supported process views are introduced. Finally the opportunity of the skill management support and the model reuse are explained.

### 7.2.1 Modelling the Process

The modelling with the K-Modeler is done directly via drag and drop on a graphical user interface (see figure 8). The analyst can easily model the process by using predefined graphical elements representing the objects defined in KMDL like tasks, information objects, knowledge objects, roles, persons, or requirements (see figure 4). Attributes can be associated with each object. It is possible to modify and extend the list of attributes by self-defined attributes. The previously defined types of knowledge conversions (externalization, internalization, socialization, combination) and the information flow can be modelled with different types of pointed connections. The connections between objects without direct interaction are undirected connections (e.g. the connection between task and role).

### 7.2.2 Process Analysis

A syntax check for the model ensures that only formally correct models can be modelled by the analyst. This is done by predefined syntactical rules. The K-Modeler automatically identifies and evaluates various design patterns in the modelled processes and thus helps to analyze the process. These evaluation patterns are derived from known disadvantageous process elements and structures found in knowledge-intensive processes [Brown, 98]. When applying these patterns in an analysis, the following process potentials can be identified:

- knowledge monopolies: a single person owns knowledge demanded in the process
- unsuitable knowledge profile: no person is modelled in the process that has the demanded knowledge
- creation of unused knowledge: the created knowledge is not demanded in the process
- etc.

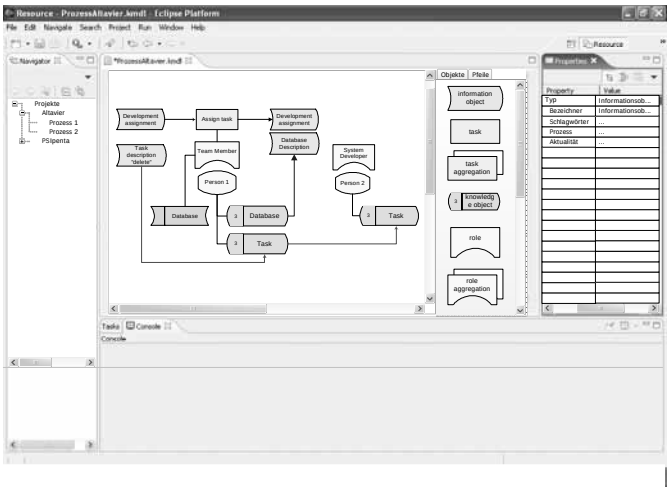


*Figure 8: Planned K-Modeler integrated in Eclipse*

The places of knowledge creation and conversion as well as knowledge processes like knowledge distribution, knowledge creation and knowledge use are visible in the model.

With the report functionality of the K-Modeler the analyst can focus on individual aspects of the modelled process and get statistical results about the model. The reports can be archived in HTML (Hypertext Markup Language). Examples for planned reports are:

- what knowledge has been expatiated by knowledge conversion
- the tacit knowledge identified in the process
- results of the analysis of the potentials identified in the process

### 7.2.3 Different Views on the Model

The K-Modeler provides different views on the process in predefined abstraction levels. This allows dissolving the aggregations and focusing on their components.

The following views on the model are distinguished:

- The task view displays the base structure of the process focussing only on the tasks in the process. A clear distinction between the tasks in the process is important in order to relate the roles to the requirements as well as the knowledge objects to the persons that hold these roles.
- The simple process view extends the task view by the information objects needed to process the tasks.
- In the extended process view the roles which execute the tasks are also displayed. With this additional information the analyst can identify the roles that are assigned to the tasks and can identify incorrect assignments or unintended multiple assignments.
- The tacit knowledge view displays all roles with the assigned actors and their knowledge objects and requirements that are modelled in the process.
- The general view shows all objects modelled for the process.

The differentiation made in the views is the representation of the object types and therefore the aggregation.

In addition the K-Modeler allows to group tasks, which enables the analyst to create task aggregations and dissolve them in order to decrease the complexity of the view on the process.

### 7.2.4 Support for Skill Management

The tacit knowledge perspective on the model contains the information about a persons' knowledge objects and the requirements of the roles. It can be used for skill management. This allows examining gaps between the requirements and actual existing tacit knowledge. This information can be used to plan training processes within the company in order to enhance the skills of these employees. When a person often demands knowledge objects of a special topic in a process, an analysis of the situation can be used to define a conception for further vocational training.

The data tracked via the process modelling can also be used to create knowledge maps (topic taxonomy) or yellow pages for the company. This in turn enables the company to identify core competences and experts.

### 7.2.5 Reuse of the Model

The K-Modeler allows exporting the modelled process into structured XML. This allows further processing of the gathered information about the process and can be used for documentation purpose in addition to the reports or to create yellow pages.

The current approach of capturing processes within the actual practical projects employs Microsoft Visio. Because of the XML data description of the objects model it is possible to import these models. Therefore the further use especially for process evaluation is guaranteed.

## 8 Practical Experiences

There are several practical projects in which the KMDL was used for modelling, analysing and improving knowledge-intensive business processes. The following section gives a short introduction in the objectives and results of these projects.

In the first application, a big German component supplier uses the KMDL to capture its quality management processes at the reference processes specific level to the organisation. The objective was a better integration of existing knowledge management applications within the company. The component supplier plans the improvement of access to quality management processes via KMDL models and other appropriate tools.

With the assistance of KMDL, a German producer of groceries investigates its information and communication relationships between the customer care department and the product development. By the KMDL analysis of the captured process it could be observed, that there was no formalised connection of information between the question and topics which occurred in the customer care and the knowledge of existing new products in the product development. The result of the analysis was the development of a concept for implementing an Intranet-based tool.

One of the practical projects was in the area of E-Government. In the context of introducing an intranet in the county, selected knowledge-intensive business processes were modelled and analysed. By doing this, it was possible to design the required knowledge management functionalities. Furthermore the modeller was able to identify technical and organisational process improvements. The results of the KMDL analysis were part of the conceptual and technical configuration of the Intranet.

## 9 Outlook

Currently the research group of operational knowledge management uses the adopted KMDL specification V1.1 for capturing knowledge intensive business processes. Because of the experiences in the mentioned practical projects and further research a new version, the KMDL 2.0 is under development.

The present work concentrates on the realisation of a model-driven procedural method to improve the capturing and analysing of knowledge-intensive business processes. First of all it is necessary to examine existing meta-models within the business process modelling and the knowledge modelling. Appropriate concepts

should be identified and compared as well as evaluated with the meta-model of the KMDL V1.1. The results of the analysis conduce to the determination and specification of the single process models on different level of abstraction. This method will be supported by the KMDL modelling tool K-Modeler.

Furthermore, the offered functionalities of the K-Modeler will be extended. One of these future functionalities is the ARIS-model import. The use of existing ARIS models within the company supports the analyst by defining the simple process view.

It is also required to integrate the so called “person-repository”. This enables the modeller to capture the not attributable objects besides required information and knowledge objects to fulfil the task. Sometimes the knowledge which exists beyond the knowledge-intensive business process is very important for the company.

The description of KMDL-models with Petri-nets supports the simulation of knowledge-intensive business process. At the moment the simulation is only used in much formalized business processes. It should be investigated whether the simulation of this process specification is reasonable or there are other techniques to simulate the processes, e.g. multi-agent systems.

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