Collaborative Development of Informal Processes

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Abstract

Enterprises are trying to document their business processes in a structured way in order to better understand, share, and optimize them. But still most of the process knowledge remains either in people's heads, or as textual and graphical descriptions in the Intranet as HowTos, guidelines, or methodology descriptions. The cost of an upfront, complete formalization of all business processes is prohibitive, and the benefits often seem elusive, especially under the stress of the daily work.

Informal, knowledge-intensive processes are omnipresent in the daily task of knowledge workers. They change frequently and are typically not documented. Nevertheless, it can be beneficial for efficient process management in enterprises to document and share such processes, so that less experienced employees can be guided through these processes without consuming time from an expert.

Traditionally, domain experts are interviewed by process modeling experts, who capture the process knowledge and create process descriptions. The resulting process descriptions are often not adjusted when changes in the real process occur as these traditional process elicitation methods are expensive and time consuming. Recently, a trend toward collaborative, user-centric, on-line business process modeling can be observed. Current Social Software approaches, satisfying such a collaborative modeling, mostly focus on the graphical development of processes and do not consider existing textual process descriptions such as HowTos or guidelines.

In this context, current state-of-the-art methods and tools do not provide the most appropriate support for the development of process descriptions, in particular for informal, knowledge-intensive processes. In this thesis we address this issue by combining traditional process modeling techniques with a collaborative, semantic wiki-based approach. As a result we present the integration of Semantic MediaWiki with a graphical process editor featuring the collaborative creation of process descriptions with graphical representations, textual descriptions and formal semantic annotations. Our approach allows for reusing existing textual process descriptions by translating them automatically in graphical descriptions and formal semantic annotations. These structured process descriptions can be further modified and refined collaboratively. As a result, we provide a holistic approach for collaborative process development that is designed to foster process knowledge reuse and maturing within the enterprise.

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Foundations

Chapter 1

Introduction

1.1 Motivation

Increasing the productivity of the knowledge workers is, according to Drucker [Dru99], the most important management contribution in the 21st century. Consequently, the efficiency of the knowledge-driven work should be increased to significantly boost economic productivity. Therefore, tacit knowledge has to be captured that it can be reused and shared. However, it is still hard for today's enterprises to transform most of their essential task knowledge into transferable, easily accessible, and actionable knowledge assets, because such hidden knowledge is typically held by individual knowledge workers.

Knowledge workers deal with processes during their daily task. These can be business processes, formally defined within an organization, but also informal processes, which are rarely documented and mostly knowledge-intensive [WKT+09]. Informal processes can vary from person to person even when those involved are pursuing the same objective. The processes define the operational communication and interaction between knowledge workers. Although enterprises are trying to formalize their processes in order to better understand, share, and optimize them, most of the process knowledge remains either in people's heads, or as textual and graphical descriptions in the Intranet as HowTos, guidelines, or methodology descriptions. Nevertheless, the costs of a complete formalization of all processes are prohibitive, and the benefits often seem elusive, because processes are often subject to frequent changes.

For instance a proposal created as a response to a request can be seen as a result of knowledge-intensive, informal processes, collaboratively performed by a proposal team. Depending on the complexity and the time constraints of a proposal many people with different expertise, skills and roles are involved in the proposal development. The single proposal development processes typically deviate from each other, because no proposal is a copy of another one. Core activities can be identified like *selecting proposal team* or *getting approval for pricing* but most activities, in which the content of the proposal is created, are distinct to a certain extent. Common sections from previous proposals can be reused; others have to be adjusted to the customers and their requirements or created from scratch. Much in the way the underlying activities are executed depends, however, upon the proposal team member's expertise and previous experience, on tacit knowledge which is not recorded in formal procedures, but exists in the individuals' head, and in undocumented social communication and collaboration processes [Dav05]. The knowledge workers need system support for creating, reusing, sharing and also improving these informal, knowledge-intensive processes.

Traditionally, workshops and interviews of domain experts performed by process modelers have been used to develop the process descriptions. An alternative to interviews is the group storytelling approach. It transforms stories told by individual process performers into process descriptions [SBP08]. However, the costs of a complete formalization of all processes through a small highly-skilled business process development team conducting these workshops or interviews are prohibitive, and the benefits often seem elusive, especially under the stress of their daily work. But it is crucial to include domain experts in process modeling activities, because they have the experiential knowledge [MS08]. Especially for these knowledge-intensive, informal processes, alternative approaches are required that allow people to directly influence the process descriptions [HYJK06].

Current research focuses on the use of Social Software to support an agile, bottom-up Business Process Management (e.g. [SN09, EGH+10, BDJ+11]). Within this research area various approaches have been developed in the last years using semantic wikis to model processes in a collaborative manner (e.g. [HBV09, GKL+09, GRS10a]. An advantage of these approaches compared to the traditional interview method is that all stakeholders can be involved in process modeling, which is considered as too time-consuming with traditional methods and tools [HV04]. However, by including all stakeholders, also users which are novices in process modeling are involved. Consequently, this requires easy-to-use and straightforward process modeling solutions [Kir09].

1.2 Research questions and contributions

In order to support such a collaborative, easy-to-use and straightforward process modeling, we present an approach combining the Semantic MediaWiki wiki software with process modeling and visualization functionalities. The suggested approach relies on the collaborative aspect of wikis [LC01] allowing collaborative modeling of processes in an iterative way. By leveraging natural language, graphical representation and formal semantic annotations for process modeling, we reduce the barrier for manipulating process descriptions. By relying on widespread and well-accepted wiki technologies, we enable users to model and update organizational processes in a familiar environment by reusing externalized knowledge already stored in wikis. The following hypothesis captures the motivation for the research questions of this thesis.

Hypothesis 1: *Traditional process modeling tools are inadequate for documenting and modeling informal, knowledge-intensive processes.*

Approach: *Analyze existing process modeling tools and existing process documentations.*

In order to support our first hypothesis, we investigate in this thesis how current tools support process modeling and how companies document knowledge-intensive, informal processes. We support this hypothesis by comparing current solutions for process modeling and point out their shortcomings.

Hypothesis 2: *Adequate tools have to support textual and graphical descriptions, collaboration, and structured documentation.*

Approach: *Develop a wiki-based approach for maturing process descriptions, comprising textual descriptions, graphical representation and formal semantic annotations.*

The second hypothesis postulates that adequate tools require natural language and graphical description support, collaboration support and structured process documentation support. Semantic wikis can be applied to collaboratively make informal process knowledge explicit. This requires additional functionality on top of the provided functionality of current semantic wikis. To support this hypothesis, we develop a wiki-based approach allowing both novices and experts to create process descriptions with textual descriptions, graphical representation, and formal semantic annotations.

Hypothesis 3: *The wiki-based approach for maturing of process descriptions can be used intuitively by novices in process modeling and experts.*

Approach: *Apply the wiki-based approach in use cases with novice users and evaluate the usability.*

The third hypothesis postulates that wiki-based approaches supporting the creation of process descriptions with natural language, graphical representation, and formal semantic annotations can be used intuitively by novices. We are going to support this hypothesis by evaluating our approach in different use cases, where novices in process modeling are involved.

1.3 Outline

This thesis is structured as follows. After the introduction in this chapter, we provide the theoretical and technical backgrounds required for our approach. Therefore, we introduce terms and methods from the research areas of Business Process Management and Knowledge Management in Chapter 2. In addition, we present Semantic MediaWiki, the Oryx process editor and their functionality in Chapter 3. Finally, we close the first part by elaborating other works, which are related to this thesis, in Chapter 4.

In Part II we cover all aspects of the wiki-based maturing of process descriptions. In Chapter 5 we describe the current process modeling situation in small and medium enterprises and illustrate that current methodology descriptions in a large consulting company can also be categorized as documentations of knowledge-intensive, informal processes. In a next step, we gather requirements for the maturing of process descriptions in Chapter 6. The requirements serve on the one hand as a comparison framework for existing wiki-based solution and on the other hand as a foundation for our approach, which is presented with its implementation in Chapter 7.

Finally, we evaluate our approach and conclude in Part III. We perform an evaluation of our approach in two different scenarios in Chapter 8. A pre-evaluation with ten students is presented and an evaluation in a real use case within an enterprise. In Chapter 9 we close this work with our conclusions and point out subjects for future research.

Chapter 2

Theoretical background

In this chapter we provide the theoretical background for the work in this thesis, which has its root in the research areas of Business Process Management (BPM) and Knowledge Management (KM).

We first introduce the term business process in Section 2.1. Furthermore we define Business Process Management (BPM) and illustrate the BPM lifecycle and the core elements of BPM in Section 2.2. Business process modeling, which is part of Business Process Management is then presented in Section 2.3.

In a second step, we introduce Knowledge Management (KM) and the knowledge maturing process in Section 2.4. We further present in Section 2.5 the idea of wikis, which can be used as KM solution.

The combination of BPM and KM in form of knowledge-intensive processes and Business Process-oriented Knowledge Management is introduced in Section 2.6 and Section 2.7. Finally, we define the term informal process in Section 2.8.

2.1 Business processes

Although the basic notation of a *business process* is widely understood, many definitions can be found in literature as there are authors writing about the topic [MH06]. In the following we present a selection of these definitions. But before we comment on such business process definitions, we briefly introduce the more general term *process*. According to the International Organization for Standardization [ISO05], a process can be seen as set of activities interrelated or interacting with each other. A process uses resources to transform input into output, where output can become the input for another process. Becker and Kahn [BK03] restrict this general definition to a business context and define a process as "a completely closed, timely and logical sequence of activities, which are required to work on a process-oriented business object." Furthermore, they define a business process as "a special process that is directed by the business objectives of a company and by the business environment. Essential features of a business process are interfaces to the business partners of the company (e.g. customers, suppliers)." Apart from these definitions the terms process and business process are mostly used synonymously in literature.

A general definition for business processes is given by Hammer and Champy [HC93]. For them, a "business process is a collection of activities that takes one or more kinds of input and creates an output that is of value for the customer. A business process has a goal and is affected by events occurring in the external world or in other processes." This definition emphasize on *what* has to be done. In contrast, Davenport [Dav93] defines a process as "a structured, measured set of activities designed to produce a specified output for a particular customer or market." By emphasizing *how* the work is done within an organization, he focuses on the internal flow. He renders more precisely that a process is a "specific ordering of work activities across time and place, with a beginning, an end, and clearly identified inputs and outputs: a structure for action."

Oberweis [Obe96] puts emphasis on the execution of processes and defines a process as a set of manual, semi-automated and automated organizational activities, executed to achieve a certain goal by observing specific rules. These activities are interconnected through the people, machines, documents, resources, etc. involved in the operation of the process. Another definition was derived by the Workflow Management Coalition [Coa99], who views business processes as "a set of one or more linked procedures or activities which collectively realize a business objective or policy goal, normally within the context of an organizational structure defining functional roles and relationships." Both definitions also focus on *how* the work is done. In addition, Oberweis also highlights that many parties are involved in a business process.

While these definitions mostly focus on the business processes within an organization, Weske [Wes07] explicitly mentions the interaction among organizations. In his definition, a business process "consists of a set of activities that are performed in coordination in an organizational and technical environment. These activities jointly realize a business goal. Each business process is enacted by a single organization, but it may interact with business processes performed by other organizations."

Parts of business processes can be automated, while others are not supported by computers. The automation of a business process, in whole or in part, during which documents, information or tasks are passed from one participant to another for action, according to a set of procedural rules, is called *Workflow* [Coa99]. Thus, a workflow is a coherent computer-supported part of a business process. Workflow Management Systems (WFMS) support the execution of workflows. A WFMS is defined by the Workflow Management Coalition (WfMC) as a "system that defines, creates and manages the execution of workflows through the use of software, running on one or more workflow engines, which are able to interpret the process definition, interact with workflow participants and, where required, invoke the use of IT tools and applications." [Coa99]. We do not further elaborate on workflows as the focus of this thesis is on the collaborative process development, and not on the execution of processes.

Lindsay et al. [LDL03] give a brief overview of traditional business process definitions by pointing out the shifting of business process modeling techniques from production systems to the office environment. They conclude that most of these BPM definitions are confined to a mechanistic viewpoint of a process and depend on past knowledge. Thus, the definitions are too limited to express the true nature of business processes, and can currently only be used for representing internal business process elements, namely the needed activities and their dependencies, the data flow, the involved actors and roles and the goals.

Business processes can be divided in core, support (or enabling) and governing processes. While core processes directly create value for external customers, support processes create value for internal customers. Examples of core processes are transactional and development processes. By contrast, information system development and financial reporting are support processes. The third category, governing processes, are management processes, such as strategic planning, risk management and performance management [Ham10].

Debenham [Deb00] proposed an alternative classification of business processes by defining three process classes in terms of their technical properties:

- **"Activity-centered process"**
  This type of process has two characteristics. The process can be decomposed uniquely in sub-processes. Each sub-process ends when a specific goal is attained.

- **"Goal-centered process"**
  Two properties are related to this type of process, too. First, the processes can be split in several valid ways. Second, each sub-process ends when a specific goal is attained.

- **"Knowledge-centered process"**
  In this case the termination of at least one sub-process in the process decomposition is not determined by the achievement of a specific goal. As a result, this category includes all processes whose objectives are vague, or may change over time.

Miers [Mie04] differentiates between procedures and practices. Procedures are standardized and predictable processes, which are imposed on employees to ensure control and compliance. They can often be automated. Practices, in contrast, are the natural result of the daily work of a knowledge worker. Employees make their own decisions and develop new ways to perform their tasks. An organization needs both procedures and practices.

According to Bhat et al. [BPM+07] business processes are a core differentiator for organizations as their sequence of activities is unique to every company. Standardized, well-engineered and repeatable business processes improve organizational excellence. Thus, the optimization of business process becomes more and more important for the industry [EHLB95].

In this thesis we use the definition of the Workflow Management Coalition and focus on the more knowledge-centered processes [Deb00].

2.2 Business Process Management (BPM)

In the following we first introduce the term *Business Process Management* (BPM). In a second step, we briefly describe the BPM lifecycle. Finally, we introduce the six core elements of BPM.

2.2.1 Definition

Business Process Management (BPM) has emerged from different areas of business administration and computer science, namely *Quality Control Tradition*, *Management Tradition*, and *Information Technology (IT) Tradition* [Har10]. Thus, BPM is influenced by methods and technologies from these areas. Prominent examples from the quality control area are Total Quality Management (TQM) [Fei02], Six Sigma [BM02a], and Capability Maturity Model (CMM) [PWCC95]. The *Management Tradition* was mainly influenced by Rummler, who argues for the need to improve corporate performance with process redesign [RB95], and Porter with the value chain [Por85]. While the Balance Scorecard methodology [KN96] is also part of the management practices, Harmon [Har10] consider Business Process Reengineering (BPR) [Ham90, DS90] more on the *IT Tradition*. Other examples of IT systems that influenced BPM are Enterprise Resource Planning applications, Computer-Aided Software Engineering (CASE) tools, as well as Expert Systems and Business Rules.

Elzinga et al. [EHLB95] conducted a survey of major US companies in order to get a better understanding of BPM. They came up with a generic method for BPM, consisting of eight major modular steps, namely *Preparation for BPM*, *Process Selection*, *Process Description*, *Process Quantification*, *Process Improvement Selection*, *Implementation*, *Continuous Improvement Cycle*, and *Benchmarking*. The quality of products and services evaluated by the customers plays an important role in the continuous improvement of processes. As a consequence, they define BPM as "a systematic, structured approach to analyze, improve, control, and manage processes with the aim of improving the quality of products and services."

Another definition for BPM evolved from the workflow community. Van der Aalst et al. [AHW03] for instance restrict BPM to operational processes and use workflow terminology to define BPM as "[supporting] business processes using methods, techniques, and software to design, enact, control, and analyze operational processes involving humans, organizations, applications, documents and other sources of information." This definition excludes processes at the strategic level and processes which cannot be made explicit.

A more recent definition also includes the administration and configuration of business processes. According to Weske [Wes07], BPM "includes concepts, methods, and techniques to support the design, administration, configuration, enactment, and analysis of business processes." In order to enable the analysis, improvement and enactment, business processes have to be defined with their activities and the execution constraints between them.

BPM is a governing process (see Section 2.1). The organizational management is neither known by customers nor interesting for them. Only the results, which are outputs of business processes, count for the customers. BPM can be seen as a customer-centered approach to organizational management [Ham10].

Hammer [Ham10] summarizes the concepts of process management in terms of seven principles:

- **"All work is process work"**
  Sometimes the concepts of process and process management are only associated with highly structured, transactional work, such as procurement. Nevertheless, processes should not be seen as synonyms for routinization or automation as they can also refer to highly creative tasks such as product design. Process management can only be used to its full capacity, if all processes are managed.

- **"Any process is better than no process"**
  Without a well-defined process design results are not predictable and repeatable. Any process can serve as the basis for improvement.

- **"A good process is better than a bad process"**
  Some processes are better designed than others. The caliber of a process design is critical for determining its performance. Bad process designs have to be replaced with better ones.

- **"One process version is better than many"**
  Standardization of processes within an organization reduces the costs for support services, such as training and IT systems. It also presents a single interface to customers and suppliers. The trade-off between standardization and customized processes for different needs of business units and their customers should often be resolved in favor of standardization.

- **"Even a good process must be performed effectively"**
  It is not sufficient for high performance of a company to have a good process design. The execution also needs to be managed carefully.

- **"Even a good process can be made better"**
  Processes should be continuously improved in order to further enhance the performance. The process owner is responsible for the improvement of the process.

- **"Every good process eventually becomes a bad process"**
  Customer needs, technologies and competition are subject to change. As a result, the performance can decrease and the process might have to be replaced with a better one.

2.2.2 BPM lifecycle

In the last years, different (graphical) representations of the BPM lifecycle have been proposed in literature (e.g. [EHLB95, AHW03, MH06, Wes07]) to provide an overall understanding of the concepts and technologies being relevant to BPM. Often the term *business process lifecycle* is used synonymously for BPM lifecycle. The different phases describe the support of business processes in the lifecycle. The various proposals for BPM lifecycles vary in the level of detail and also heavily depend on the authors' views. All lifecycles include the logical dependencies between the phases, but a strict temporal ordering is not always discussed. In this thesis we use the BPM lifecycle from Weske [Wes07] for illustration purpose. This lifecycle is depicted in Figure 2.1 and is structured in four phases:

- **Design and Analysis**
  The BPM lifecycle starts with the design and analysis phase. Based on surveys, business processes are identified, modeled, refined and validated. The core task within this phase is the process modeling. Using these models, stakeholders can validate processes, for instance, in workshops. (Semi-)automated simulation techniques can be used to support validation.

- **Configuration**
  In the configuration phase, the business process model designed in the previous phase is implemented. The implementation can be realized with or without the use of a Business Process Management System (BPMS). Without the support of a BPMS a set of policies and procedures needs to be implemented within the organization that employees have to comply with. When a dedicated BPMS is used, the implementation platform has to be chosen and the business process model needs to be enhanced with additional technical information. In a second step the system has to be configured and tested.

- **Enactment**
  In this phase, instances of the business process model are enacted by initiating and executing them. The BPMS controls and monitors the execution.

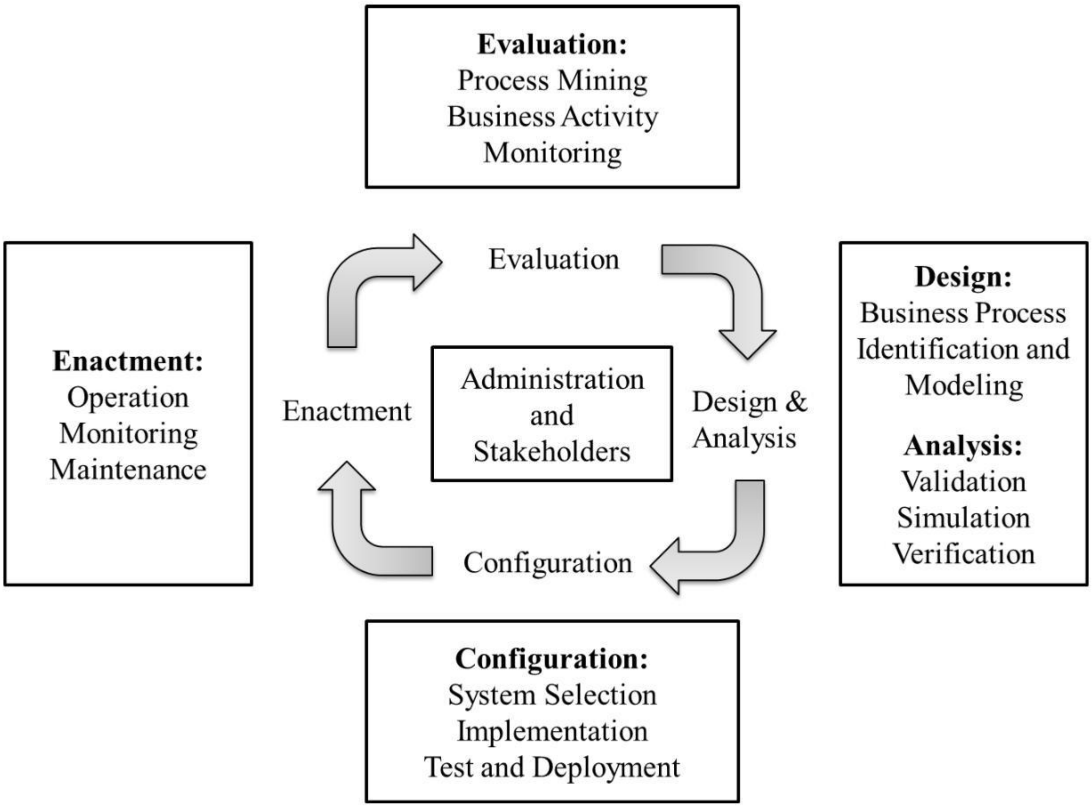


Figure 2.1: BPM lifecycle (Source: [Wes07])

- **Evaluation**
  The information gathered during the execution of the process instances is evaluated to improve business process models and their implementations. For instance, log files generated during execution are analyzed using process mining techniques [AW04].

The focus within this thesis is put on the design and analysis phase within the BPM lifecycle.

2.2.3 The six core elements of BPM

Another classification of BPM was introduced by Rosemann and Brocke [RB10]. Based on related literature, they developed a framework with six core elements representing critical success factors for BPM:

- **Strategic Alignment**
  The design, execution, management and measurement of processes have to be

aligned with the overall strategy of the company. The organizational priorities have to be synchronized with business processes by tightly linking them bidirectional. This core element can be further detailed in so-called capability areas. These areas are *Process Improvement Planing*, *Strategy and Process Capability Linkage*, *Enterprise Process Architecture*, *Process Measures*, and *Process Customers and Stakeholders*.

- **Governance**
  Process roles and responsibilities for different levels of BPM have to be defined in order to enable transparent accountability. In addition, guidelines for process-related actions need to be introduced by designing decision-making and reward processes. The capability areas are *Process Management Decision Making*, *Process Roles and Responsibilities*, *Process Metrics and Performance Linkage*, *Process Related Standards*, and *Process Management Compliance*.

- **Methods**
  Methods in the context of BPM enable and support activities on all levels of BPM, including activities within enterprise-wide BPM initiatives and along the BPM lifecycle (Section 2.2.2). The capability areas of this core element are *Process Design and Modeling*, *Process Implementation and Execution*, *Process Monitoring and Control*, *Process Improvement and Innovation*, and *Process Program and Project Management*.

- **Information Technology**
  Process activities can be enabled and supported by Information Technology (IT). The IT assessment and components also focus on the specific needs of each BPM lifecycle phase similar to the BPM methods. The capability areas are the same as the areas for methods, namely *Process Design and Modeling*, *Process Implementation and Execution*, *Process Monitoring and Control*, *Process Improvement and Innovation*, and *Process Program and Project Management*.

- **People**
  Individuals and groups enhance and apply their process and process management knowledge and skills in order to improve business performance. The capability areas of this core element are *Process Skills and Expertise*, *Process Management Knowledge*, *Process Education*, *Process Collaboration*, and *Process Management Leaders*.

- **Culture**
  The culture within an organization is the final, but nevertheless equally important BPM core element of this framework. Culture has a strong impact on the success of BPM, which requires a facilitating environment. The capability areas of this core element are *Responsiveness to Process Change*, *Process Values and*

Beliefs, *Process Attitudes and Behaviors*, *Leadership Attention to Process*, and *Process Management Social Networks*.

The framework can guide BPM decision makers to a holistic management discipline by using it for vendor management, complexity management, standards management, strategy management, and project and program management. The approach for wiki-based process maturing presented in this thesis can be classified in the elements *Methods*, *Information Technology*, *People* and *Culture*. The detailed classification is presented in Section 7.2.3.

2.3 Business process modeling

When users model business processes, information about the processes have to be elicited, modeled, and validated. Frederiks and van der Weide [FW06] analyzed the process of information modeling, including its modeling quality and the competencies required. They describe the three activities of *elicitation*, *modeling*, and *validation* and the participants, namely *domain expert* and *system analyst*. The domain experts who own knowledge about the domain can describe the domain in natural language. They can also validate process descriptions, provided that they understand the used process language. System analysts are process modeling experts, who can abstract process elements from informal descriptions and use process modeling languages to create process models.

2.3.1 Process modeling languages

Over the years many process modeling languages have arisen which were used for different purposes. Mili et al. [MTJ+10] classify business process modeling languages in four categories:

- **"Traditional process modeling languages"**
  These languages evolved from the management tradition and business process reengineering area (see Section 2.2.1). Examples are Petri Nets [Rei85] and Event Process Chains (EPC) [NR02].

- **"Object-oriented languages"**
  Object-oriented modeling has a focus on software programming. An example of this category is UML[1].

- **"Dynamic process modeling languages"**
  Languages in this category focus on the dynamic view of processes. Examples

[1] http://www.uml.org/

are Web Services Business Process Execution Language (WS-BPEL) [AAA+06] and Business Process Modeling Notation (BPMN) [BP11].

- **"Process integration languages"**
  These languages focus on the integration of processes of two or more business partners. Examples are ebXML[2] and WS-CDL [KBR+05].

Processes are formalized through process models, which are created with a process modeling language. A prevalent process modeling language in practice is the Business Process Modeling Notation (BPMN) [BP11]. The resulting models are process diagrams, which are readable by humans. As the primary goal of BPMN is human understandability [MTJ+10], we use BPMN as the graphical representation language in combination with formal semantic annotations for our approach presented in Section 7.2. In the following we briefly describe BPMN.

2.3.2 Business Process Modeling Notation (BPMN)

The Business Process Modeling Notation (BPMN) [BP11] is a standard developed by the Object Management Group (OMG). It defines the notation and semantics of *Collaboration*, *Process*, and *Choreography* diagrams. The first version of BPMN provides a large number of elements, which can be grouped into four categories, namely *Flow Objects*, *Connecting Objects*, *Swimlanes*, and *Artifacts* [Whi04]. The current version BPMN 2.0 provides additional modeling elements such as the category *Data* [BP11].

Flow objects can be distinguished in *Events*, *Activities*, and *Gateways*. There are four elements in the category Data, namely *Data Objects*, *Data Inputs*, *Data Outputs*, and *Data Stores*. Flow Object can be connected to each other or other information by using Connecting Objects. The Connection Objects can be differentiated in *Sequence Flows*, *Message Flows*, *Associations*, and *Data Associations*. Swimlanes and Artifacts have two subcategories each. While *Pools* and *Lanes* are subcategories of Swimlanes, Artifacts are further distinguished into *Group* and *Text Annotation*.

According to Genon et al. [GHA11] BPMN 2.0 provides 171 symbols to model process diagrams. Such a large amount of symbols shows the high expressivity of the language.

2.3.3 Process model generation from textual descriptions

The creation of process models can be automated. For instance, process mining approaches can be used to generate process models from analyzed event logs [AW04]. However, these mining approaches cannot be used for processes, which are executed without generating event logs in a system.

[2]http://www.ebxml.org/

Another way is to create process models from natural language descriptions. Different approaches have been proposed in the last years to automatically create process descriptions from textual descriptions. For instance, Gonçalves et al. [GSB11] combined a group storytelling [SBP08] approach with text mining and natural language processing to automatically derive BPMN models from group stories. Another approach from Ghose et al. [GKC07] identifies verb-object phrases with a syntax parser and detects predefined patterns such as conditions. The approach also allows for cross-validating the extracted processes with existing models.

The Stanford Parser[3] in combination with WordNet[4] and an algorithm resolving relative references within the text (e.g., pronouns) are used by Friedrich et al. [FMP11] to create a *World Model*. The *World Model* is further refined and then translated into a full BPMN model.

2.4 Knowledge Management (KM)

Knowledge Management (KM) is a field with multidisciplinary roots. It has its origin in the translation of organizational learning and organizational memory approaches to management terms, and in the research field of data and information (resource) management.

On the management side the view from a strategic, enterprise-wide level is included by fostering the goal-oriented design of the handling of knowledge, capabilities and (core) competencies [Mai07].

The other conceptualization of KM comparing data management and information resource management to KM (e.g., [Krc05]) is primarily technology-oriented [Mai07]. The historical development of information processing from data management to KM has different steps, starting from isolated applications over data base and data administration. Further steps are data management and information management which leads to KM as the next step in the development of organizational information processing as shown in the model for the management of knowledge from Rehäuser and Krcmar [RK96, Krc05].

2.4.1 Definition

In the following we give a brief overview of the different perspectives on KM with an example. A detailed survey can be found in [Mai07]. Many authors view KM as a lifecycle or as a complex organizational function or process, which can be divided into subtasks and activities. For instance, Alavi and Leidner [AL01] see KM as "a process involving various activities." They further refine that "at a minimum,

[3] http://nlp.stanford.edu/software/lex-parser.shtml

[4] http://wordnet.princeton.edu/

one considers the four basic processes of creating, storing/retrieving, transferring, and applying knowledge." Another definition from Bhatt [Bha01] views KM as "a process of knowledge creation, validation, presentation, distribution, and application. These five phases in knowledge management allow an organization to learn, reflect, and unlearn and relearn, usually considered essential for building, maintaining, and replenishing of core-competencies." Other definitions focus on the strategy and the management side of KM: For instance the definition of Skyrme and Amidon [SA97], who see KM as "understanding the strategic role of knowledge, linking it to key management decisions and business processes, and improving processes for knowledge creation, sharing and use. Knowledge activities are closely allied, and can evolve from established activities or other initiatives, such as total quality management, business process re-engineering, competency planning and the learning organization."

There are also technology-oriented definitions from the field of information management or from authors defining Knowledge Management Systems (KMS), and thus implicitly requiring a KM definition. By combining the views from the different research fields, common definitions can be derived representing a unified approach on KM. According to Maier [Mai07] KM is defined as "the management function responsible for the regular selection, implementation and evaluation of goal-oriented knowledge strategies that aim at improving an organization's way of handling knowledge internal and external to the organization in order to improve organizational performance. The implementation of knowledge strategies comprises all person-oriented, organizational and technological instruments suitable to dynamically optimize the organization-wide level of competencies, education and ability to learn of the members of the organization as well as to develop collective intelligence." Abecker [Abe04] also defines KM as a "structured holistic approach for sustainable improvement of handling tacit and explicit knowledge (e.g., know-how, skills, notes, documentation) in an organization on all levels (individual, group, organization, interorganizational level) in order to better achieve one or more of the organization's strategic goals, such as decreasing costs, improving quality, fostering innovation, increasing customer satisfaction etc." Both definitions show that a holistic definition of KM includes approaches from different roots of KM.

KM initiatives can be supported by *Knowledge Management Systems* (KMS). The findings and ideas of the rather human-oriented KM approaches from the field of Artificial Intelligence and Management Information Systems are translated to the development of Knowledge Management Systems [Mai07]. Knowledge management systems are according to Alavi and Leidner [AL01] "a class of information systems applied to managing organizational knowledge. That is, they are IT-based systems developed to support and enhance the organizational processes of knowledge creation, storage/retrieval, transfer, and application." Maier [Mai07] enhances this definition and includes a dedicated functionality description: "KMS offers integrated services to deploy KM instruments for networks of participants, i.e. active knowledge workers, in knowledge-intensive business processes along the entire knowledge lifecycle. Ultimate aim of KMS is to support the dynamics of organizational learning and organizational effectiveness." Remus and Lehner [RL00] categorize KMS in portal- and community-oriented KMS, and in process-oriented KMS, which "seek to provide employees with task-relevant knowledge within the business processes that are operating in the company." They further elaborate that "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." Process-oriented KMS support knowledge-intensive processes (see Section 2.6) and knowledge processes (see Section 2.4.3).

2.4.2 Knowledge

The concepts of tacit and explicit knowledge [Pol66] and their conversions [NT95] are basic terms in Knowledge Management. Tacit knowledge can be mental models, know-how applicable to specific work or knowledge rooted in actions and experience [AL01]. Explicit knowledge in contrast is documented and thus can distributed, organized and managed. Nonaka and Takeuchi [NT95] introduced the four modes of knowledge conversion (SECI model):

- **Socialization** (From tacit to tacit)
  When people share experiences, tacit knowledge is created even if directly acquired from others without using language.
- **Externalization** (From tacit to explicit)
  In this conversion, tacit knowledge is made explicit by articulating the knowledge in explicit concepts.
- **Combination** (From explicit to explicit)
  Different bodies of explicit knowledge are combined to create new knowledge.
- **Internalization** (From explicit to tacit)
  When individuals embody explicit knowledge, the knowledge is converted into tacit knowledge.

There are different views of knowledge influencing the perception of KM and KMS, namely *a state of mind*, *an object*, *a process*, *a condition of having access to information*, and *a capability* [AL01]. In addition, there is also the traditional hierarchical view of data, information, and knowledge (e.g., [Ack89, Krc05]). Alavi and Leidner [AL01] summarized the different knowledge perspectives and discussed their implications on KM and KMS as illustrated in Table 2.1.

Perspectives	Descriptions	Implications for Knowledge Management (KM)	Implications for Knowledge Management Systems (KMS)
Knowledge vis-a-vis data and information	Data is facts, raw numbers. Information is processed/interpreted data. Knowledge is personalized information.	KM focuses on exposing individuals to potentially useful information and facilitating assimilation of information.	KMS will not appear radically different from existing IS, but will be extended toward helping in user assimilation of information.
State of mind	Knowledge is the state of knowing and understanding.	KM involves enhancing an individual's learning and understanding through the provision of information.	The role of IT is to provide access to sources of knowledge rather than to the knowledge itself.
Object	Knowledge is an object to be stored and manipulated.	The key issue of KM is to build and manage knowledge stocks.	The role of IT involves gathering, storing, and transferring knowledge.
Process	Knowledge is the process of applying expertise.	The focus is on knowledge flows and the process of creation, sharing, and distribution of knowledge.	The role of IT is to provide link between sources of knowledge to create wider breadth and depth of knowledge flows.
Access to information	Knowledge is a condition of access to information.	The KM focus is organized access to and retrieval of content.	The role of IT is to provide effective search and retrieval mechanisms for locating the relevant information.
Capability	Knowledge is the potential to influence action.	KM is about building core competencies and acquiring strategic know-how.	The role of IT is to enhance the intellectual capital of enterprises by supporting development of individual and organizational competencies.

Table 2.1: Knowledge perspectives and their implications (Source: [AL01])

2.4.3 Knowledge processes

Depending on the context, the term *knowledge process* can have different meanings. Two different views evolved namely the process-oriented and the technology-oriented views from a Knowledge Management System (KMS). Often the term *knowledge management process* is used synonymously for the process-oriented perspective. In the following we briefly elaborate on both views.

A knowledge process describes how knowledge items are handled within a KMS. According to Staab et al. [SSSS01] a knowledge process includes the following steps:

- **Creation or import**
  Knowledge is either created within the KMS or imported from external systems. The imported knowledge items must satisfy the rules and guidelines of the organization.

- **Capture**
  Contents of knowledge items have to be captured to determine their importance.

- **Retrieve and access**
  Knowledge workers must be able to explore the knowledge stored within a KMS by searching and querying.

- **Use**
  The use of the retrieved knowledge is another important aspect. Often knowledge workers derive further knowledge, when they apply their knowledge.

In contrast to the technology-oriented perspective, the process-oriented view emphasis the following steps [DP98, AL01]:

- **Creation**
  Knowledge has to be created which involves a continual interplay between the dimensions of tacit and explicit knowledge (see Section 2.4.2). This activity can be difficult to manage, because it can be totally unstructured, immeasurable and unrepeatable [Dav10].

- **Storage/Retrieval**
  While organizations develop knowledge and learn, they also forget [ABE90]. It is important to enable storage and retrieval of knowledge to facilitate later use.

- **Transfer**
  The knowledge has to be transferred to despartments and teams where it is needed and can be used. This can be very hard, because of the distributed nature of organizations. Individuals requiring the same knowledge can be distributed across different organizational groups.

- **Application**
  The application of knowledge is more important for companies than the knowledge itself to create a competitive advantage. Humans have to filter the knowledge and apply it to their job tasks [Dav10].

As knowledge management "consists of a dynamic and continuous set of processes and practices embedded in individuals, as well as in groups and physical structures", the knowledge process cannot be seen static and individuals and groups can be engaged in several activities of the it [AL01].

Strohmaier [Str03] focuses on the knowledge activities involved from a (business) process view and defines knowledge processes as "the generation, storage, transfer and application of certain knowledge domains across or within business processes." He further developed a framework for modeling organizational knowledge processes on the basis of business processes. With the help of this framework, business processes can be analyzed in terms of their contribution to specific knowledge processes (see also Section 2.6).

2.4.4 Knowledge reuse

A prerequisite for knowledge reuse is that the knowledge has to be captured and documented. Therefore tacit knowledge has to be made explicit (see Section 2.4.2). Markus [Mar01] identified three major roles in the knowledge reuse process:

- **"Knowledge producer"**
  The knowledge producers are the originators of knowledge. They document the knowledge by recording explicit knowledge or externalize tacit knowledge.

- **"Knowledge intermediary"**
  The knowledge intermediary further processes the knowledge for reuse. Therefore, the knowledge is for example abstracted, indexed, summarized, packed and filtered. The role is very important to turn produced knowledge into reusable knowledge, which fosters faster knowledge reuse.

- **"Knowledge consumer"**.
  The consumer takes advantage of the existing knowledge by applying it in some way.

People can have multiple roles in the knowledge reuse process. If someone has the roles of a producer and consumer, the term *prosumer* can be used [GM96].

Additionally, Markus has identified four distinct types of knowledge reuse situations, involving *shared work producers*, *shared work practitioners*, *expertise-seeking novices*, and *secondary knowledge miners*. In the following we will briefly describe the different types and their roles:

- **"Shared work producers"**
  Shared work producers are people who work together in a homogeneous or cross-functional team. They are creators of the knowledge which they later reuse. As a consequence, they do not have many problems with reusing knowledge, but capturing the appropriate information and searching for it are the challenges for them.

- **"Shared work practitioners"**
  Members of a community of practice [Wen98] are shared work practitioners. They do similar work in different settings, and reuse knowledge produced by other members of the community. Their challenges are the location and selection of the knowledge. They often cope with these tasks by asking experts from their networks of contacts. Once the required knowledge is located and selected, there are almost no issues with applying it.

- **"Expertise-seeking novices"**
  This role refers to novices who do not possess the required knowledge to execute their task. The challenges are the definition of a proper search question, the location and quality judgment of knowledge sources, and the application of the knowledge.

- **"Secondary knowledge miners"**
  By analyzing the knowledge produced by other people, secondary knowledge miners try to answer new questions and develop new knowledge. Secondary knowledge miners have the same challenges as the expert seeking novices, but they possess methodologies which enables them to cope better with reusing the knowledge than novices.

2.4.5 Knowledge maturing

In contrast to the knowledge reuse scenarios described in the previous section, research work in the area of knowledge maturing emphasizes on how the knowledge is developed that it can be reused. Knowledge maturing [SHL+08, SHL+09, MS07] was mainly analyzed within the EU project MATURE. A knowledge maturing process model illustrated in Figure 2.2 has been developed. The model structures five phases for the maturation of knowledge. The phases build upon each other [SHL+08]:

- **Expressing ideas**
  Individuals develop new ideas either from personal experiences or in informal discussions. The developed knowledge is subjectively and vaguely expressed and thus often restricted in its use, because it is deeply embedded within the context of the person expressing the idea.

- **Distributing in communities**
  A common terminology has to be developed and shared among community members. Tools such as discussion forums, blogs and wikis can support this phase.

- **Formalizing**
  The unstructured and subjective artifacts created in the preceding phases and

embedded in the content of the community have to be structured and documented. For instance, knowledge can be made explicit in project reports and process models.

- **Ad-hoc learning**
  The documents from the previous phase cannot be directly used as learning materials because they lack didactical considerations. When the topic is refined by improving comprehensibility, the knowledge is easier to consume and reuse.

- **Standardization**
  All individual learning objects, which are the outcome of the previous phase are put together to cover a broader subject area. As a result also novices can be taught and can become an expert after they have achieved a certain degree of proficiency.

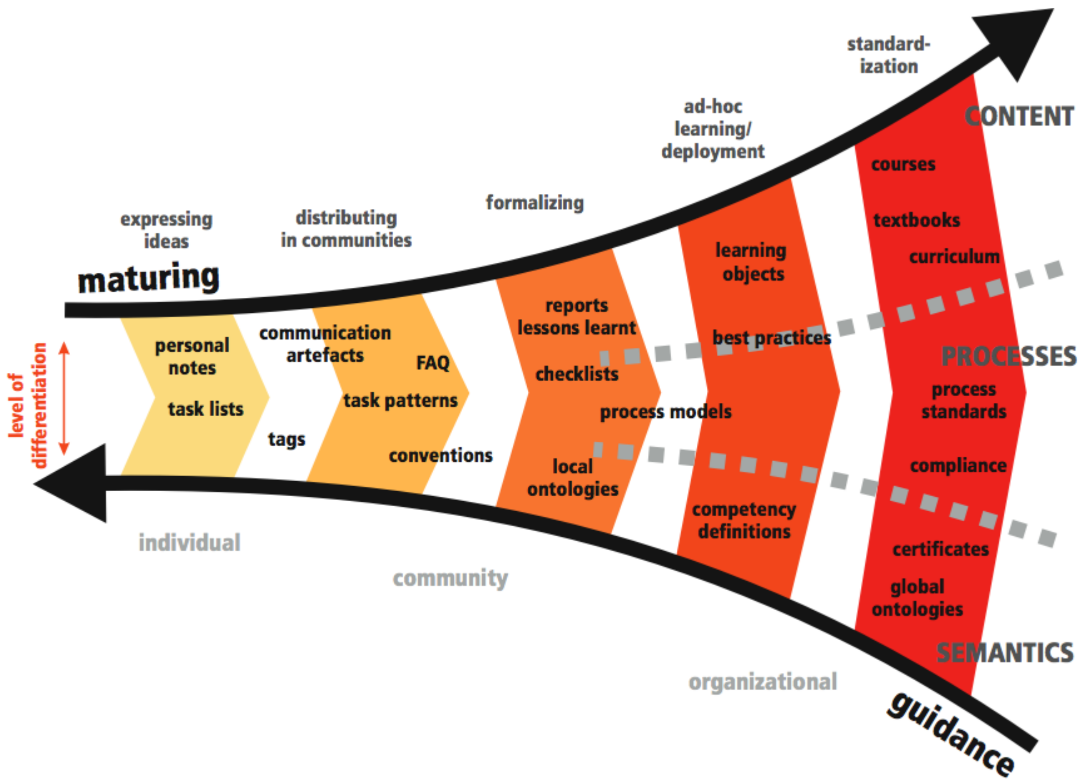


Figure 2.2: The knowledge maturing process (Source: [SHL+08])

Schmidt et al. [SHL+09] further differentiate among three knowledge asset types, which are closely interrelated and depend on each other in various respects:

- **Content**
  The best managed type of knowledge assets is content, providing a static picture of the world. A value-oriented view is put on knowledge elements (business value). This perspective shows the high value of knowledge for the functioning of an organization's processes.

- **Processes**
  While content was static, this type of knowledge asset is more related to the dynamic aspects of the organization. The development of business process models and workflows are already supported by most organizations, but also the recording and sharing of individual work practices have to be enabled. Especially, because organizational learning processes are much more agile and the costs of modeling are considerable.

- **Semantics**
  Without semantics there is no mutual understanding. The individual views, experiences and insights would be misinterpreted. A common terminology provides the basis for knowledge exchange. Examples for these knowledge assets can be tag clouds and emerging folksonomies, folder structures, competence models, local or global enterprise ontologies. A common terminology provides the basis for knowledge exchange.

Regarding the maturation of business process models, which is part of this work, the conceptual model proposes to start with individual task lists and routines. Task patterns can be distilled for recurring tasks and shared between individuals. In a next step, a wider community of people is allowed to discuss, refine, enhance and complete these procedures in a social and collaborative manner. Eventually, this evolutionary process results in business process models which are adequate standardizations of real-world practice. Even though, we concentrate on the more informal and less formal phases of the proposed model in this thesis.

2.5 Wikis

The term *wiki* originates from the Hawaii word meaning *fast*. The idea of wikis was developed by Cunningham, who wanted to build "the most simple online database that could possibly work" and created the first wiki in 1995 with the name *WikiWikiWeb* [LC01]. As pioneer in the development of new methods, like object-oriented programming, design patterns, and extreme programming, he looked for a new documentation system that better supports programmers than conventional word processing programs. As a result he developed a simple software enabling collaboration on software codes that could immediately be published in the Web, including the documentation of all editing steps [EGH05]. While wikis started textual, also rich Wikis can be found, including pictures, movies and audio [Lev09]. A prominent wiki engine is *MediaWiki* (see Section 3.1.1), which runs the popular Wikipedia web site. According to Ebersbach et al. [EGH05] a wiki is a "web-based software that allows all viewers of a page to change the content by editing the page online in a browser. This makes wiki a simple and easy-to-use platform for cooperative work on texts and hypertexts."

2.5.1 Principles

The wiki derives its uniqueness from the openness and the ease of user participation by providing syntax that is easy to learn. Users can easily add and edit existing content, which enables users to work together and share their contributions. According to Murugesan [Mur07] a wiki has the following features:

- **"A wiki markup language"**
  The wiki provides an easy syntax to format text and to link external documents and content.
- **"Simple site structure and navigation"**
  New pages can be easily created and linked to other pages. The flat hierarchy and structure allows for simple navigation.
- **"Simple templating"**
  As soon as a wiki page is requested, the wiki engine translates the wiki markup into HTML syntax and automatically creates hyperlinks between pages. The converted content is wrapped in a template to provide a consistent look to all pages in the wiki.
- **"Support for multiple users"**
  The wiki engine offers a special syntax for internal links and creates hyperlinks based on the title of the page. As a result, the author does not need to use, remember, or type long URLs to link one page to another within a wiki.
- **"Simple workflow"**
  Everybody is allowed to write or edit and publish without editorial control or approval. The content of wiki is managed through change monitoring (history) and the revert functionality to roll back to a previous version and prevent spam. In addition, user access and privileges can be controlled, if required.
- **"A built-in search feature"**
  Search functionality is offered by the wiki engine to enable searching for specific information or topic within a wiki using associated keywords.

While these features above are more from a user perspective, Cunningham [Cun11] formulated the wiki design principles shown in Table 2.2 from a technical view.

Principle	Explanation
Simple	Easier to use than abuse. A wiki that reinvents HTML markup ([b]bold[/b], for example) has lost the path!
Open	Should a page be found to be incomplete or poorly organized, any reader can edit it as they see fit.
Incremental	Pages can cite other pages, including pages that have not been written yet.
Organic	The structure and text content of the site are open to editing and evolution.
Mundane	A small number of (irregular) text conventions will provide access to the most useful page markup.
Universal	The mechanisms of editing and organizing are the same as those of writing, so that any writer is automatically an editor and organizer.
Overt	The formatted (and printed) output will suggest the input required to reproduce it.
Unified	Page names will be drawn from a flat space so that no additional context is required to interpret them.
Precise	Pages will be titled with sufficient precision to avoid most name clashes, typically by forming noun phrases.
Tolerant	Interpretable (even if undesirable) behavior is preferred to error messages.
Observable	Activity within the site can be watched and reviewed by any other visitor to the site.
Convergent	Duplication can be discouraged or removed by finding and citing similar or related content.

Table 2.2: Wiki design principles (Source: [Cun11])

In addition to these core principles, also trust is an important factor in a wiki setting. Everybody can control and check the content published by others. Another aspect is the sharing of information, knowledge, ideas and experiences. The easy creation of links between terms, pages and titles results in another dimension of knowledge sharing [Lev09] (see Section 2.5.4).

2.5.2 Function

As the result of the design principles presented in Section 2.5.1, every wiki engine provides basic functionality, which can be extended according to specific user requirements. The main characteristic of a wiki is the free editing of content within a Web browser [MG09]. The technical core functions of a wiki according to Ebersbach et al. [EGH05] are:

- **Editing**
  The editing of pages is the main typical feature of a wiki. In a standard wiki environment everybody can edit every page. This can be restricted to dedicated users like on the main page in Wikipedia.

- **Links**
  By linking articles to other articles in the wiki a new network structure exists. Links to other pages can be created by using a special syntax such as CamelCase or placing the title in square brackets. A hyperlink is generated by the wiki engine on the page view. Links to not existing pages are often displayed in separate layout (e.g. red links in MediaWiki). If users click on a link to a page that does not exists, they are directly forwarded to the editing mode to create the page. This functionality makes it easier to add new content.

- **History**
  All previous modifications are stored within the wiki engine to document all changes. Previous versions can be viewed, compared or reverted. The history function is also an instrument against vandalism.

- **Recent Changes**
  An overview page of a certain number of recent changes is produced automatically by the wiki engine. The page cannot be modified by users and either shows changes of a dedicated wiki page or all changes within a predefined time period. Some wiki engines, like MediaWiki (see Section 3.1.1), additionally provide watch list functionality, which allow user to select wiki pages that will be monitored.

- **SandBox**
  A playground for users is called *SandBox*. It is normally a dedicated wiki page, which is emptied on a regular basis.

- **Search function**
  Most wiki engines provide a classic full-text or title search to access wiki pages faster and easier.

The title of a wiki pages is unique. To avoid similar names in different context, most wiki engines use name spaces that can be customized. Typically, standardized name spaces exist for users, discussion and internal administration [MG09].

2.5.3 Semantic wikis

Although wikis have these beneficial characteristics explained in the previous sections, they also have some limitations. According to Krötzsch et al. [KVV+07] the core problems of today's wikis are:

- **"Consistency of content"**
  There is no mechanism to ensure consistency of the same information on different pages. Wikis rely on the contribution of people, who are free to edit and modify, which can result in inconsistency.

- **"Accessing knowledge"**
  Large wikis consist of thousands of pages. Thus, information retrieval and the comparison of information from various pages are challenging and time-consuming.

- **"Reusing knowledge"**
  The information is only accessible to people, because the content of classical wikis is text based and can only be consumed by people reading pages in a browser or similar application.

To overcome these limitations, wikis are augmented with Semantic Web technology and Semantic Web applications are wiki-fied [VS06]. Semantic wikis enable users to structure content by assigning semantics to the existing relations between wiki pages and facts (properties). In addition to these properties, semantic wikis often provide a class hierarchy to further structure wiki pages by assigning pages as instances of classes. According to Schaffert [Sch06] most semantic wikis provide the following features:

- **"Typing/Annotating of Links"**
  Users are allowed to assign certain types to links in virtually all semantic wikis. The annotation of a link carries meaning beyond mere navigation. The way users can create annotations differs from semantic wiki to semantic wiki. While in some systems the annotations are included as part of the wiki syntax (e.g., Semantic MediaWiki [KVV+07]), other systems provide a separate editor for adding annotations (e.g., IkeWiki [Sch06]).

- **"Context-Aware Presentation"**
  The presentation of content in semantic wikis can deviate from classical wikis. For instance, Semantic annotations can be used to display semantically related pages in a separate link box, to show derived information from the underlying knowledge base and to present the content in a different manner that is more suitable for the context (e.g., charts).

- **"Enhanced Navigation"**
  The annotations of links provide additional information about the link, which can be used to offer additional or more sophisticated navigation.

- **"Semantic Search"**
  Most semantic wikis allow for querying the underlying knowledge base. Usually, queries are expressed in a specific query language such as SPARQL [PS08], a W3C recommendation, or ASK QL [KVV+07], provided by Semantic Media-Wiki. Semantic search can be used to ask queries like *Show me all people in the wiki and their corresponding email address*.

- **"Reasoning Support"**
  Additional, implicit knowledge can derived from the facts entered into the semantic wiki using predefined or user-defined rules in the knowledge base. Reasoning is only supported by a small number of wikis because it is time-consuming, memory intensive, and can yield results that are not expected and/or traceable by the user.

Semantic wikis enhance classical wikis by providing additional functionality to the user and the system. According to Schaffert et al. [SGW05] possible advantages of semantic wikis are:

- The technical barrier for non-technical users is lowered by hiding (to some extent) the complexity of Semantic Web technologies such as RDF or OWL.
- The evolution of knowledge from informal text to formal ontologies or similar representations is supported.
- Instant access to and usability of knowledge are provided, even if it is not yet completely formalized.
- Collaborative creation of knowledge structures is allowed. Domain experts and ontology experts can work together.
- Freedom over the knowledge creation process is given to users.

Over the time various semantic wiki engines have been developed. A prominent example is Semantic MediaWiki (SMW) [KVV+07], which is presented in Section 3.1.2. A detailed list of existing semantic wiki engines can be found in [FTD10].

2.5.4 Wikis for KM

Until recently, KM initiatives focusing on the creation of central knowledge repositories, encouraging knowledge reuse and collaboration based on these repositories were typical top-down approaches [Avr06]. In contrast to these top-down approaches, the usage of wiki is an informal and bottom-up approach [Gra09]. The majority of organizational knowledge is still in the people's heads (tacit knowledge), which require tools that make it simple for people to express, share and find knowledge (explicit knowledge) [Wag04]. Thus, wikis, especially semantic wikis, are very well suited for KM [Wag04, HP06, Sch06]. They have the potential to make tacit knowledge, distributed over far-reaching sources, explicit [OLe08].

Corporate wikis meet the requirements of current knowledge intensive work environments due to their simplicity, openness and transparency [MD06]. In classic knowledge management, experts are responsible for the acquisition of knowledge from the domain experts, but with wikis, the intermediary is removed and people can share their knowledge directly [OLe08]. Wikis are dynamic knowledge bases, which can adapt knowledge of users to their respective requirements. In contrast to static KMS, they store information as Web pages, which can be adjusted by combining and dividing the information [MG09]. Users can directly influence the content of knowledge base and its structure. Müller and Dibbern [MD06] analyzed the influence of the wiki design principles on KM. Table 2.3 shows the principles and their influence on KM.

Principle	Explanation
Simple	Users can easily access the system. Only low barriers exist for documenting knowledge.
Open	Every employee is a potential expert; knowledge is free accessible.
Incremental	Knowledge deficit are presented to the user.
Organic	Knowledge and its context are dynamic. They are developed according to the requirements.
Universal	Knowledge management roles do not have to be defined.
Precise	The context of knowledge is considered.
Observable	The history of knowledge can be analysed.
Convergent	Redundant knowledge can be consolidated.
Trust	The success of a corporate wiki also depends on the organizational culture.

Table 2.3: Influence of wiki design principles on KM (Source: [MD06])

Wagner [Wag04] started from another perspective. He explored the needs of conversational knowledge management and identified wiki features that facilitate them. As a result, he concludes that wiki characteristics address several knowledge needs as shown in Table 2.4. An important fact is the multi-participant feature of wikis, addressing many knowledge needs and leading to better quantity and quality of knowledge.

In contrast to traditional KMS, where content is normally defined by knowledge experts, by expert groups or by specifications of the system, the content of a wiki is developed, organized and adjusted by the users. As result, wikis foster employees to participate in KM [MG09]. For instance, wikis can be used for KM in companies to maintain and share knowledge about software projects, such as source code, documentation, project work plans and bug reports [SBBK08].

Wiki users in a KM initiative can be seen as consumers and prosumers, if they also contribute with their knowledge in the wiki. It is also helpful to have knowledge intermediaries often called *wiki gardners*, who help to combine, split, and reorder content and also delete outdated content. (see Section 2.4.4)

While traditional wikis already support easy and free authoring and content creation, semantic wikis offer functionality to structure knowledge for easy retrieval and for finding related information [Sch06], which makes the wiki more powerful

User Needs	Principles	Wiki Characteristics and Features
Ad-hoc knowledge	Incremental, Organic, Universal	Incremental knowledge creation as question answering; Power of N; Wiki editing features (speed of publication)
Finding knowledge	Unified, Precise, Incremental	Knowledge indexing and hyperlinking; Backlinking; Centralized, web-based resource
Filtering knowledge from noise	Unified, Precise, Convergent	Hyperlinking; Power of N; Removal of duplication
Quality of source	Open, Organic, Observable	Power of N; Record of history of changes with author information; Ability to comment on changes
Dynamically changing knowledge	Organic, Observable	Power of N; Wiki editing features (history and version management)
Distributed knowledge	Organic	Power of N
Errors and recovery	Open, Tolerant, Observable	Power of N; Wiki editing features (history and version management)
Publication overhead	Mundane, Universal, Overt	Wiki editing features; Wiki publication features

Table 2.4: Knowledge management needs and corresponding wiki design principles, characteristics, and features (Source: [Wag04])

as a knowledge management solution. As soon as semantic annotations and hence structures are available, the user can actively be supported by the semantic wiki. For instance, the semantic wiki can offer graphical visualization of the structured data or structured data can be exchanged with other wikis or applications [SBBK08]. Repositories for knowledge reuse can be basically categorized in repositories of documents and repositories of data [Mar01]. A semantic wiki combines both natural language (documents) and semantic annotations (data) and can thus be used to support knowledge reuse (see Section 2.4.4).

The use of wikis is beneficial for companies, especially as a KM solution [Gra09], because wikis support the knowledge capturing stage, the retrieval and storage and information transfer stage of the knowledge process, presented in Section 2.4.3 .

2.6 Knowledge-intensive processes

A knowledge-intensive process is another category of business processes. The term *knowledge-intensive process* is used, when a process relies on specialized professional expertise, continuous learning and transformation of information [BPM+07]. A high degree of expertise and certain skills are required to execute a knowledge-intensive process. The term *knowledge worker* [Dru99] is often used in this context.

2.6.1 Knowledge worker

The term *knowledge worker* is intimately connected with knowledge work and was established by Drucker [Dru57]. Over time, many definitions and characteristics for knowledge workers have evolved. We will exemplify a few of them in the following to give a brief overview.

Characteristics of knowledge workers are derived from a study by Kidd [Kid94]. The study identified three distinguishing characteristics of knowledge workers:

- **"Diversity of output"**
  Knowledge workers are valued for diversity rather than consistency between their responses.
- **"Low dependence on filed information"**
  Knowledge workers do not heavily rely on information once it has been filed.
- **"Importance of spatial layout and materials"**
  Knowledge workers use their desk and floors as a spatial holding pattern for paper-based inputs and ideas.

While the first two characteristics are still relevant today, the latter one has shifted from paper-based to computer-based work. According to Drucker [Dru99], the productivity of knowledge workers is determined by six major factors:

- For the productivity of knowledge workers we have to ask, what the task is.
- Knowledge workers have to be responsible for their productivity. They must manage themselves, which requires autonomy.
- Continuing innovation is a requirement being part of the work, the task and the responsibility of knowledge workers.
- Knowledge work requires both continuous learning and continuous teaching on the part of the knowledge worker.
- Productivity of the knowledge worker is not primarily measured by the quantity of output, but also by the quality.
- The knowledge worker must be seen and treated as an "asset" rather than "cost". They must want to work for the organization in preference to all other opportunities.

Dove [Dov98] sees "anybody who must use their head on the job" as a knowledge worker. Davenport [Dav02] defines knowledge workers as "people with a high degree of education or expertise whose work primarily involves the creation, distribution, or application of knowledge. Knowledge workers have high levels of autonomy and discretion in how they do their work; others have more structured roles. Their activity – which includes R&D, marketing, engineering, planning, customer service, and management – is critical to innovation and growth."

Davenport [Dav10] further differentiates knowledge workers according to the work they do by taking a process perspective on knowledge work. He differentiates four key types of knowledge work and give hints how these types can be moved in a more process-oriented direction to make knowledge work more productive:

- **"Transaction workers"**
  These workers have to do routine work that highly relies on formal rules, procedures and training. They need the knowledge to perform their work, including the process flow. Their time is limited for consulting external guidelines or knowledge sources. They can be supported by workflow applications, bringing all information and knowledge required for the task to the workers. By applying such a system, process and productivity can be controlled and measured.

- **"Integration workers"**
  This type of work is systematic and repeatable, highly relying on formal processes, methodologies or standards. The processes can be documented and the workers normally have enough time to read the process documentations.

- **"Expert workers"**
  These workers have high autonomy in their judgment-oriented work, which highly relies on their individual expertise and experience. They typically do not pay much attention to process flows, because it is a challenge to pre-structure their work. They can be supported with templates, sample outputs and high-level guidelines.

- **"Collaboration workers"**
  This type of work is improvisational, highly relying on deep expertise across multiple functions and depending on fluid deployment of flexible teams. Their work cannot be fully mediated and structured by a computer. Required external knowledge and information have to be made available through documents and repositories.

2.6.2 Characteristics of knowledge-intensive processes

Knowledge-intensive processes are, according to Tautz [Tau01], the latter two types of processes specified by Debenham [Deb00] (see Section 2.1), namely goal-centered and knowledge-centered processes. According to him, knowledge-intensive processes have the following characteristics:

- Their sequence of activities cannot be predefined as they involve a creative element.
- Some activities require personal decisions based on experiences and comprehensive historical knowledge.
- The overall process description is often sketchy or incomplete and can only be given at an abstract level.

The first two characteristics are also mentioned by Eppler et al. [ESR99]. They classify business processes in regard to their process complexity and knowledge intensity by defining attributes that characterize complex and knowledge-intensive processes. The complexity dimension is further refined by the number of process steps and involved agents, the interdependencies between agents and process steps as well as the process dynamic. The attributes for knowledge-intensive processes are:

- **"Contingency"**
  Environmental factors can have a high influence on the activities. Hence, agent activities are contingent.
- **"Decision scope"**
  During the execution, the agent has many choices and possibilities for process-related decisions.
- **"Agent innovation"**
  Creativity and innovation is required to solve problems, arising during process execution.
- **"Half-life"**
  The knowledge required for the process is only relevant for a short period. The process-relevant knowledge has to be update many times.
- **"Agent impact"**
  The expertise and knowledge of an agent has major influence on the process outcome.
- **"Learning time"**
  The skills required for the activity cannot be acquired in a short time period.

While these previous characteristics have been derived from a business process perspective, knowledge-intensive processes have also been analyzed within the field of knowledge management. The concepts of tacit and explicit knowledge [Pol66] and their conversions [NT95] form the basis for the examination of knowledge-intensive processes from a knowledge management perspective. A further classification of knowledge-intensive processes takes the externalization of tacit knowledge into account [MSMG07, MS08]. The framework from Miers [Mie04], briefly described in Section 2.1, has been extended to describe the knowledge dimensions of different types of business processes:

- **"Procedure-oriented business processes"**
  Well-structured, repetitive, normatively regulated business processes can be seen as standardized organizational procedures. The process structure is defined by a procedural component. A procurement process can be a prominent example.

- **"Practice-oriented business processes"**
  In contrast to the previous category, people develop new experimental knowledge by executing task and solving problems in a practice oriented business process. This task can be performed collaboratively or individually. The people are only guided by policies to stay within the normative boundaries of their companies.

- **"Case-handling business processes"**
  The third category is typically customer-facing processes. They involve both procedural and practice components. To offer personalized services, employees have to deviate from standardized procedures.

The procedure-oriented business processes mostly include predetermined tasks and do not postulate knowledge for follow-up activities, but exceptions require a lot of experience and previous knowledge.

A knowledge-intensive process consists of at least one knowledge-intensive task. Sarnikar and Deokar [SD10] defined knowledge intensive tasks "as requiring high agent innovation, involving multiple decision paths, contingent upon numerous eventualities and being highly dependent on agent actions. They are also characterized by long learning time to perform the task and lower knowledge half-life, where knowledge quickly becomes obsolete."

2.7 Business Process-oriented Knowledge Management (BPoKM)

The research stream of *Business Process-oriented Knowledge Management* (BPoKM) [AHMM02] started to combine knowledge management with BPM. The main idea was that knowledge management activities can be incorporated into BPM activities to reduce the effort required to perform both task. From a KM perspective also the term *Process-oriented Knowledge Management* is used.

Existing knowledge is continuously used during the execution of a process, but also new knowledge is generated. Within BPoKM two different types of knowledge are differentiated. The knowledge about the whole process, including the required functions and their relations, can be described as *process knowledge*. Thus process knowledge comprises for example the flow of the required activities, the involved people and roles. The second type of knowledge required for executing a process step (activity) is called *functional process knowledge*. Functional process knowledge can only be integrated in processes as parameters like certain competences and skills required for a role within a process [NS02].

Abecker et al. [ABN+01] propose promising integration possibilities for BPoKM on three levels:

- **System design**
  BPM and KM projects should share their analysis and planning. The BPM methodology can be used as a driver for the KM specific work.
- **System use**
  KMS should interoperate with the BPMS to achieve a higher degree of overall system services. This integration can be achieved in various ways. A *process-oriented knowledge archive* can be created by using business process models for organizing knowledge archives. The relevant predefined information can be presented to the user during process execution within an *active information delivery* setting. The support of a *dynamic process context* extends the active information delivery approach by also allowing dynamic resource allocation. If the process context is automatically stored with the information, a *contextualized information storage* can be created. *Context-embedded discussions* should be supported to allow users to discuss content and quality of the information objects retrieved.
- **System evolution**
  Everything should continuously be improved, which is a KM process itself.

Today, there is a smooth transition between KM and BPM. The functional knowledge is also considered in BPM approaches (e.g. [Dav10, KB06, CPHC11] and KM initiatives are more process-oriented (e.g. [Pri08]). Example approaches for BPoKM are listed in the related work chapter in Section 4.1.

2.8 Informal processes

Knowledge workers in organizations deal with processes during their daily task. These can be business processes formally defined within an organization as specified in the previous sections, but also processes which are rather informal, rarely documented and mostly knowledge-intensive [WKT+09]. In this section we will outline such informal processes and their characteristics.

Although most common business processes are standardized, well-engineered and repeatable, there are also parts or whole business processes which are rather informal and require specific expertise and knowledge during execution. These processes can either be categorized as knowledge-intensive processes or as simple informal processes, which have to be made explicit by documenting them. A wide diversity of business processes depending on these informal processes [HYJK06]

Informal processes are mostly either in individuals' heads or written down in a textual format (e.g. HowTos). In addition, they could also be described in informal sketches of process models by using free-form diagramming tools, such as Powerpoint and Visio [MDS+10]. While the knowledge to perform a processes remains in the people's head (tacit knowledge) it can only be shared according to Nonaka and Takeuchi [NT95] between persons (socialization) or by making it explicit (externalization) in documents and graphical representations.

2.8.1 Characteristics of informal processes

In contrast to business processes, which are highly standardized and mature, informal processes can start from a vague idea, how to achieve a certain goal. They can be repeated and mature over time. These processes can vary from person to person even when those involved are pursuing the same objective [WKT+09]. Depending on the number of repetitions and the resulting documentation, an informal process can become a standardized business process over time.

An informal process can be run either in parallel to a business processes or vertical to different business processes. Parallel running informal processes support activities of business processes, which are not specified detail. For instance, the business process activity normally does not describe how to gain specific information. The informal process is in this case the providing of the required information.

Different names for these informal processes have been used in literature. Beardsley et al. [BJM06] call them *tacit interactions*. Tacit interactions are "the searching, coordinating, and monitoring activities required to exchange goods, services, and information" [BJM06]. The authors further state that the productivity of the knowledge workers performing these tacit interactions during their daily task cannot be standardized and automated.

Another name for informal processes is *artful business processes* [HYJK06]. As they "depend on the skills, experience, and judgment of the primary actors", it "would be extremely difficult, if not impossible, to codify in an enterprise application."

These informal processes have to be made explicit that they can be reused. As a result, the process knowledge must be captured and documented, which requires alternative approaches that allows people to directly influence the process descriptions [HYJK06]. In this thesis we thus propose an bottom-up approach, which can used to make the process knowledge explicit.

3

Chapter 3

Technical background

After having established the theoretical fundamentals in the previous chapter, we now introduce two different tools, namely Semantic MediaWiki (SMW) and Oryx, which serve as a basis for our tools supporting our wiki-based light-weight approach (see Section 7.2).

First Semantic MediaWiki (SMW) and its functionalities is introduced in Section 3.1. As SMW is an extension to MediaWiki, also the functionality and features of MediaWiki required to describe our tools are briefly explained.

The Oryx process editor introduced in Section 3.2 provides a graphical editing interface. Its features and functionality is also described as required to understand our implementation presented in Section 7.3.

3.1 Semantic MediaWiki

Semantic MediaWiki [KVV+07] serves as a foundation for Wikiing Pro (see Section 7.3) supporting our wiki-based light-weight approach for maturing process descriptions. Semantic MediaWiki is an extension for the MediaWiki software that runs e.g. the popular Wikipedia site.

3.1.1 MediaWiki

MediaWiki [Bar08] is an implementation of the wiki concepts presented in Section 2.5. It is one of the most prominent wiki engines, as Wikipedia runs on it. Originally, MediaWiki [Bar08] has been developed to run Wikipedia on it, but it is also used now for several other Web projects and within organizations. MediaWiki is an open source software, written in PHP, which is a scripting language used for Web development. Users can create and edit wiki pages. Basic collaboration functionality is provided by MediaWiki:

- **Versioning**
  Each version is stored in the data base, including the date and the user id of the editor. Thus, changes are tracked and the user can compare different versions.

- **Reverting**
  Changes on wiki pages can be undone by reverting to an older version.
- **Discussing**
  A corresponding discussion page can be created for each wiki page. Users are enabled to discuss statements made on the original wiki pages.

MediaWiki offers 18 default namespaces to group wiki pages with a similar content purpose. Namespaces are used to separate main content pages from support pages. Normal wiki pages are in the main namespace, which has no prefix. The other namespaces use prefixes, which are included as the first part of the page title, separated by a colon. For instance, a discussion page for the article *Process* is in the Talk namespace, expressed with *Talk:Process*. Each namespace has a corresponding index. An overview is provided in Table 3.1. In addition, custom namespaces can be defined, like the namespace *Form:* introduced by the Semantic Forms extension.[1].

Index	Name	Purpose
-1	Special	Holds special pages
-2	Media	Alias for direct links to media files
0	Main	"Real" content; articles
1	Talk	Talk pages of "Real" content
2	User	User pages
3	User talk	Talk pages for user Pages
4	Project	Information about the wiki
5	Project talk	Talk pages for Project pages
6	File	Media description pages
7	File talk	Talk pages for File pages
8	MediaWiki	Site interface customization
9	MediaWiki talk	Talk pages for MediaWiki pages
10	Template	Template pages
11	Template talk	Talk pages for Template pages
12	Help	Help pages
13	Help talk	Talk pages for Help pages
14	Category	Category description pages
15	Category talk	Talk pages for Category pages

Table 3.1: Default MediaWiki namespaces (Source: [Fou11a])

MediaWiki also provides a special syntax, which is used in the edit mode and later translated by the wiki engine into HTML code. Parts of the MediaWiki syntax are presented in Table 3.2. The presented syntax is required to get a better understanding of the presented tools in Chapter 7. A full description can be found in [Bar08].

An internal link is used to link a wiki page to another wiki page. By clicking on that link, the linked page is opened within the browser tab. If the wiki page does not

[1] http://www.mediawiki.org/wiki/Extension:Semantic_Forms

Description	Syntax
Bullet list	* item1 * item2
Numbered list	# item1 # item2
Internal Link	[[Wiki Page]]
Redirect	#REDIRECT [[Wiki Page]]
Template	{{Template name}}
Category	[[Category:Name]]

Table 3.2: Brief selection of MediaWiki syntax

exist, a red link is shown to the user (see also Section 2.5.2). By clicking the red link, the new wiki page in edit mode automatically appears within the browser tab, which enables the user to easily add new wiki pages. With help of the internal links the user can easily browse to related content within the wiki.

Wiki pages can be assigned to categories by using the category syntax shown in Table 3.2. Categories are another method to group similar wiki pages. In contrast to the namespace categorization, a wiki page can have multiple categories. If a category is assigned to a wiki page, a link to the wiki pages appears on the category page.

MediaWiki also provides template functionality, which allow to structure wiki content. Templates in MediaWiki can be used to display predefined text on multiple wiki pages. A template page is a wiki page stored in the template namespace. Its content can be embedded into wiki pages by using the include syntax {{Template Name}} within another wiki page. The template namespace prefix is not required for including templates, it is sufficient to only use the template name. While all wiki pages can be included in other wiki pages, parameters can only be used within templates. Different content can be produced by using parameters in templates. An example for passing the parameters *Process Name* and *Owner* to the template *Process* can be found in Wiki Syntax 3.1. Parameter values are separated by a pipe char and a parameter name can be assigned for an easier reuse within the template text.

```
{{Process
  | Process Name=Test Process
  | Owner=Frank
}}
```

Wiki Syntax 3.1: Example template call passing parameters to the template

Within the template, parameters can be referred by using the parameter index or name in three braces ({{{ }}}). An example template text using the parameters *Process Name* and *Owner* is presented in Wiki Syntax 3.2.

```
This is an example text:
The name of the process is {{{Process Name}}} and
the owner is {{{Owner}}}.
```

Wiki Syntax 3.2: Example text within template using parameters

In addition, *parser functions* [Fou11b] can be used for customized parsing of wiki text. A parser function requires a *magic word*, a kind of keyword used to identify different parser functions. MediaWiki adds a hash character to the magic word by default. An example of a typical syntax for a parser function can be found in Wiki Syntax 3.3.

```
{{#magicword: parameter1
| parameter2
| parameter3
}}
```

Wiki Syntax 3.3: Example syntax to call a parser function

The parameters used within the parser function syntax are passed as separate arguments to the parser function and can thus be used in the customized code. Another feature of MediaWiki is its expandability. Various extensions have been developed for MediaWiki to extend the basic functionality. Therefore, MediaWiki provides the so called *hooks*,[2] which allow to execute custom code, when one of many specific defined events occurs. A prominent example of a MediaWiki extension is the Semantic MediaWiki extension, which will be briefly introduced in the following section.

3.1.2 The Semantic MediaWiki extension

Semantic MediaWiki (SMW)[3] combines Semantic Web technology with collaborative aspects of wikis to enable large-scale and inter-departmental collaboration on knowledge structures. SMW is an extension for MediaWiki, that provides further functionality by allowing the user to add semantic annotations, to define class and property hierarchies, and to query for the structured knowledge (see Section 2.5.3). Knowledge can be expressed by using natural language in combination with formal annotations allowing machines to process the thus created knowledge.

An extension to the MediaWiki syntax, partly presented in Section 3.1.1, is provided by SMW to define class and property hierarchies, and semantic properties related to wiki pages. A class is equivalent to a category in MediaWiki. By using the category syntax within a category page, a sub hierarchy can be expressed. The category page is now interpreted as a subclass of the assigned category. To add a property

[2] For a complete list of hooks, please see http://www.mediawiki.org/wiki/Category:MediaWiki_hooks

[3] http://www.semantic-mediawiki.org

between two wiki pages (relation) or to a data value, a special property syntax is provided by SMW. For instance a property *has Successor* to a wiki page *Next Step* can be added with the syntax shown in Wiki Syntax 3.4.

```
[[has Successor::Next Step]]
```

Wiki Syntax 3.4: Example syntax for adding a property *has Successor* with the value *Next Step*

The property can be a relation between two concepts (wiki pages) or a data type property referring to a literal value. Each property has a corresponding property page in the namespace *Property:* provided by SMW. On this property page, the type of the property and thus the range of the property can be assigned by using the type syntax illustrated in Wiki Syntax 3.5.

```
[[has type::String]]
```

Wiki Syntax 3.5: Example syntax for adding a type *String* to property page

The currently available basic types in SMW can be found in Table 3.3. While the default type *Page* describes a relation, the other available types are data types.

Type	**Description**
Page	links to pages (the default)
String	text strings that are not longer than 255 characters
Number	integer and decimal numbers with optional exponent
Boolean	restricts the value of a property to true/false (also 1/0 or yes/no)
Date	specifies particular points in time
Text	like type *String* but can have unlimited length; the trade-off is values of this type cannot be selection or sort criteria in queries.
Code	like type *Text* but with additional precautions to preserve special formatting as used for technical texts. The value displays as regular text everywhere else (query results, fact box, "Pages using the property", etc.).
Temperature	variation of Type:Number that supports units of temperature (cannot be user-defined since converting temperature units is more complicated than multiplying by a conversion factor).
Telephone number	validates and stores international telephone numbers based on the RFC 3966 standard
Record	type for compound property values that consists of a short list of values with fixed type and order
URL	displays an external link to an URL
Email	displays an email address as a link (with mailto:)
Annotation URI	similar to Type:URL but with some technical differences in SMW's RDF export

Table 3.3: Supported basic Semantic MediaWiki type syntax. Further SMW extensions can provide additional types. (Source [Med11b])

The property name is only visible in the edit mode of the page and on the special page *Browse properties*. Depending on the type, the value is presented either as a link or as a string. Property hierarchies can be expressed in the same manner as it is done for classes/categories. Therefore a special property is used as presented in Wiki Syntax 3.6.

```
[[Subproperty of::Property:has Resource]]
```

Wiki Syntax 3.6: Example syntax for adding a subproperty relation on a property page with the value of the superproperty, in our example *has Resource*

The property and category syntax provided by SMW can also be used in templates as illustrated in Wiki Syntax 3.7. As a result, standard users do not need to care about the property syntax. By using the property syntax in templates, it can be assured that the same property names are used.

```
This is an example text:
The name of the process is [[Process Name::{{{Process Name}}}]]
and the owner is [[Process Owner::{{{Owner}}}]].
[[Category: Process]]
```

Wiki Syntax 3.7: Example text within template using parameters, category and property annotations

To access the formalized knowledge within wiki pages, SMW offers an inline query language [Med11a] (ASK syntax) to allow tree-shaped queries. The syntax for a query asking for all instances belonging to the category *Process* and their properties *Summary* and *Type* is shown in Wiki Syntax 3.8. The result of the query is presented in Figure 3.1.

```
{{#ask: [[Category:Process]]
| ?Summary
| ?Type
| format=table
}}
```

Wiki Syntax 3.8: Example query syntax to retrieve instances belonging to the category *Process* and their properties *Summary* and *Type*

Without stating a specific output format, the query result will be displayed by default as a table on the corresponding wiki page as shown in Figure 3.1. By using predefined standard parameters in the query syntax, the appearance of query results can be influenced. The most important parameter for controlling how the results are displayed is the parameter *format*. The default formats are described in Table 3.4. A full description of the standard parameters can be found in [Med11a]. SMW also allows

	Summary	Type
Example process	This is an example process to demonstrate the tool.	http://b3mn.org/stencilset/bpmn2.0#
Greet a Girl		http://b3mn.org/stencilset/bpmn2.0#
Parallel Test	This is a test process	http://b3mn.org/stencilset/bpmn2.0#

Figure 3.1: Example query result asking for all instances belonging to the category *Process* and their properties *Summary* and *Type*

Format	**Description**	**Additional parameters (usually optional)**
list	Comma-separated list, with additional outputs shown in parentheses	sep, template
ol	Ordered list, with additional outputs shown in parentheses	sep, template
ul	Bulleted list, with additional outputs shown in parentheses	sep, template
table	Tabular output	
broadtable	Tabular output, where the table is as wide as the article.	
category	List in columns, with first letters as section headers, in the style of MediaWiki category pages	sep, template, delim, userparam, columns
embedded	Embed selected articles.	embedonly (if set, don't show article link), embedformat (can be ol, ul, h1, h2 ..., h6)
template	Print results by passing result fields as parameters to a given template.	template (mandatory)
count	Just the number of results (a count of the number of matching pages), instead of the results themselves	
debug	Debugging information for analyzing problems in query answering.	
rss	Print links to RSS feeds for query results.	title, description
csv	Export result table as CSV (comma-separated values)	sep
json	Export result table in JSON format, available since SMW 1.4.2	
rdf	Export result table as RDF, available since SMW 1.5.5	syntax

Table 3.4: Default formats provided by Semantic MediaWiki. Further SMW extensions can provide additional formats. (Source[Med11a])

extensions to add additional parameters and formats. The Semantic Result Formats[4]

[4] http://www.mediawiki.org/wiki/Extension:Semantic_Result_Formats

extension for instance adds additional query formats to the basic SMW formats.

To make the formalized knowledge also available for other applications, SMW provides several export functionalities, e.g. in JavaScript Object Notation (JSON) [Cro06] and Resource Description Framework (RDF) [Bec04]. This standard formats can be used in other applications to further process the knowledge stored in SMW.

3.2 Oryx process editor

An open modeling platform for the BPM community called Oryx [DOW08a] has been originally developed by the Business Process Technology Research Group at the Hasso-Plattner-Institute, University of Potsdam. Oryx is an academic Open Source project.[5] Oryx is a web-based graphical process editor licensed under the MIT License.[6] It currently supports various modeling languages such as BPMN [BP06, BP11], Event-driven Process Chains (EPC) [NR02], Petri Nets, Workflow Nets, as well as the Unified Modeling Language (UML), and can easily be extended to handle further process modeling languages.

3.2.1 Features

Oryx is realized as a web-oriented solution and supports the following features [DOW08b]:

- **"Support for Multiple [Process] Languages"**
  Models are domain specific abstractions, which are very important in several disciplines of economics and computer science. They serve as blueprints for organizational and system design and development. Knowledge in form of ideas, decisions and operation guidelines are documented and exchanged with these models. Many modeling languages exist and even within a particular domain different notations are used.

- **"Meta-Information and Feature Extensions"**
  Models can be used as a basis to build new systems. For instance, process models can be used to encode process specification, which can be executed with a workflow engine. These models influence the system behavior of the workflow execution engine instantiating the model. Large sets of meta-information are typically required by such an execution environment (e.g., technical configurations for Web Services).

[5] The project homepage can be found at `http://oryx-project.org` and the source code is hosted as a Google code project, see `http://code.google.com/p/oryx-editor/`

[6] For further information about the MIT License see `http://www.opensource.org/licenses/mit-license.php`

- **"Data Portability"**
  Various stakeholders are involved in modeling activities such as system architects, developers, customers, and end-users. Stakeholders individually use the models for their various purposes within different tools. To support the different use cases well documented data formats have to be used.

- **"Language Support via Stencil Sets"**
  In contrast to the elements of a generic drawing tool, stencil sets additionally allows for explicit typing, connection rules between elements, and other features. Oryx current focus is on business process modeling languages, but stencil sets for other modeling languages can also be created.

- **"Feature Extensions via Plugins"**
  By providing a plugin architecture, the basic Oryx viewer can be easily extended with generic and notation specific extensions. Examples for a plugin feature are element selection and cut and paste functionality. Also more advanced plugins such as model checking can be realized.

- **"Data Portability beyond Oryx"**
  Every process model in Oryx is stored with a URI and can be accessed via this URI. The returned representation is typically displayed in Oryx, but can also be accessed and processed by other systems.

3.2.2 Implementation

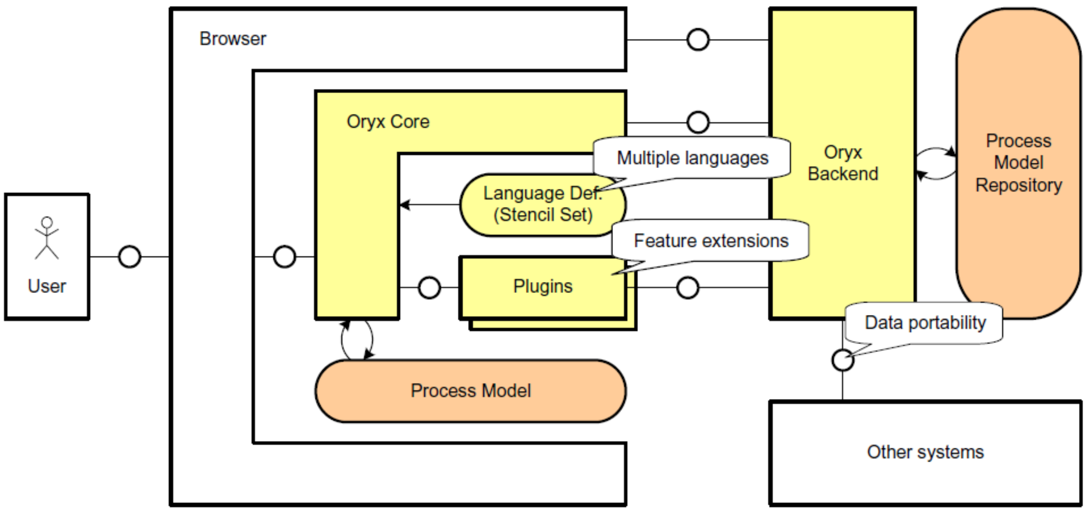


Figure 3.2: Basic Oryx architecture (Source: [DOW08a])

Oryx consists of a set of JavaScript routines. The basic architecture of Oryx is shown in Figure 3.2. Oryx can be divided into two parts, a backend repository and the graphical editor interface [DOW08a]. The Oryx backend repository is required to store and manage process models, but can be replaced (for instance within the Wikiing Pro tool, the Oryx backend repository is replaced by Semantic MediaWiki, see Section 7.3). The backend repository stores the process models and allows the user to rate, filter and select process models. A screen shot of the Oryx backend repository is shown in Figure 3.3. Miniature graphical representations of the process models as well as additional meta information are presented to the user. If a model is selected the user can choose between different formats, namely editor, SVG, PDF, PNG, JSON, Sketch and RDF.

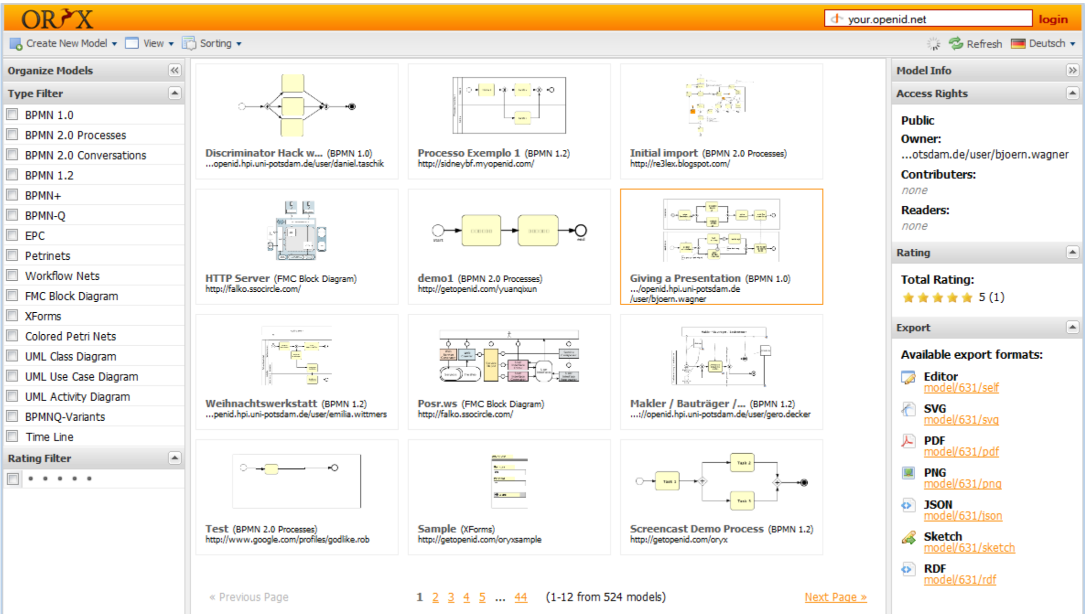


Figure 3.3: Screen shot of Oryx process repository

The repository also provides access control functionality. Models can be either public or private. If a model is private, the owner can grant read-only or contribution permission to other users. The whole access control is managed by the backend repository. To login, an OpenID[7] is required and a cookie is set by the backend repository. The model can only be accessed and stored when users have the credentials for it.

The core of Oryx is the graphical process editor. The functionality can be extended via plugins and new stencil sets can be added. A screen shot of the Oryx process editor is presented in Figure 3.4. The user interface of the Oryx process editor is

[7] http://openid.net/

structured in three regions, namely *shape repository*, *process canvas* and *property window*. The offered elements in the shape repository depend on the used modeling language. Oryx also allows extending and reducing the set of elements by defining stencil set extensions. Additional element properties can also be added to the elements. The process canvas is the area, where the process model is created. Oryx offers drag and drop functionality. Elements from the shape repository can be selected and dropped at designated location on the canvas. Oryx also offers a context menu to easier add successor elements and supports morphing of elements belonging to the same type. Each element has a set of corresponding properties, which are displayed in the property window, where the user can modify the properties. The graphical model is automatically adjusted after a user changes a property value (e.g., the color of an element).

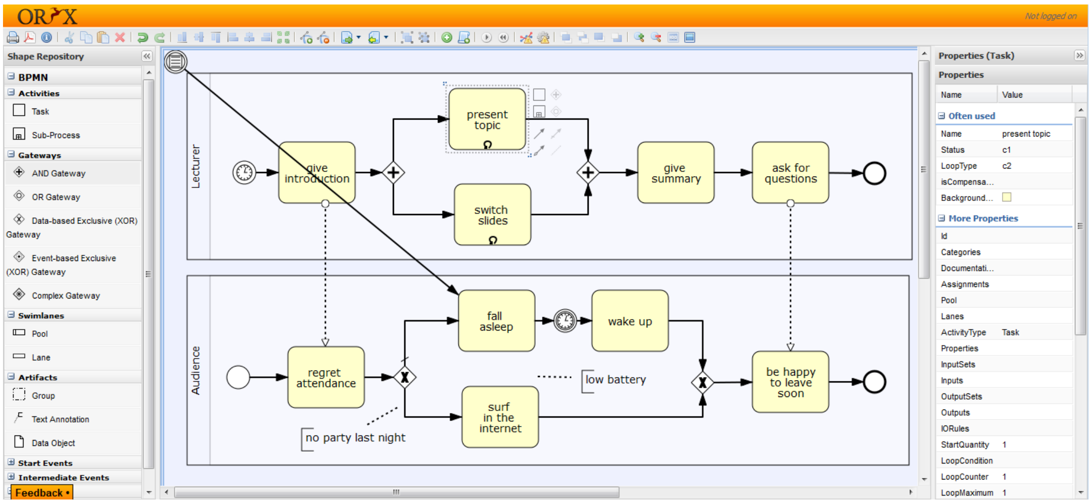


Figure 3.4: Screen shot of Oryx graphical process editor

The Oryx process editor uses the access control functionality of the backend repository and does not have its own. Only the login name is displayed by accessing the information stored in the cookie. Within the editor models can be created, modified and stored back to the repository. Models are exchanged via JSON objects between the process editor and the backend.

Chapter 4

Related work

In this chapter we elaborate on other works which are related to our approach presented in Chapter 7. As we propose a new approach for a wiki-based light-weight maturing of process descriptions, related work can be found in the area of business process management and knowledge management because we deal with informal, knowledge-intensive processes in this thesis.

While traditional BPM solutions for process modeling are mostly top-down, a new trend to bottom-up approaches can be observed. In this context Social Software, defined as software systems that support human communication and collaboration [Bä06] (e.g., forums, blogs, wikis, social bookmarking, and social networks), plays an important role. Social Software with its characteristics enables bottom-up knowledge engineering and management, which can be applied on process modeling. The top-down and bottom-up approaches for process modeling are related to the work presented in this thesis.

First, we show how our approach is related to top-down methods and tools for process modeling in Section 4.1. We discuss limitations of methods and tools dealing with routine processes and knowledge-intensive processes. In contrast to these top-down methods, Social Software can support collaborative process modeling in a bottom-up manner. Such approaches to process modeling and their current limitations are presented in Section 4.2. Wikis as an instance of Social Software are very suitable for knowledge management in particular for collaborative knowledge maturing. For this reason we analyze current wiki-based tools for process development separately in Section 4.3 and later compare them against the requirements for wiki-based maturing of process descriptions derived from literature in Section 6.4. In a next step, we analyze existing Web community solutions and browser-based commercial tools for process modeling in Section 4.4.

4.1 Traditional, top-down support for process modeling

As discussed in Section 1.1 enterprises are trying to describe their business processes in order to better understand, share, and optimize them.

Traditionally, process descriptions are developed by using well-established and widespread methods and tools, which are based on the idea of a top-down approach. Interviews and workshops are performed between process modelers or consultants and process knowledge owners (domain experts) to capture business process knowledge. In this context, various modeling methods and tools have been developed in the past such as BPMS [KJS96], ARIS [SJ02], IDEF3 [MMP+95], or CommonKADS [SAA+99]. They have evolved in different core areas of BPM (see Section 2.2.1) but also from the knowledge management field (see Section 2.4) with a focus on the knowledge created and used in processes.

Such approaches are proven as extremely useful for creating, refining, and optimizing process descriptions consisting of highly repetitive tasks, which should be standardized and automated as workflows in a centralized fashion. The resulting models serve as guidelines and rules for process executors and as the basis for standardization and automation.

The modeling of these workflow descriptions is not necessarily in the main focus of the application for our approach, which is presented in Chapter 7. Nevertheless, even in this case, we see the following potential advantages of our approach presented in Chapter 7:

- As we build our approach on the knowledge maturing process (see Section 2.4.5), which starts locally supported by lightweight technology, more stakeholders can be easily involved discussing the sequence of the process. Compared to time-consuming interview and workshop sessions, stakeholders can collaboratively bring in their process knowledge in a simple and effortless manner. If more stakeholders participate in the process modeling phase, the quality of the resulting model is perceived as higher by the stakeholders [HV04].

- The continuous, collaborative process knowledge evolution can be a very simple, yet powerful instrument to reduce the model-reality divide [SN09]. Changes in the real-world process execution can be incorporated in the process model without having to repeat the process analysis again and again. Practical experience shows that single, "one-shot" BPM/BPR projects cannot keep pace with the fast changes in the organizational work procedures, and thus the organizational benefits of business process reengineering are often very limited [LD98, EGH+10].

- The low-barrier wiki approach presented in this thesis with its discussion functionality may also be a very suitable means for the systematic collection of more and continuous improvement suggestions. Currently, the learned lessons in business process management are not collected systematically and their analysis for improvement purposes is hardly feasible or associated with expensive additional software and organizational overhead [DANT01].

An alternative method to interviews is the group storytelling approach [SBP08, GSB10, GSB11]. Individual process performers make their way of acting explicit by simply telling stories. In a second step these stories are connected and made coherent by creating abstractions, of which the process descriptions are derived [SBP08]. This basic approach has been further refined and automated for instance by applying text mining to collaboratively create stories to extract process models from text [GSB11]. A collaborative tool such as ProcessTeller supports the first phase. However, individuals tell their stories. They can only influence the model with their story and cannot comment or discuss the final process model extracted from the stories within the system. The storytelling approach is suitable for creating process descriptions in a centralized fashion, but cannot really cope with weakly-structured, frequent-changing processes, as it is too time-consuming, when stories have to be created for each change in the process.

Knowledge-intensive processes (see Section 2.6), which are typically realized through weakly-structured workflows [SAMS01] are the actual target of our approach. Methods and tools have been proposed to model knowledge-intensive processes such as PROMOTE [WK05], GPO-WM [Hei05], DECOR [Abe04], or KMDL [GMK05]. BPM and in particular the process modeling phase of BPM is extended by these approaches in different ways:

- Some of these approaches support knowledge-related process perspectives such as knowledge flows between activities or the knowledge required to perform an activity.
- Knowledge management oriented activities or sub-processes such as information retrieval tasks or sub-processes for the documentation of lessons learned are integrated in BPM.
- Knowledge creation, knowledge retrieval and knowledge transfer are described at a greater level of detail for each activity.
- Knowledge-oriented process analysis is suggested to facilitate the design of organizational knowledge infrastructures [ST05].

However, although some of these approaches significantly extend the process-modeling paradigm, they nevertheless suggest to keep a top-down, interview-based, "one-shot" process-knowledge acquisition and to use "traditional", centralized modeling tools. Although many modeling tools publish process models which are linked to other information resources on the Intranet (e.g., [HB06]), neither the decentralized collection of process knowledge, nor its evolution with light-weight, wiki-based technologies is foreseen in these scenarios. As both characteristics are required for process knowledge maturing, the development of process descriptions from informal process knowledge is not supported adequately.

4.2 Social Software for process modeling

In contrast to the top-down approaches presented in the previous section, a new research stream has evolved in the last years, combining BPM and Social Software to also support social interaction and social production within the BPM lifecycle [SN09]. Different approaches for managing processes with Social Software have been proposed [EGH+10, BDJ+11]. Some of them extend the top-down methods and tools into Social Software features, for instance they integrate social networks to support process modeling. For example, Koschmider et al. [KSR08] propose to use social network structure, which is derived from the usage behaviour of a process model repository and social networks from a recommendation history to support process modelers in creating the process description.

Other approaches in contrast use Social Software to enable bottom-up process modeling by allowing to involve nearly all users into the design phase [SN09]. For example, Rito Silva et al. propose Processpedia [RSRM11], a new knowledge creation model for BPM that combines bottom-up, Web 2.0-based knowledge management, top-down BPM paradigms and collaborative BPM modeling tools. The authors therefore apply and analyze the SECI model (see Section 2.4.2) on top-down BPM, Wikipedia as a popular instance of well-known Web 2.0-based knowledge management environment, and collaborative BPM tools. In a second step, they derive the Processpedia SECI model that integrates the SECI models for top-down BPM, Wikipedia and collaborative BPM modeling tools. The Processpedia platform combines modeling and (ad-hoc) execution of business processes at the same time and also makes tacit knowledge of users explicit while they perform their work. Unfortunately, the concept of Processpedia is only roughly described by the authors and is thus only a broader concept with no current implementation. However, the idea of Processpedia fits very well to the work presented in this thesis as the approach introduced in Chapter 7 can be seen as a step towards Processpedia.

Another approach of using groupware tools for process elicitation is described in [FBSP03]. The tool supports collaborative modeling by allowing users to model and comment process activities and by displaying modification to other users. For the graphical modeling a self-defined graphical representation is used. Although the tool displays changes in the model to the user, it does not provide the full collaboration functionality of a wiki engine such as reverting. In addition, the process models have no formal semantics and thus they are not machine-processable, which is required to allow users to search within the process description or to export in different formats.

To support workflows, Dello et al. [DNT08] have extended the Makna Semantic Wiki by integrating the workflow engine jBPM. The system approach was further extended to Process Makna [PTHL09, PZ10] to support scientific workflow execution. It enables the coordination of interactions within a wiki system, but does not support the collaborative creation of the workflow. Thus, these approaches are not further considered in this thesis.

Another approach proposes to implement a wiki with workflow management system and provides a prototypical implementation for wiki-based workflow system, allowing users to create workflows and execute them in the wiki [NE09]. In contrast to the Process Makna, the solution provides support for creating workflows collaboratively. The resulting workflow system is based on an open-source XoWiki [NS08]. A wiki workflow is defined on a single wiki page with a formal definition of a workflow containing states and actions. The workflow definition has to be coded in a predefined syntax. The workflow is visualized as a simple workflow graph via Graphviz[1] and can be executed within the wiki. For each instantiation of the workflow a new instance page is created that refers to the workflow definition page. Although this solution offers support for the collaborative creation of workflow definitions, users have to learn an extra syntax in addition to the wiki syntax. Furthermore, support for workflows, which are executed outside the wiki, is not foreseen. These limitations do not allow an efficient process knowledge maturing as most real enterprise processes cannot be executed within a wiki. As a result, this approach is not further considered in this work.

In the following section we further elaborate on wiki-based bottom-up tool, which supports process knowledge maturing within a wiki.

4.3 Wiki-based tool support

We conducted an intensive literature review, where we looked for wiki-based solutions designed to develop process descriptions and found four wiki-based tools, which are related to the work in this thesis. In contrast to the wiki-based tools presented in the prvious section, they all can be used for collaborative wiki-based maturing of process descriptions. Unfortunately, demos are not available for all tools in the Web. In the following we briefly describe each tool.

[1]Graphviz is open source graph visualization software, see http://www.graphviz.org

4.3.1 SMW+BPEL

The approach for semantic wiki aided business process specification was developed by Hussain et al. [HBV09]. The tool is based on Semantic MediaWiki (SMW) [KVV+07], which enhances the MediaWiki software with semantics (see Section 3.1), and is designed to collaboratively model business applications. Enterprise knowledge workers, in particular business domain experts and business analysts, are assisted in capturing the requirements of a business application and later translating these requirements into executable BPEL [OAS07] code. The authors therefore propose a modeling method including the following four steps:

1. System requirements are described by the business domain experts in natural language. The textual descriptions are further enhanced with semantic annotations by the business analysts.
2. The structured descriptions capturing knowledge about processes, instances and relationships are exported via RDF [Bec04] and translated into BPEL using an RDF to BPEL translator developed by the authors.
3. The complete system is defined by linking the inherent relationships and processes from the BPEL files together.
4. The generated BPEL can be visualized in a graphical modeling tool to validate it. Finally the BPEL descriptions are passed to a BPEL engine such as Microsoft BizTalk Server for creating the interface definition code.

The tool uses the functionality provided by SMW to collaboratively gather the requirements, semantically annotate them and export them as RDF. The BPEL descriptions are created from the exported RDF files with help of a self-developed translator, which parses the RDF and transforms it into BPEL. A separate process modeling tool has to be used to validate the resulting BPEL code.

While the system allows domain experts to use natural language for modeling process descriptions, it does not support graphical editing within the wiki. The approach was developed to create fully-structured process descriptions, which can be executed in a BPEL execution engine. Process descriptions consisting of textual and graphical elements as described in the following chapter in Section 5.1.4 and Section 5.2.4 cannot be modeled due to the missing graphical editing functionality. Unfortunately, neither a demo nor the system itself are available in the Web. As the approach is based on SMW and BPEL, we refer to it as *SMW+BPEL* in the following.

4.3.2 MRM wiki

Another wiki-based system was developed by Fellmann et al. [FTD10] to overcome the limitations of current approaches when capturing relationships between models such as hierarchical decompositions and complex semantic relations between multiple modeling tools. While the knowledge about semantic model relations is only available in the heads of employees as tacit knowledge within traditional approaches, it is made explicit with this wiki-based solution.

A prototypical implementation for the management of model relations also uses a semantic wiki as a baseline technology. The authors compared various semantic wikis against derived requirements for documenting models and managing the model relations. In addition, a metadata ontology was developed, which provides a structure for the management of model relationships specifying how semantic data for representing model relationships have to be structured.

The different process models, stored in the Model Relations Management Wiki (MRM wiki), can be described and linked by using this metadata ontology. Keyword and facet search are offered to the users to retrieve and prune the relevant models. The relation types are presented as links, which enables the user to easily navigate from one model to another. As a result, the use of the ontology improves navigation and model retrieval. For instance, affected models can be detected manually by simply following the relationship links, when a model is changed.

Process models are only represented as a single wiki page, which does not allow to further describe single process elements of the model. As a result, process descriptions consisting of textual and graphical elements as described in the following chapter in Section 5.1.4 and Section 5.2.4 cannot be captured.

A demo is also not available on the Web. The presented prototypical implementation does not support graphical editing of process models, although the authors suggest that wikis could be used to document the design rationals of the developed models. The authors also plan to develop a new prototype combining Microsoft Visio and the semantic wiki *Makna*, but currently this new prototype is not available.

4.3.3 KnowWE extension

A wiki-based approach for modeling knowledge about diagnostic guidelines was developed by Hatko et al. [HRBP10]. They have extended the semantic wiki *KnowWE* to enable users to model clinical diagnostic protocols. The KnowWE extension[2] integrates an AJAX-based editor for DiaFlux into the semantic wiki KnowWE. DiaFlux is a knowledge representation for clinical protocols developed by the authors for domain specialists to intuitively model executable protocols.

The graphical DiaFlux model provides seven different elements, namely *start*, *test*, *solution*, *wait*, *composed*, *exit*, and *comment*. These elements are visualized as nodes, which can be linked with flow representations in form of edges. Nodes represent

[2] A KnowWe extension demo can be accessed via http://knowwedemo.informatik.uni-wuerzburg.de/

actions, while edges describe the sequence of the execution of these actions. Corresponding wiki pages are not created for any graphical element.

The created DiaFlux model is encoded in XML and integrated in a wiki page. In addition, users can further describe the protocols by using natural language. For a better usability, the stored XML code is parsed and rendered as a graphical model in the Web browser.

The concepts already existing in the wiki can be reused in the DiaFlux editor by dragging them into the flowchart. A wizard within the editor can be used to create new concepts. As the wiki offers versioning functionality, users can access previous revisions of a model and the corresponding textual descriptions.

The authors additionally propose to use the idea of the knowledge formalization continuum [BRP09] for developing models with the KnowWE extension. The use of such a methodology of gradual refinements is expected to lower the entry barrier for domain specialists. In a first step informal knowledge about the clinical protocol can be gathered in wiki pages, which can be further refined by adding a semi-formal flowchart containing only comment, start, and exit nodes connected through edges. These semi-formal models can be executed manually for testing purposes within the system. Finally the models have to be further formalized in a full DiaFlux model, which can be automatically executed.

Discussion functionality is not available. Consequently, users are not able to discuss changes in the clinical protocol within the wiki and design rationals resulting from these changes remain undocumented.

A demo of the system where users can develop clinical protocols is available on the Web. It supports the simple, collaborative development of declarative and procedural diagnostic knowledge required for modeling executable clinical protocols. Although these protocols can be seen as a process flow, the modeling of business process descriptions is not supported by the extension. The underlying schema is limited and does not allow to model process elements such as gateways. As no corresponding wiki page is created for a graphical element, users cannot add textual descriptions to each element to describe a single clinical protocol step in more detail. Also users are not able to browse through the clinical protocols.

4.3.4 BP-MoKi

Another wiki based tool supporting the collaborative development of process descriptions is BP-MoKi [FGR+11]. It is a further development of MoKi – the enterprise modeling wiki [GKL+09, GRS10a, GRS10b].

MoKi [GKL+09, GRP09] (**Mo**deling Wi**Ki**) was created to access and develop enterprise models describing the domain, processes and competencies of an enterprise. Typically different skills are required to build an enterprise model ranging from knowing the different aspects, encoding the knowledge into formal statements and integrating these aspects into a coherent model. Consequently, the focus of MoKi was on collaborative modeling support to capture all the relevant aspects of an enterprise.

The tool[3] provides integrated modeling support for enterprise models. The domain and the competencies of an enterprise are modeled as ontologies, and each concept and instance are represented as a wiki page. To hide the formal structure from the users, the formal semantic annotations are created within templates provided by MediaWiki (see also Section 3.1.1). Additionally, the Semantic Forms extension[4] is used for a better usability enabling the users to add and edit predefined data structures using forms within SMW.

A process can be modeled with basic elements, namely *tasks*, *sequence flows*, *start events*, and *end events*, in a simple visual editor based on Java Script. The process model is stored in a XML serialization format within a process wiki page. Additionally, a wiki page and a subprocess property are created for each task element. The visual editor does not allow to navigate through the process, as the graphical elements are not linked to the corresponding wiki pages. The versioning functionality can only be used to revert to previous versions, but does not allow to compare different versions of the process model. Only the XML serializations of the corresponding versions can be compared. The sequence flow is not translated into semantic annotations. Consequently, the SMW query language can only be used to access ontology elements and subprocess and description relations, but not the process flow.

The tool also offers import and export functionality. Ontologies stored in OWL and structured lists of domain concepts can be imported. The structured knowledge stored in MoKi can be exported in two ways. While a specific OWL format[5] is used for ontologies, processes are exported in a BPMN serialization as an eRDF file, which can be opened with the Oryx Process Editor (see Section 3.2).

A newer version of the tool[6] [GRS10a, GRS10b] facilitates modeling at different levels of formality, namely informal, semi-formal, and formal. Therefore, each wiki page is composed of an unstructured and structured part. While the unstructured part contains text formatted in the MediaWiki syntax and is the same for all types of models, the structured part is either a RDF/XML serialization for ontology elements or a Oryx JSON object describing the process model.

The users can access the ontological and procedural knowledge stored within MoKi in three different ways, namely unstructured, lightly-structured and fully-structured. The standard MediaWiki interface is used to view and edit text in the unstructured access mode while hiding the structured part from the user. For the

[3]The demo of the first version can be accessed via `https://moki.fbk.eu/moki/tryitout/index.php/Main_Page`

[4]For more details see `http://www.mediawiki.org/wiki/Extension:Semantic_Forms`

[5]A detailed description of the OWL format can be found in [GRP09]

[6]A demo of the extended version can be accessed via `https://moki.fbk.eu/moki/tryitout2.0/index.php/Main_Page` – note that this demo does not include the BP-extension

lightly-structured and fully-structured access modes, form-based viewing and editing are used for ontology elements. The Oryx process editor [DOW08a] (see Section 3.2) is tightly integrated to provide viewing and editing functionality for process models.

The processes are modeled in BPMN. While the full expressivity of BPMN 1.2 is supported in the fully-structured access mode, only a subset of BPMN elements are used in the lightly-structured access mode, namely *task*, *sequence flow*, *general gateway start event*, and *end event*. The process can be modeled in both access modes. A change in the lightly-structured model is updated in the fully-structured model and the other way round. Within the graphical representation hyperlinks cannot be created to the corresponding process element wiki pages. Consequently, users cannot browse through the process wiki pages by simply clicking on a process element. The wiki pages representing a process element can only be accessed via the *list all processes* summary page, where all processes and their process elements are displayed in a table. This can be very exhausting in the case that a user wants to get a complete overview of the process including graphical (structured) and textual (unstructured) descriptions. The versioning functionality provided by SMW does also not allow to compare the different versions of a process as in the previous version of MoKi. As only the subprocess relation is translated into SMW properties, the remaining structured knowledge cannot be queried with the ASK query language available within SMW.

A further version called BP-MoKi [FGR+11], which also combines and extends SMW and Oryx, focuses on modeling business processes. According to the authors, it can be used to model and semantically annotate business processes, to create and edit ontologies, define constraints, and to export and validate process models. Unfortunately, a demo is currently not available on the Web.

The structured process descriptions in form of graphical objects and natural language structured with predefined templates including semantic annotations are automatically translated into the Business Process Knowledge Base (BPKB) [DFGR+08] containing a BPMN Ontology (BPMNO), Business Domain Ontology (BDO), merging axioms, and Business Process Diagram (BPD) instances, which can be instances of the BPMNO and BDO. Each BPD element is an instantiation of an BPMNO element that can also be an instance of a BDO ontology. While elements of BPO can be added, deleted, and refined within BP-MoKi, the BPMNO cannot be modified within the tool.

A wiki page is created for each process element, where semantic annotations to concepts taken from the BDO can be added via predefined forms. Annotation constraints can be defined via predefined forms on the wiki pages describing the concepts of the BPMNO and BDO. Structural constraints are defined on separate pages in a similar manner.

The tool also provides validation support in order to check the correctness of semantic annotations of the business processes and to verify the satisfiability of the defined constraints with an integrated Java tool based on Jena [7] and Pellet[8]. When unsatisfiable classes are detected, the authors suggest to use explanation techniques as described in [HPS08] to provide business experts with justifications but this feature is planned as future work.

In summary, BP-MoKi supports the collaborative development with a focus on the outcome of a fully-structured process description stored in their BPKB. Hence, structured predefined templates, where semantic annotations are incorporated, are always used on wiki pages. For a better usability, the templates are hidden and only editing forms are shown to the users. Process elements can only be annotated with concepts that are previous created in the BDO. Simple semantic annotations expressed with SMW property syntax are not considered, because they are not translated and added into the BPKB. BP-MoKi basically supports capturing of informal process knowledge as described in Section 2.8, but it was not designed to automatically translate existing textual process descriptions into graphical representations. Consequently, users always have to start graphical process descriptions from scratch, even if textual descriptions already exist.

As hyperlinks to the corresponding wiki pages are not integrated into the graphical representation of the process elements, it is not possible to easily browse and navigate through the unstructured and structured process descriptions. Process descriptions having textual and graphical elements as described in the following chapter in Section 5.1.4 and Section 5.2.4 can be modeled, but the internalization of the process knowledge, made explicit in these descriptions, is difficult, because the users cannot directly browse through the process descriptions.

4.3.5 Summary

The wiki-based tools presented in this section support the collaborative development of process descriptions in different ways. The first two tools, namely SMW+BPEL and MRM wiki, use semantic annotations to specify process relations between process elements, as well as relations between process models, but do not allow users to edit graphical process descriptions. The tools supporting graphical editing of process descriptions have other limitations such as the discussion functionality and process modeling support in the case of KnowWE extension. In the case of BP-MoKi existing textual descriptions are not reused for the graphical model.

Although all tools offer support for maturing process descriptions, they cannot efficiently cope with hybrid process descriptions. The four tools were developed to

[7]Jena is a open-source Java framework for building Semantic Web applications, see `http://jena.sourceforge.net/`

[8]Pellet is a OWL2 Reasoner for Java, see `http://clarkparsia.com/pellet/`

generate a fully-structured process descriptions and relations between process models. The created BPEL models should be passed to an execution engine and the formalization of the model relations should help to detect dependencies. The clinical protocols should be automatically executed in the end and business processes should be fully annotated with semantics to improve the level of automation. Nevertheless, the support for the development and reuse of less structured process descriptions is not sufficient, because the tools do not provide adequate functionality that users can internalize the stored process knowledge.

To further illustrate the limitations of these tools, we derive requirements for wiki-based light-weight maturing of process descriptions in Chapter 6 and compare the tools against these requirements in Section 6.4.

4.4 Community and commercial solutions

In the last few years, different Web communities evolved with focus on collaborative business process modeling solutions. Oryx [DOW08a], which is an open source modeling platform for the BPM community (see Section 3.2), is one of the most prominent examples in this context. Another open-source project is Activiti[9], a light-weight workflow and Business Process Management (BPM) Platform, which is based on the Oryx process modeler and the BPMN 2 process engine for Java. Both solutions allow for collaborative modeling but also require process modeling expertise as novice users cannot model unknown constructs via natural language.

In contrast to these open source community projects, the BPMN-Community[10] is an open platform that people can use for collaborative process modeling. The platform integrates social software approaches such as forums, tagging, rating, and commenting within the Oryx process editor. The platform is structured similarly to a forum. It starts with the forum topics, which are called projects. Each project can have threads that are displayed on the project summary page in addition to a textual description. A thread contains a process model and text. Users can rate and comment each thread and can compare different versions of the process model. In addition, users can comment upon single process elements in the process diagram. However, the comments are not accessible from the process model edit mode. Although many Social Software features are integrated within the platform, users cannot link between different elements such as process models and single process elements. In addition, users can only add natural language on the process summary page.

In all these community solutions, only predefined process properties can be used to further formalize processes. Users can only model properties provided by the modeling tool. Since the flow structure is only stored in the process diagram and

[9] http://www.activiti.org/
[10] http://www.bpmn-community.org/

not as semantic descriptions, the search is rather limited compared to our approach presented in Chapter 7.

Vendors of BPM solutions have also started to support collaborative business process modeling with browser-accessible solutions. In the following we introduce three browser-based examples and show these limitations compared to our approach presented in Chapter 7:

- ARISalign[11] integrates social network functionality and real-time collaborative process modeling. Therefore, it uses a whiteboard in combination with a graphical process editor. Users can brainstorm about process stages and activities in the whiteboard window and model the process later in the editor. Activities from the whiteboard can be incorporated in the process model by using drag and drop. Users can collaboratively edit process models and can discuss them. The tool provides a news feed about recent changes. However, different version of the process model cannot be viewed or compared. The whiteboard functionality allows novice users to easily contribute, but the tool is not built to handle large textual descriptions.

- IBM Blueworks Live[12] also integrates social network functionality with process modeling. A discovery map similar to the whiteboard in ARISalign is used to create a process outline consisting of milestones and activities. These are automatically translated into a process diagram, which can be further refined in a graphical editor. Users can comment each process and activity individually. The platform offers three different views on the process, namely a light-weight discovery map, a process diagram, and a textual documentation view. Textual descriptions can be used to add new information to an element. However, the focus is also only on the collaborative development of the process model and different versions cannot compared. Only a list of recent changes is provided. Textual process descriptions already existing in enterprises are not considered. Only existing graphical process descriptions modeled in BPMN or with Visio can be imported into the tool.

- A process diagram modeling plugin[13] for the confluence wiki[14] enables users to draw process models and save them in the wiki. However, the process models are stored as pictures, which do not allow further interaction in form of browsing and searching.

[11] http://www.arisalign.com/
[12] https://www.blueworkslive.com
[13] http://www.gliffy.com/products/confluence-plugin/
[14] The confluence wiki is an enterprise collaboration software, see http://www.atlassian.com/software/confluence/

The commercial solutions discussed above do not automatically reuse existing textual descriptions and transform them into graphical representation and formal semantic annotations. Furthermore, only predefined process properties can be used to further formalize processes. If a property is not included in the process modeling language, it cannot be used. All tools only store the process flow in the process diagram and not as semantic descriptions. As a result the process search is rather limited compared to the approach presented in this thesis.

Part II

Wiki-based light-weight maturing of process descriptions

Chapter 5

Scenarios

As stated in the introduction in Chapter 1, most of the process knowledge gathered through the execution of new tasks remains in people's heads. Most of this tacit knowledge has to be made explicit in informal or formal process descriptions, so that the processes can be shared, reused, and collaboratively improved. After having shown the scientific foundations in Chapter 2 and the related work including wiki-based approach in Chapter 4, we further motivate our work by showing how enterprises deal with tacit process knowledge and that these enterprises lack adequate solutions to make this process knowledge explicit.

In this chapter, we describe the current process modeling situation in two small and medium enterprises (SMEs) and illustrate that current methodology descriptions in a large consulting company can also be categorized as documentations of knowledge-intensive informal processes. In Section 5.1 we show how BPM is currently applied in two SMEs. In the second part of this chapter, we look at existing informal processes, namely methods, from a large consultancy company in Section 5.2. Finally, we summarize our findings in Section 5.3.

Part of this chapter are based on [BDJ+11, DV11, KES+11].

5.1 BPM at SMEs

SMEs have an enormous urge to grow, but they are also under increasing pressure due to a global competitive environment [Uni06]. The growth and profit performance of an SME can be measured among other things by financial outcomes, sales or market grows, and customer satisfaction [DSS93]. While financial outcome and customer satisfaction is directly connected to the efficiency of the processes within the company, an SME can grow either by investing in new products and in product improvements or by improving internal organizational processes, which increase operational efficiency [WP06]. Additional resources can be added or existing resources can be used more efficiently.

The constantly changing business requirements and challenges such as decreasing product life cycles and increasing cost pressure force companies to improve their processes [Neu09]. Consequently, small and medium enterprises have started to adopt

Business Process Management (BPM) in order to keep pace with fast changing markets.

Especially, certifications for quality management standards, like ISO 9000,[1] which is one of the most popular quality certifications [TSD97], demand for documented processes. The motivation for these certificates can arise in the presence of regulatory or procurement requirements from other companies for goods and services [ADJ99]. Consequently, SMEs have started documenting their processes as part of BPM activities. Processes required by regulations are created and introduced. In addition, SMEs capture the tacit process knowledge that evolves from their daily work by making it explicit in process descriptions.

In this section, we therefore analyze and document the characteristics of SMEs in Section 5.1.1 and show that SMEs need a minimalistic, agile BPM approach due to their specific characteristics. We further describe an agile BPM for SMEs in Section 5.1.2 and depict some example scenarios in Section 5.1.3. We close this section by studying existing process descriptions from the innovation and business development department of an SME in Section 5.1.4.

5.1.1 Characteristics of SMEs

SMEs are defined according to the European Commission [Com03] as companies, where less than 250 persons are employed and the annual turnover is lower than 50 million Euros and/or the annual balance sheet total does not exceed 43 million Euros.

SMEs have special characteristics, which differ from the ones of larger companies. According to Hoyer and Christ [HC07] these characteristics are:

- **"Specialization and Individuality"**
  SMEs are characterized by a high individuality and specialization. They often act in niches, which are not covered by larger companies.

- **"Proximity to markets"**
  In contrast to large companies, SMEs always provide services that are oriented at the need of their customers instead of focusing on exchangable products or on anonymous markets. Their strong focus on their end users allows a high proximity to markets.

- **"Flexibility"**
  SMEs are more flexible than larger firms. They can make faster decisions and changes in organizational structures, because they have flat hierarchies and simple decision processes.

[1] http://www.iso.org/iso/iso_catalogue/management_and_leadership_standards/quality_management.htm

- **"Limited resources"**
  As every company, SMEs have limited resources, especially missing financial resources. In addition, the employees do not have all the required know-how, which can be somehow compensated with foundational knowledge of the employees in many areas.

- **"Technical heterogeneity"**
  Many different IT systems are often used within a small company due to the lack of a coherent IT strategy. Standard office tools are often used for various tasks.

- **"Globalization"**
  SMEs are under enormous pressure due to internationalizations of markets. Previously existing market barriers have been abolished. This can be a chance but can also foster a more competitive environment.

These characteristics illustrate that SMEs are more customer-oriented, flexible, and agile than larger companies, which are beneficial for the introduction of BPM. But they also have other characteristics, such as, limited resources, the technical heterogeneity due to the lack of a coherent IT strategy, and the enormous pressure due to the globalization, which complicate the introduction of new solutions such as BPM solutions. Kirchmer [Kir05, Kir09] substantiate the following characteristics of SMEs causing challenges for the application of BPM solutions:

- **"Cost pressure"**
  Costs play a very important role in SMEs as the money was either provided by the owners or by third parties, which want to achieve a proper return on investment. Projects with high costs are an enormous risk for SMEs. Although the benefit of an investment is identified, SMEs often do not have the money for it. As a result, BPM solutions can be seen as beneficial, but SMEs are not able to afford them.

- **"Human resource capacity"**
  Employees with expert skill in BPM are not available in the majority of the cases. Thus companies often lack the skills required to start and manage the organization based on the principles of BPM. While larger organizations can employ an adequate number of business analysts, SMEs are normally not able to hire process modeling experts due to limited human resource capacity.

- **"Time pressure"**
  Projects in SMEs are under a tremendous time pressure, because they cannot be staffed over a long time period. SMEs only have a small number of employees

and cannot afford to hire additional people for specific projects. Often, project team members are only available on a part-time basis for the project.

- **"Multiple roles of employees"**
  Employees usually have multiple roles within an SME. They are responsible for various tasks, requiring different expertise. This situation consequently requires a BPM implementation that is well integrated with the other multiple tasks of SME employees.

- **"Skill level of employees"**
  The employees of an SME are normally more "all-rounders" than specialists. SMEs often cannot afford to hire new employees with specific expertise.

Consequently, SMEs have to get out the maximum benefit and productivity from their employees due to the limited human resource capacity [WP06]. While all these characteristics challenge the roll out of BPM approaches, there are also characteristics of SMEs, that simplify the introduction of BPM solutions [Kir05, Kir09]:

- **"Fast decision making"**
  SMEs typically have small hierarchies. Even if the owner of the company does not decide himself or herself, the number of involved people is lower than in large companies, which makes the decision process faster.

- **"Integration of activities"**
  BPM initiatives can also benefit from the multiple roles of employees. Due to their involvement in various tasks, they know how things fit together. Compared to larger organizations, where employees are often responsible for a single task, the multiple roles of employees are very helpful for designing process descriptions.

- **"Employee work ethic"**
  The employees in an SME typically work result-oriented. They are used to work quickly and efficiently to be successful, which simplifies the application of a BPM solution

Taking all the above characteristics into account, which cause challenges for the application of a BPM solution, SMEs need a cheap BPM approach, which can be integrated within the multiple tasks environment and the existing IT infrastructure. In addition, novices in BPM should be able to work with the solution. Consequently, SMEs require a consolidated, agile BPM approach integrating all employees to quickly react on changes in their markets.

5.1.2 Requirements for agile BPM in SMEs

SMEs are usually built on unique and innovative business ideas. In contrast to larger companies, SMEs must be faster and more agile to survive, because they do not have any significant economy of scale [Kir09]. This need for agility also affects the way how BPM has to be performed within an SME. The flexibility of SMEs can cause radical changes in the daily work of an employee. Tasks can be added, changed or removed overnight due to shifts of business strategies. As a result, the process descriptions often do not describe the executed processes in practice. There is a model-reality divide [SN09]. An agile BPM approach [BDJ+11], which is capable to react quickly to internal and external changes, is required to support such an agile enterprise [Cum08].

The traditional BPM lifecycle approach presented in Section 2.2.2 is based on assumption that interactions follow ordered steps and use more or less predefined information flows, which only allow few modifications [BDJ+11]. The BPM lifecycle is divided in procedures often exclusively assigned to a single stakeholder [BDJ+11]. Only the stakeholders predefined by the BPM lifecycle are allowed to contribute, which can cause a multitude of communication bottlenecks [MH06].

Therefore, the BPM lifecycle has to become agile as presented in Section 2.2.2. Organizational barriers, excluding stakeholders from contributing to the requirement elicitation process, have to be eliminated through organizational integration. An agile BPM is required to include all stakeholders in the modeling process. Nobody should be excluded because of his process modeling skills or the organizational unit, he belongs to.

A common understanding of terms and their relations is also important to rapidly react to changes. Misunderstandings can prolong the process definition phase, which can be avoided with a common terminology. Especially, when external consultants are involved in the modeling process, the terminology of the consultants can be imposed on the employees of the SME. Consequently, all stakeholders should be involved in defining a common language. An agile BPM for SMEs needs semantic integration through the definition of a common language.

Finally, barriers created by the management processes of business processes such as an inappropriate support of information and knowledge sharing within the BPM lifecycle have to be eliminated by implementing a responsiveness BPM. A responsiveness BPM requires flexible BPM processes and information flows in order to quickly react to internal and external events [BDJ+11]. While classical BPM lifecycles only support a top-down flow of information, agile BPM also requires a bottom-up flow of information in near real time [BDJ+11]. Changes in process execution, which often happen in SMEs, have to be directly reflected in the corresponding process model to eliminate the model-reality divide [SN09].

5.1.3 Example scenarios at a SME

Although SMEs have adopted BPM, often dedicated BPM departments, responsible for capturing, documenting, managing and improving processes in the company, do not exist. Typically, processes have been captured and documented by external consultants, being experts in BPM. Also employees have started to capture and document their daily processes on their own. In this section, we present two different scenarios at two SMEs, namely innovation and development processes at company A and business design processes at company B, which we explain in the following.

Innovation and development processes in the engineering company A can be seen as example scenarios for process modeling within an SME. Many departments are involved such as sales, development, controlling, assembly, and quality control that need to be coordinated for each customer product. In order to comply with ISO regulations, all activities required to produce the product in mass production have to be captured and documented. As soon as there is a customer demand for a new engineering product, company A must start the development process. Blueprints of the new engineering product are created and aligned with the customer. After the customer places the order, the different departments have to enter the data (e.g. SAP task lists, quality control plan, evaluation category, etc) into their systems. An initial sample is produced. If the sample is approved by the customer mass production can begin.

Within company A these processes are typically documented by the involved employees using standard office software such as Microsoft Word, Excel and Visio, which do not support process modeling to full capacity. The thus created models are then further refined and formalized by the quality department to fit the certification requirements. The design rationals are often lost during this translation into formal process models and the processes are only documented in the beginning. Changes in the real processes that have emerged during executions are not adjusted in the model, which result in a model-reality divide [SN09]. This issue especially comes up, when ISO recertifications are under consideration.

Another example is the **business design process**, implementing guidelines for creating new businesses, at company B. It can be seen as a method consisting of three stages for selecting promising new ideas and business opportunities such as new products within company B. In the first stage, the different ideas are refined during an iterative process and required documents such as idea paper, planning paper, and business plan are created. Three predefined milestones at the end of each step are used to decide about the potential of the ideas. If an idea is rejected, it will not further be elaborated. Within the second stage a new business unit is established responsible for maturing the product to bring it to the market. This stage is also divided in three steps, in which different documents such as prototype description, marketing and sales description, and advanced business plan are created. In the third stage the expansion of the new business unit takes place. The business design process is highly knowledge-intensive. The high level process stages and steps are the same, but for each new idea, the process has to be adapted.

5.1.4 Existing process descriptions within a SME

We performed our process analysis in the innovation and business development division of company B, an SME IT company with international subsidiaries. The company has approximately 240 employees all over the world. The innovation and business development division comprises two departments, namely *administration* and *research management*. Currently, 11 employees are working in the research management department. Among other things, the department is responsible for acquiring and managing national and European funded research projects. Hence, guidelines in form of a PDF document have been developed for the research management department. All employees of the department have contributed to these guidelines.

The guideline document for national and European research projects contains the mission statement, the division structure and instructions for project execution. In the following we describe the different sections in detail.

Within the **mission statement** section the responsibilities within the company and the strategic goals of the division are described by using natural language. For a better overview, the goals and responsibilities are formatted as bullet items. Graphics are not used within this section.

The **division structure** is described in the second section of the document. The section contains a graphic showing the division structure and their interaction with other divisions. The responsibilities of the division are stated as bullet items, again. High-level task descriptions are also included for each department. The task descriptions are also formatted as bullet items including optional sub items for more detailed descriptions.

The **project execution instructions** are included in the last section of the document. First, the different existing national and European sponsors are mentioned in a table. In a second table, the in-house classification of the five strategic project types (e.g. national founded or European founded) and the involved tasks are described in natural language. The two project roles (participant or coordinator) and their tasks are also introduced in another table. A graphical overview of the project phases is given in the second part of the section. Each step is further described with natural language formatted as bullet items. Eventually, three project workflow descriptions and corresponding document workflow descriptions complete the document.

Graphical representations of processes are used within the guideline document. The task and the dependencies of the different project phases are illustrated with four graphical representations in combination with complemented textual descriptions.

The graphics contain 19 process elements in average, including boxes for the phases, milestones, related roles and resources. Each phase is also described with natural language mostly formatted as bullet items. Each phase has at least 2 items.

The three project workflow diagrams make use of four element types, namely appointment, document, task and sequence flow. In average 6.7 elements are used in a project workflow diagram. In total 10 appointment elements, 7 document elements and 3 task elements are used in the 3 diagrams. The size of element labels varies between one word and several bullet items.

The corresponding document workflow diagrams also include pool elements to assign responsible roles. In average 22 elements are used and 3 roles are assigned (3 pools are used) in each diagram. In total, 8 applications elements, 3 task elements and 21 document elements are used in the 3 diagrams. The size of the element labels also varies between one word and several bullet items.

Some process models include pools assigning a task to the responsible department, but pools are not used according to the BPMN standard, because tasks are placed directly on the lines of two or more pools. The modelers wanted to express that both departments or both roles have to contribute to that specific task.

In summary, the processes are made explicit as either full textual descriptions or a mixture of graphical and textual descriptions. The level of detail also varies between the different graphical and textual process descriptions and also between the elements used within process descriptions.

5.2 Existing informal process descriptions at a larger organization

In contrast to BPM at SMEs, described in the previous section, most larger organizations have fully implemented BPM over the last years, by founding dedicated departments, staffed with BPM experts. Most of the business processes, which can be automated, have been formalized by these experts, like the procurement process, travel expense process, etc. However, there are also many informal knowledge-intensive processes, which cannot be easily formalized and automated. People engaged in these informal knowledge-intensive processes have to be managed differently. Changes, learning, collaboration, and innovation have to be supported by the management and organizational barriers have to be reduced [BJM06] in order to provide better support for informal knowledge-intensive processes.

In this section, we therefore describe the characteristics of larger consulting companies in Section 5.2.1 and show that larger consulting organizations require an agile BPM in Section 5.2.2. We further illustrate that the proposal development process is a knowledge-intensive, informal process (Section 5.2.3). Finally, we analyze existing informal process descriptions at company C in Section 5.2.4.

5.2.1 Characteristics of larger consulting organization

Larger consulting organizations have developed internal methods used by consultants in tackling a particular problem, challenge, or client engagement. These methods exist in a large number and provide a structured approach to solve specific problems. Werr and Stjernberg [WS03] analyzed the knowledge system in consulting organizations, consisting among other things of these methods. To support the consultants with a common language and structure, the methods provide models, templates and checklists. According to Werr and Stjernberg [WS03] the consultants do not rigidly adhere to these methods, but see them as an enabler of the communication between project groups that include senior and junior consultants. The improvement of communication can be exemplified when a senior consultant explains to less experienced colleague what to do by referring to a corresponding method. Although the methods are used by junior consultants as direct guides for actions, they serve as a common framework and terminology for all consultants. Exchange of experience, which is either tacit in individual heads or explicit in documents, between different projects is improved by using the common framework and terminology provided by the methods. The methods are derived from best practice (e.g., previous or ongoing projects) and continuously updated by expert groups and all consultants have to be familiar with them. While mandatory training courses are offered to newcomers, experienced consultants have to stay updated.

The application of such methods by consultants can be seen as an execution of informal knowledge-intensive processes, which are described in Section 2.8. However, the available follow-up actions are somehow limited by the methods, but also depend on the expertise and knowledge of the consultants and their interpretation.

5.2.2 Requirements for agile BPM in large consulting organizations

The larger consulting companies have to become more flexible in supporting these informal, knowledge-intensive processes (see Section 2.8), which also requires a more agile BPM as presented for SMEs in Section 5.1.2.

The flexibility of the knowledge-intensive work can demand for the adjustment of the provided models, templates and checklists. Tasks described within the methods can be added, changed or removed. As a result, the descriptions often do not describe the executed methods in practice. There is a model-reality divide [SN09]. An agile BPM approach [BDJ+11], which is capable to react quickly to internal and external changes, is required to support such informal, knowledge-intensive work.

Therefore, the BPM lifecycle has to become agile. In an agile consulting company, all consultants are able to contribute with their knowledge to the creation of the consultancy methods. A common understanding of terms and their relations is also important to rapidly react to changes. Misunderstandings can prolong the process definition phase, which can be avoided with a common terminology. Especially, when external units create the method descriptions, the terminology of the external unit can be imposed on the consultants. Consequently, consultants working with the methods in practice should be involved in defining a common language.

5.2.3 Example scenario at a consulting company

A proposal created by a consulting company as a response to a Request for Proposal (RfP) from another company can be seen as a result of knowledge-intensive, informal processes, collaboratively performed by a proposal team. Typically, there is one proposal manager who is responsible for the proposal. He initializes the proposal development process and selects the proposal team. Depending on the complexity and the time constraints of a proposal many people with different expertise and roles are involved in the proposal development. The proposal team consists of knowledge workers with various skills, experience and knowledge relevant for the proposal. As proposals cannot easily be copied, the development processes can also deviate from each other.

A proposal is a description of the products and services delivered by the company at an estimated cost to a potential customer. It is a knowledge product and includes various types of information [Fre01] (e.g., marketing, programmatic, technical, institutional, pricing and certification information) provided by various enterprise departments such as technical consultants, product specialists and sales persons. It is an agile process [And03] typically including activities such as *selecting the proposal team*, *gathering information about the customer*, *discussing customer issues and possible solutions*, and *getting approval for pricing*. As a result, most activities, in which the content of the proposal is created, are distinct from each other to a certain extend. Common sections from previous proposals can be reused; others have to be adjusted to the customers and their requirements or created from scratch. The follow-up activities depend upon the proposal team member's expertise and previous experience, on tacit knowledge which is not recorded in formal procedures, but exist in the individuals' head, and in undocumented social communication and collaboration processes [Dav05]. Thus, the process can hardly be recorded through standard office software which is often used in this context, such as Microsoft Word, Excel and SharePoint, nor by communication services [STW+10].

5.2.4 Existing process descriptions within the consulting company

For our further analysis we looked at process descriptions, in particular methods used by consultants in tackling a particular problem, challenge, or client engagement, from a large consultancy company C. Today, most process descriptions published within the whole company are developed by a team of experts, interviewing domain experts. As soon as the final models are released, employees cannot interact with the process descriptions. There is no support for users to edit the process model or to discuss process aspects. Process modeling experts from a specific department have designed the models. The update of existing process and methodologies heavily depends on their workload and priorities.

Within this thesis we took 20 methods from company C and analyzed them. The methods describe processes which guide consultants, i.e. knowledge workers, in their daily work. They define a number of activities and their sequence, by comprising central concepts in thinking about a client organization and the consulting process [WS03]. The methods are defined by experts, but junior consultants with only little experience in process modeling have to work with them.

The older versions of the method descriptions are documented in Microsoft Word, accessible from the Intranet of company C. Graphical representations of the processes described by the methods are created with Microsoft Visio and included in the Microsoft Word documents. A newer version of the method descriptions, that replaces the older version of method descriptions incrementally, is created with Web standards. An interactive graphical representation is designed with Flash, which is embedded in HTML files. The new method descriptions are also accessible on the Intranet.

The method descriptions stored in Microsoft Word documents are structured as follows. A method describes a process with graphical and textual representations. A process can have subprocesses which are stored in separate files and interrelated to each other via links. Each process document contains a short description, inputs and outputs, a flow diagram, and extensive textual descriptions of each process step. The process flow is expressed by a process picture created with Microsoft Visio, which does not capture the formal semantics of the picture. Consequently, the semantics are not accessible to the machine for further processing. The textual descriptions are composed of detailed action instructions, formatted as bullet items. They additionally contain links to other resources, and the roles responsible for each step.

We observed that every description of a (sub-)process contains less than 10 steps. The creators of the process descriptions only include a few modeling constructs within the flow models, namely *tasks*, *sequence flows*, *conditions*, and *pools*. Pools are used to assign a task to the responsible department or role. Also in this scenario, tasks are placed on the pool lanes to assign two or more roles to them. The conditions are labeled sequence flow elements, which directly connect tasks with each other without using a gateway element.

Instead of using a more expressive modeling language such as BPMN to capture the more intricate details of the processes, the expressivity of the flow model is complemented by the textual descriptions, e.g. exception handling is described in detail within the action instructions.

The newer process descriptions stored as Flash and HTML files are less complex than the descriptions documented in Microsoft Word. Only task elements are used and the sequence flow is modeled by the sequential arrangement. Additional information formated as textual descriptions is presented, when a user clicks on the corresponding task in the Flash graphic.

5.3 Summary

In this chapter, we have analyzed the current process modeling situation in small and medium enterprises and in a large consulting company with focus on methods guiding consultants through their daily work. We have shown that informal process descriptions already exist in the scenarios and how they are currently handled. Most process descriptions are stored in simple Microsoft Word files. They contain a graphical representation of the process flow and a detailed textual description explaining each task for each single process step. Only a few modeling constructs are used in the analyzed scenarios.

However, there is no collaboration support and feedback mechanisms are not in place. Thus, the process development is more or less a top down approach. Typically, design rationals are not documented with the current tools, which do not allow reconstructing the ideas incorporated in the process descriptions. The presented scenarios are not adequately supported in order to enable an agile BPM approach, which can include the required stakeholders and can quickly react on internal and external events. Also the current approaches presented in Chapter 4 cannot support the creation and reuse of these process descriptions adequately. Consequently, we analyze further requirements in Chapter 6 and present an wiki-based light-weight approach in Chapter 7, which can support bottom-up process development and enables agile BPM.

Chapter 6

Requirements for wiki-based light-weight maturing of process descriptions

The various scenarios presented in Chapter 5 illustrate that there are many different cases in companies, where people use their expertise and previous experience to perform a specific task, which in turn is part of an entire process. This informal process knowledge is very valuable for a company, especially when it can be made explicit. As a result, companies are interested in documenting these processes so that they can be reused, shared, and collaboratively improved.

When dealing with processes in a company, there are often people from different departments with different level of modeling expertise involved. Some of them only have to read and understand the process (e.g., methods are designed by experts and have to be read by junior consultants) and others are directly involved in creating the process descriptions (e.g., process modeling workshop participants).

In this thesis we develop a wiki-based light-weight approach for maturing process descriptions, which supports process modeling. Existing approaches in this area have already been presented in Section 4.3. Different semantic wiki engines have been compared to find an appropriate wiki engine for managing model relations [FTD10] and frameworks for the collaborative specification of semantically annotated processes have been proposed [FGR+11, HRBP10].

To find an appropriate wiki-based light-weight solution to support people in collaboratively making informal process knowledge explicit, we have to gather requirements for the maturing of process descriptions. The requirements serve on the one hand as a comparison framework for existing wiki-based solution and on the other hand as a foundation for our approach.

In order to collect the requirements for enabling both novice users as well as process modeling experts to capture process descriptions and cooperate together, we analyze previous literature in Section 6.1 and derive requirements. In a next step, we take these requirements and show in Section 6.2 that these requirements are valid because they can also be found in the scenarios presented in Chapter 5. We discuss the results and some limitations of our requirement gathering in Section 6.3. Finally, we used the derived requirements to compare the existing wiki tools for maturing of process descriptions in Section 6.4.

Parts of this chapter are based on [DV11, DVS11b, DVS11a].

6.1 Requirement analysis

In the following we analyze existing literature about process modeling, collaborative modeling, knowledge maturing and novice modeling. As a result, we derive requirements for wiki-based light-weight maturing of process descriptions. The requirements are mainly gathered from the research areas of business process management (see Section 2.2) and knowledge management (see Section 2.4).

In order to reuse, share, and collaboratively improve processes, they have to be externalized either by process mining [AW04] or by people, who examine process execution or are involved in the process [HK99, FW06]. Often, process mining techniques and tools [AW04] are used to capture and analyze activities performed by knowledge workers with the focus on the causal relations between the activities. Explicit process models are derived from executed processes by extracting the information from event logs.

But many tasks of knowledge workers are outside the grasp of mining algorithms because they are performed without any machine interaction. A study of task switching and interruptions of knowledge workers [CHW04] shows that more than 14% of the work time of knowledge workers is spent in phone calls or meetings. Thus, information about process activities or information required for performing a specific task are often exchanged informally between knowledge workers, e.g., during phone calls, during a discussion at the water cooler, or over lunch. Today, these tasks cannot be sufficiently monitored to be a viable source. They are mostly unlisted in the event logs serving as a basis for process mining. They can be classified as *hidden tasks*, which are challenging for process mining [AW04].

Complementary to capture the activities of the knowledge worker with process mining techniques, process modeling tools can be used to explicitly capture the processes.

6.1.1 R1: Natural language support for novice users

Knowledge workers can externalize their knowledge about a process by manually modeling their own processes, or simply telling their own stories. In such a setting, people with different levels of expertise create process descriptions. These are according to Renger et al. [RKV08] experts, stakeholders and users, which can often be differentiated in domain and modeling experts (see Section 2.3). Therefore, it is important to provide means for the individual knowledge worker to externalize their process knowledge (domain experts), as well as for process modeling experts to efficiently work on the abstraction level they are used. Rosemann [Ros06] further suggest to include direction providers and idea creators. Direction providers guide the process modeling project by knowing the overall objective, the timeframe, and the constraints. The idea creators know about the project objectives, unutilized capabilities, current common practices, and future developments. For Rosemann, "the right mix of business representatives is crucial for the [process modeling] project success."

More and more process descriptions have been created due to today's popularity of BPM and process modeling in organizations. As people from different departments are involved in creating these process descriptions, the higher number of process descriptions increases the number of involved departments and their representatives, who can be novices in process modeling. As a result, high demands are made on the understandability of process models [BRvU00]. The base mechanism for communication, which each general modeling technique such as business process modeling should support to some extent, is natural language. Considering the information modeling process proposed by Frederiks and van der Weide [FW04, FW06], informal specifications are created in natural language during the elicitation phase and iteratively evolve to formal specifications later. The informal specifications contain all relevant information in a verbal way, which are abstracted by the process modeling experts [FW06]. In practice, modeling experts and domain experts learn from each other, while developing formal specifications, which makes the role of natural language less emphasized, as domain experts can start with more formal specifications [FW04]. But natural language does not become redundant as long as people with less expertise in process modeling are involved. Taking this information modeling process into account, approaches for wiki-based light-weight maturing of process descriptions have to allow the use of natural language for creating informal specifications.

In practice, there are not only positive aspects of the usage of natural language because people have problems using natural language in a complete, non-verbose, unambiguous, and consistent way, expressed on a uniform level of abstraction [FW04]. The impact of these disadvantages can be reduced by requiring base skills from domain experts and modeling experts [FW06] or by also allowing graphical modeling. Recker et al. [RSR10] have investigated how business processes are modeled by novices in the absence of tool support. They have found that design representation forms chosen to conceptualize business processes range from predominantly textual over hybrid to predominantly graphical types. The hybrid process descriptions, combining graphical and textual types, achieve a higher quality. These results also corroborate the requirement for **natural language and graphical modeling support for novice users**.

6.1.2 R2: Intuitive graphical rendering and editing of processes

Business process modeling should not be seen as a domain of modeling experts, who are the only ones who can cope with their models [BRvU00]. As a consequence, process models must be comprehensible for all stakeholders. The integration of many stakeholders as possible into the creation, adaptation, and revision of process models has been shown beneficial especially for model accuracy and verification [HV04]. Process knowledge is typically distributed across a number of individuals and a group can better detect and correct deficiencies than an individual [Hen05]. But the involvement of stakeholders heavily depends on the acceptance of the used methods and tools. The complexity of the method and tools has a direct impact on the time and effectiveness of process modeling. If a tool is too complex, stakeholders need more time to learn how to use it and the acceptance suffers, which slows down the modeling project [HV04]. As a consequence, the intuitive usability of the tool is very important. This requires the tool to enable bridging the gap between the modeling expertise levels of the knowledge workers and the modeling experts. Small and medium enterprises (SMEs) and independent organization or subsidiaries of larger organizations operated as a self-sufficient unit require easy-to-use and straightforward BPM solutions. As a result, the implemented solutions have to require only a low level of specialized BPM skill level, because it is very expensive for SMEs to improve the skill levels of their employees [Kir09]. Complementary to natural language support, **intuitive graphical rendering and editing of processes** is another requirement for wiki-based light-weight maturing of process descriptions. Domain experts can start modeling their process, which can later be refined by (external) modeling experts.

Moody [Moo09] analyzed the physics of notation and summarized the following most important differences in the way novices and experts create and use diagrams:

- Experts can better discriminate between symbols than novices [BJ99, KA90].
- While experts intuitively use symbols, novices must consciously remember what symbols mean [WW93].
- Complexity affects novices more than experts, as novices lack alternative strategies [BD00].

Novices have more difficulties to cope with a large amount of modeling constructs and with complexity. Consequently, the number of modeling constructs should be reduced to allow an intuitive modeling.

The usage of modeling constructs within models has been analyzed for various languages, especially for rich semantic and complex modeling languages such as UML and BPMN [SC01, RRIG06, MR08]. As introduced in Section 2.3.1, processes can be modeled with Business Process Modeling Notation (BPMN) [BP11]. A survey analyzing the used modeling constructs of BPMN[1] shows that in most BPMN diagrams not even 20% of the BPMN vocabulary constructs are frequently used and the most occurring subset is the combination of *tasks* and *sequence flows* [MR08]. This study shows that users reduce the set of constructs for complex modeling languages in practice. Taking the study of the used modeling constructs in practice and the study from Moody [Moo09] into account, only a small subset of BPMN constructs has to be supported to provide the user with means for developing processes in a highly intuitive manner.

6.1.3 R3: Collaboration support

Risks, which can occur in the BPM lifecycle, are among others the lack of communication between process modelers and stakeholders and the lack of well-defined feedback mechanism [MH06]. Both risks can be mitigated, if proper collaboration mechanisms are in place. Discussion functionality can be used by the stakeholders or by the controller to give feedback to the process modelers. Business modeling can be seen as a collaborative activity between modeling experts (business analysts), domain experts, and business representatives [Ros06]. Investigations of Hengst and Vreede [HV04] show that stakeholders perceive models to be of higher quality when they are more detailed and correct. In addition, the involvement of more stakeholders results in more complete and correct models, but companies consider it as too time-consuming to involve as many people as possible with traditional methods and tools. Thus, **collaboration support** is required allowing people to model process descriptions together. An asynchronous collaboration support can be beneficial, because people can contribute without participating in a workshop or meeting. The collaboration support should also allow people to easily refine existing process descriptions created by other people. The users should be enabled to revert models to previous versions, if necessary. Thus, errors can be reverted that can eliminate the participation barrier for novices. The disadvantages of the usage of natural language [FW04] such as ambiguity can be further reduced through collaborative refinement. In addition, process knowledge can be matured by formalizing it in a collaborative way. By allowing collaborative modeling, the model-reality divide [SN09] can be reduced. The collaboratively aggregated process descriptions and stories can be used to arrive at a high-quality description of the actually performed processes.

6.1.4 R4: Definition of a common language

According to Becker et al. [BRvU00] a business process model should provide the communication base for all persons involved. Research on cross-organizational busi-

[1] http://www.bpmn.org/

ness processes has shown that stakeholders have different ways to communicate and use many different modeling languages [BGL+09]. This given fact also exists within companies, where stakeholders use their own language and terminologies that they are familiar with. The usage of synonyms and homonyms can cause misunderstandings. As a result, more time is required, especially if misunderstandings are detected in later phases and have to be removed [BDJ+11]. A shared understanding of the elements and relations have to be created which is defined by Renger et al. [RKV08] as "the extent to which specific knowledge among group members of concepts representing system elements and their relations overlaps." Becker et al. [BRvU00] suggest to start with a business term catalog substituting existing textual glossaries and include semantic relationships between the single concepts. A shared common terminology serves as a basis for an effective and efficient, agile BPM. The **definition of a common language** is required for collaborative process development so that misunderstandings can be eliminated. Frederiks and van der Weide [FW06] give an example how domain experts and modeling experts can develop a common language by describing the different steps and the required skills. Domain experts start formulating a significant number of sample sentences. If a sentence is too complex (verbose), the domain expert has to split it. The domain expert further judges the relevance of the sentence for the domain. The modeling expert checks for consistency and looks for ambiguities. In addition, he reduces similarities in sentences by abstracting them. The abstracted sentences are the basis for the formal model. The sentences abstracted and refined by the modeling experts are then validated by the domain experts. During this interaction a common language between all stakeholders is defined as they all agree on a common vocabulary.

6.1.5 R5: Structured process documentation support

The management of unstructured data is according to Blumberg and Atre [BA03] a very large problem. For instance, the weakness of basic keyword search can be seen as one issue, although the vendors have continued to improve their search technologies. A solution to this issue can be the use of structured data such as classifications or taxonomies for unstructured data. Informal specifications of processes, created by the domain experts, are unfortunately poorly structured and need to be transformed into formal specifications [FW06]. Process modeling experts are responsible for this transformation. They must have the skills to translate process descriptions and comments into structured and overall appropriate process models [Ros06]. While practitioners see standardization, which leads to a structured documentation, as the most significant current issue of business process modeling, the model-driven process execution was ranked as most important issue by vendors and second important issue by academics [IRRG09]. Especially for processes, which have to be executed automatically, the process descriptions have to be formalized and semantically correct. Therefore, structured models must be created capturing all relevant facts about real-world practice [KB06]. But also for processes executed by humans, it can be beneficial to have structured process documentation. In this setting, the single activities have not to be structured in such a detailed way as it is the case for automated execution of processes. Also informal descriptions can be used to describe a process. Nevertheless, a structured process representation increases the search and navigation functionality in process descriptions for users. Various process model query languages have evolved allowing users to formulate queries containing process model structure information. These queries retrieve models or patterns from a process model repository, matching the structure specified in the queries [APW08, LS06, BEKM06, VKL06, WLK06]. For instance BPMN-Q [Awa07] has been developed for querying structured process models expressed in BPMN. Another approach for structuring process description uses a Business Process Modeling Ontology (BPMO), which enables querying, sharing, mediation, and translation of business processes [CND09]. Especially for collaborative maturing of process descriptions, structured process documentation must be supported so that computers can further process and analyze them (**support for structured process documentation**).

6.1.6 R6: Automated translation of text into structured process descriptions

The design of a new process model is a highly complex, time-consuming and error-prone task. For instance, investigations from Herbst and Karagiannis [HK99] show that 60% of the total time within a workflow project was spent on the capturing of the as-is model. As a consequence, costs can be reduced by using appropriate tools speeding up the acquisition phase [FMP11].

A solution is the reuse of existing process descriptions that reduce the process modeling time [MP08]. Studies from Hengst and Vreede [HV04] have shown that stakeholders perceive it as difficult to start process modeling from scratch. While cases starting from scratch were evaluated negatively, the strategy, which partly uses old models, was rated better.

Detailed information about processes in the form of informal textual descriptions, such as policies, reports, forms, manuals, content of knowledge management systems, and e-mail messages, can be used to create process models [FMP11]. Especially, as the unstructured data make up the biggest share (Merrill Lynch estimates it on more than 85 percent) of all business information [BA03]. For instance, many textual descriptions already exist as HowTos, guidelines, or methodology descriptions in wikis like in WikiHow.[2] It is beneficial to reuse them by automatically translating

[2]WikiHow is a wiki platform where users can collaboratively create, edit, and share textual HowTos, see http://www.wikihow.com

them into process models. As a result, people do not have to start from scratch. By automating the translation, less time is required to translate the textual descriptions into graphical representations and thus costs can be reduced. As a consequence **automated translation of text into graphical process descriptions** should be supported by approaches for wiki-based light-weight maturing of process descriptions.

6.1.7 R7: Mechanisms for process description validation

Since modeling is an error-prone activity, validation techniques should be in place to ensure that the process models make sense and are semantically correct [WHM08]. Validation techniques have evolved for instance in the model checking community (e.g., [CGP99]) and in the workflow community (e.g., [AvH04]). Other approaches such as Semantic Business Process Validation [WHM08] introduce a formal execution semantics for business processes. The thus generated annotations and ontology are taken into account in order to determine whether the processes are consistent with respect to each other.

The advantages of automatic detection of constraint violations during the integration of different perspectives on the same process was studied within BP-MoKi [FGR+11]. The support for a final integrated and compliant process provided by the tool in terms of required effort and benefits was analyzed. A case study with three domain experts integrating three processes provides a hint that the automatic detection of constraint violation can have an impact, when different experts converge on an integrated compliant process. Within the study, the automatic detection of constraint violations led to the introduction of one new process element and to the removal of an existing process element.

The approach from Vrandečić [Vra10], who uses queries to evaluate ontologies, can also be used to detect errors in process models, when the process is documented in a structured way. For instance, a query for all process steps and their corresponding role can be used to detect missing role assignments.

Validation techniques are required within collaborative process development, which support the user to detect and point out model errors. These **mechanisms for process description validation** can be implemented within the system (automatic validation mechanism) or can be extended by the users (query evaluation).

6.2 Mapping the requirements on the example scenarios

In this section we show how the requirements derived from literature in Section 6.1 can be applied to the example scenarios introduced in Chapter 5.

6.2.1 Example scenario at a consulting company

The example scenario at a consulting company described in Section 5.2.3 shows that people with different level of modeling expertise are involved. The process descriptions are created by experts, but junior consultants with only little experience in process modeling have to work with them. This setting requires **R1: Natural language support for novice users**, which must be able to read and understand the process descriptions. The used terminology is imposed upon the junior consultants.

The company uses process descriptions consisting of natural language and graphics for that purpose. Only a few modeling constructs are used within the flow models, namely *activities*, *sequence flows*, *conditions*, and *pools*. Instead of using BPMN to capture the more intricate details of the processes, the expressivity of the flow model is complemented by the textual descriptions, for instance exception handling is described in detail within the action instructions (**R1: Natural language support for novice users** and **R2: Intuitive graphical rendering and editing of processes**).

As each proposal development process is different, it can be beneficial to also allow the knowledge workers involved in the process to edit the standard processes and enhance it with their own experiences. This requires **R3: Collaboration support** and **R2: Intuitive graphical rendering editing functionality**. Even if the management does not allow knowledge workers to directly modify processes, discussion functionality can be used to communicate process experience to the modeling experts. As a result, the model-reality divide [SN09] can be reduced.

The expertise gathered in previous proposal activities and common sections from previous proposals can be reused in the new proposal. To support new proposal team members, the old processes and best practices have to be documented. Proposal documents and external information have to be linked to the processes. In addition, the documentation has to be found by people who require enhanced search and navigation functionality compared to existing keyword search. Therefore, the processes must be documented in a structured way, which improves search and navigation (**R5: Structured process documentation support**).

6.2.2 Example scenarios at SMEs

In the example scenarios at SMEs described in Section 5.1.3 many people are involved in process modeling. Often they are not modeling experts, because domain experts have not learned how to model processes and SMEs cannot afford to train all their employees dealing with processes in BPM. As a consequence novices are involved, who require **R1: Natural language support for novice users**.

Although there exist professional process modeling tools, the domain experts often use standard office software to document processes which does not support modeling to full capacity, but offers intuitive usability. **R2: Intuitive graphical rendering and**

editing of processes seems to be also a requirement from the SME scenario.

As many people from various departments are involved in the development process such as sales, development, controlling, assembly and quality from company A, all these people should be included in process modeling activities. The design rationals are often lost, if the model is translated from standard office software into a professional process modeling tool by the quality department in company A. As a consequence, **R3: Collaboration support** is required, which allows all people to contribute to the process descriptions and also documents design rationals.

Especially, when so many people from various departments are involved, they can have different perspectives on the process and can use different terminologies. Misunderstandings can occur, which can be reduced by **R4: Definition of a common language**, if everybody agrees on using it.

For the quality department, it is important that there is no error in the process models. Correct process documentation is required to get an ISO quality certificate. Therefore, the process model has to be checked and validated. **R7: Mechanisms for process description validation** can help them to do these checks automatically.

Employees have started to capture and document their daily processes, often in a textual format in Microsoft Word. As SMEs are under enormous time and cost pressure, they can benefit from **R6: Automated translation of text into structured process descriptions**, because the previous captured textual descriptions can be translated, which saves time and thus costs compared to starting again from scratch.

6.2.3 Conclusion

We showed in this section that all requirements derived from literature are also important for our different scenarios. The example scenario at a consulting company illustrate that their current process documentation combining graphical and textual representations are designed for junior consultants, who have to understand and apply them. This underpins the requirement for natural language support for novice users and the intuitive graphical rendering. In addition, the junior consultants have to find the process descriptions they want to execute. Hence, structured process documentation is required to improve the search and navigation functionality. As the models are designed by experts, they define the terminology. The automatic validation mechanisms and the translation of textual descriptions into graphical representations are not so important aspects, because only experts are involved in the process development. As soon as the proposal team is allowed to model their own proposal process, these requirements come to the fore.

In the SME scenario, the people from the different departments are involved in process modeling activities and thus they do not only have to read and understand the process descriptions, but also contribute to them. Therefore, collaboration support and support for novice in the form of textual and intuitive graphical descriptions is required. As textual descriptions already exist, they should be transformed automatically into graphical representations to save time. In the absence of process modeling experts, it can be beneficial to have some validation mechanisms in place, which detect model errors.

Consequently, we have shown that the derived requirements for a wiki-based lightweight process description maturing approach are also present in our example scenarios. A wiki-based tool developed to support these process modeling scenarios must fulfill the first five requirements. The automatic translation and validation support can be beneficial for the solution but is not necessarily required. As a result, we can use these requirements to compare existing approaches (see Section 6.4) and to serve as a basis for our new approach presented in Chapter 7.

6.3 Discussion and limitations

In this section we discuss the requirement elicitation and also elaborate some limitations of our approach. We have only collected the different requirements, but did not further analyze them according to their connections and importance.

The requirements were derived from different approaches described in literature. Thereby, the requirements were mainly observed for the specific approaches, but there are often trade-offs between the single requirements. Renger et al. [RKV08] found four key trade-offs which have to be considered for successful collaborative modeling:

- The involvement of more stakeholders and experts results in larger groups, which can cause conflicts and misunderstandings between the participants finding a common terminology and perspective. But it can also improve the completeness and correctness.

- Another trade-off can be found between model quality and level of participation. If participants can actively contribute to the process model, they have feelings of ownership. However, the participants do not necessarily have the required modeling skills, which can result in a poor model quality.

- Expert or analysts from outside the group can start with a preliminary model to speed up the process, but this can also lead to avoidance or rejection of the process and its model. The selection of the appropriate starting point is another critical challenge.

- Parallel modeling can improve the efficiency but also requires rules, tools and techniques to integrate submodels, changes or different perspectives.

Considering these challenges in combination with the requirements, the first trade-off shows that collaboration support, which allows the integration of more stakeholders, also requires support for the definition of a common terminology. The second challenge further requests an intuitive interface and natural language support for novice users in a collaboration setting. The third trade-off can be solved by automatically translating existing textual descriptions into graphical representations. The graphical process modeling task does not have to start from scratch, but start with informal descriptions created by the domain experts. The fourth and final challenge can be addressed by appropriate community rules, but is also connected with the requirement for process description validation. An example use case for such a scenario is evaluated within BP-MoKi, where three processes have to be integrated with each other by three experts [FGR+11]. Within this use case, constraint violations can be automatically detected and highlighted during the integration of the process models. By using a wiki-based light-weight solution, we can address most of these challenges and reduce them.

We do not claim that we did an exhaustive analysis of the requirements. The method of gathering the requirements could also be enriched by interviewing the relevant stakeholders, analyzing and ranking their inputs by following the Delphi analysis similar as it was presented in [IRRG09]. If such a mixed method approach is followed, the level of generalization of the results would be much higher, and the accuracy of the provided requirements would be better. For our comparison framework, developed to compare the existing tool in Section 6.4, our derived requirements are sufficient to show the diversity of the different tools. They also serve as a basis for the development of our approach presented in Chapter 7.

In this thesis we map the requirements to the different use case scenarios in a large consultancy company and SMEs. We have shown that all requirements derived from existing literature are also present in the example scenarios. The mapping to the example cases additionally illustrates to some extent, how the different companies have solved some issues. For instance, the large consulting company uses intuitive graphical models in combination with textual descriptions that the junior consultants are able to understand without asking an expert, what process activities they have to perform. The mapping also supports the importance of these requirements for the scenarios.

As a result, an approach, which supports the presented scenarios, has to incorporate these requirements. Large companies and SMEs can benefit from such a wiki-based light-weight solution. In the future, the importance of the different requirements should be further analyzed to create a ranking. The ranking should also include the variable characteristics of different use cases. As a result, a framework can be developed, which allows for classifying wiki-based light-weight approaches for maturing of process descriptions according to their applications in various use cases.

6.4 Comparison of existing wiki-based solutions

The derived requirements for wiki-based maturing of process descriptions presented in Section 6.1 can be used as a comparison framework for wiki-based solutions. Having such a list of requirements, we are able to compare the different existing tools presented in Section 4.3. A tool can fully address a requirement, can support it partly or cannot meet it.

Table 6.1 shows the result of the comparison of the different tools. A filled out circle ● indicates that a tool fully satisfies the requirement. If it only supports a part, a half-filled circle is used ◑. An empty circle ○ indicates that the tool does not meet the requirement.

Approach	**R1: Natural language support for novice users**	**R2: Intuitive graphical rendering and editing of processes**	**R3: Collaboration support**	**R4: Definition of a common language**	**R5: Structured process documentation support**	**R6: Automated translation of text into structured process description**	**R7: Mechanisms for process description validation**
SMW+BPEL [HBV09]	●	○	◑	◑	●	○	○
MRM wiki [FTD10]	●	○	●	◑	◑	○	○
KnowWE extension [HRBP10]	●	●	◑	◑	◑	○	○
BP-MoKi [FGR+11]	●	●	●	●	●	○	◑

Table 6.1: Comparison of the existing tools presented in Section 4.3 according to the different requirements for wiki-based light-weight maturing of process descriptions.

As the existing tools are all wiki-based solutions, all of them enable the user to use textual descriptions in natural language (*R1*).

While all of the tools allow the users to express their process knowledge with natural language, only half of the tools provide an intuitive graphical interface for rendering and editing processes (*R2*). The KnowWe extension therefor implements an own formal representation language, called DiaFlux, which allows to create and execute clinical workflows. The BP-MoKi uses all BPMN elements and a subset of it, which allows for intuitive modeling for novices with subset of BPMN constructs. Although the MRM wiki stores graphical process models, the models cannot be edited within the wiki version presented in [FTD10]. The focus of the MRM wiki approach is on the relations between the models.

The collaboration support (*R3*) is automatically available in most of the tools as it is also a basic wiki feature: Versioning is provided by each used wiki engine. As a result, users can revert to previous versions in all systems. Additionally, the documentation of design rationals is supported in all tools. However, the semantic wiki KnowWE does not provide explicit discussion functionality and the SMW+BPEL approach only supports collaboration during the creation of structured descriptions. After the structured descriptions are translated into BPEL descriptions, no collaboration support is offered to the users.

By using a wiki-based approach, people can collaborate to define a common vocabulary (*R4*) to avoid misunderstandings. Everybody can access the wiki with a simple Web browser, which is typically shipped with each computer. As soon as people collaborate, it crystallizes a common terminology. An explicit standardization of terminologies is only supported by BP-MoKi. Predefined templates and forms are used to create and edit ontologies. By providing such functionality, BP-MoKi fully supports the creation of a common vocabulary, including hierarchy and relation structure. The other tools partly support the definition of a common terminology by providing discussion functionality. The users can collaboratively agree on the usage of similar names for semantic annotations.

All systems store the models in a machine-processable documentation format (*R5*). While the focus of the SMW+BPEL, KnowWE extension, and BP-MoKi is on the development of process models, the MRM wiki solution emphasizes on the relation between different models and their management. Hence, the relations between the models are stored in a machine-processable format and not the model itself. The MRM wiki does also not allow interlinking between process descriptions and external resources. The KnowWe extension allows creating and reusing ontological concepts in the models, but the new concepts can only be linked within the decision flow and not as external resources to nodes in the model.

The automated translation of textual process descriptions into graphical representations (*R6*) is not supported in any of the tools. As natural language can be used to supplement the graphical representation, it can be also beneficial to automatically detect process flow information in the textual description of process elements and automatically adjust them in the graphical representation. Unfortunately, none of the tools support these detections and adjustments.

BP-MoKi is the only tool that partly supports the automated validation of process descriptions (*R7*). While constraint violation can be detected, there is currently no support for automatic interpretation, location and resolution of detected constraint violations [FGR+11].

The analysis of the different tools by means of the requirements shows that all approaches offer natural language to describe processes. Collaboration is also supported by all systems, although the KnowWE extension does not provide discussion functionality and the SMW+BPEL approach does not allow to discuss the exported BPEL models. Basic structured process documentation support is also offered by all tools. Additionally, a basic common vocabulary can automatically be defined with all the solutions, when people collaboratively work with each other. All these features are basically available because all solutions are based on semantic wikis, which already provide at least parts of the required functionality [BGE+08, FTD10]. The remaining three requirements have to be implemented additionally. Consequently, the SMW+BPEL tool, which was one of the first wiki-based process development approaches, does not provide a graphical interface for editing processes. While the automatic translation of text into graphical representation is not supported by any tool, process validation is partly supported by BP-MoKi.

The last two requirements are not supported by most of the tools as the automated translation of text into graphical representation and the model validation are current research areas in BPM. Thus, current tools only provide automated translation and validation functionality to a very small extent.

Chapter 7

Wiki-based light-weight maturing of process descriptions

Business process modeling can be supported in different ways. In this chapter we introduce a new approach for wiki-based light-weight maturing of processes descriptions based on the knowledge maturing approach described in Section 2.4.5.

Today, most of the process knowledge remains either in people's heads, or as textual and graphical descriptions in the Intranet as HowTos, guidelines, or methodology descriptions. If it is in people's heads, the process knowledge is tacit and has to be made explicit in informal or formal process descriptions. The informal descriptions including HowTos, guidelines, or methodology have to be further refined and formalized. Traditionally, process descriptions have been developed by process modelers interviewing domain experts. This interviewing based method has been further extended to a group storytelling approach, transforming stories told by individual process performers into process descriptions [SBP08, GSB11]. Unfortunately the costs of an upfront, complete formalization of all business processes with these traditional modeling approaches are prohibitive, and the benefits often seem elusive, especially under the stress of the daily work.

We address this issue by introducing an approach for wiki-based light-weight maturing of process descriptions, which includes a methodology and a wiki-based platform that allows capturing process descriptions through several channels, with different speeds and goals. It supports the capturing of stories and natural language process descriptions, rendering and editing of graphical representations, and creation of formal models from the graphical representations, which can be exported with a well-defined semantics and used for the further processing and validation. It provides users with means to intuitively model processes graphically with basic (but widely used) process elements, namely *tasks*, *sequence flows*, *parallel* and *exclusive split gateways* required to support all of the *Basic Control-Flow Patterns* [RHAM06] (see Section 7.2.1). Hence, users can develop process knowledge by using graphical descriptions, natural language, and formal semantic annotations.

Our approach heavily builds on the requirements from Chapter 6. It is derived from the knowledge maturing process, presented in Section 2.4.5. Although, this evolutionary process results in business process models which are adequate standardizations of real-world practice, we concentrate on the more informal and less formal phases of the proposed model. The explicated knowledge should be gradually interconnected, enabling the organization to follow a continuous knowledge maturing effort instead of requiring a steep and complete formalization step. Users can start to model their processes by formulating a first idea with natural language or with an incomplete model. These models can be further refined and consolidated by others. This allows integrating all stakeholders into the creation, adaption, and revision of the process descriptions. A single person typically does not have a complete overview of a process.

A first approach supporting wiki-based process development, implemented as an extension to SMW is presented in Section 7.1. This solution serves as a basis for our wiki-based light-weight approach. By semantically connecting wiki pages, a graphical process model is created. After a brief introduction of the approach, the functionality and its implementation is described. The application in use cases of the ACTIVE project shows that it can support users but also has some deficiencies due to the lack of a graphical process editing interface.

The overall approach for wiki-based light-weight maturing of process descriptions is presented in Section 7.2. Therefore, the supported graphical elements and their mappings to wiki pages are introduced. Furthermore the approach is classified into the research area of BPM and applied to the scenarios explained in Chapter 5. A summary of the advantages and a discussion conclude this section.

The implementation of Wikiing Pro is described in Section 7.3. SMW (see Section 3.1) and the Oryx process editor (see Section 3.2) are combined to support our wiki-based light-weight approach.

The transformation of existing structured textual descriptions is presented in Section 7.4. Therefore, the translation of single wiki pages (HowTos) and multiple wiki pages connected with predefined SMW properties is explained.

The chapter ends with Section 7.5 in which our tools are compared with the existing solutions presented in Section 4.3.

Parts of this chapter are based on [DLHA09, DVS11c, DV11, GRD11].

7.1 Semantic Result Formats – Process extension

Traditional process management methods apply interview- and workshop-based techniques to capture structured knowledge about organizational processes. In contrast to these methods which tend to be time-consuming and inefficient, we present a collaborative approach to process modeling where process descriptions are gradually improved by different contributors.

We extended Semantic MediaWiki (SMW) with process modeling and visualization functionalities in order to support such a collaborative, distributed, and iterative process documentation. Thereby, we are able to capitalize on the fact that process activities can already exist in corporate wikis and only have to be arranged in a meaningful manner.

7.1.1 Approach

The extension enables the wiki users to develop processes by making informal processes (see Section 2.8) explicit. People can express their ideas about a process (steps) in natural language and further refine it by adding semantic annotations, which can define either the process flow (process knowledge) or additional parameters (functional process knowledge) as described in Section 2.7.

Our methodology for collaborative development of processes, connecting multiple wiki pages, is based on the knowledge maturing process model (see Section 2.4.5). Although, this evolutionary process results in business process models which are adequate standardizations of real-world practice, we concentrate on the more informal and less formal phases of the proposed model. With this approach, multiple wiki pages describing tasks (e.g., HowTos) can be connected with predefined process properties. The process extension supports most of the *Basic Control-Flow Patterns* introduced in [RHAM06], namely *sequence pattern*, *parallel-split pattern*, *multi-choice pattern*, and *exclusive-choice pattern*. At the moment, there is no support for the *synchronization pattern* and the *simple-merge pattern*, because it would require that the information about a synchronization or a simple merge has to be included with predefined properties in more than one process step. It can happen in such a setting, that users have to modify process properties at more than one different place for changing the process. As a consequence, we do not support such patterns for a better usability and leave the interpretation to the readers.

In our approach every single process step (activity) is represented as a wiki page belonging to categories *Process* and the corresponding process name. To express the sequence of the process, special predefined process properties are used, which are explained in Section 7.1.2. The process models are stored in a machine-processable format, which allows the reuse of the process knowledge created in the wiki.

The process extension builds on the capability to query for semantic properties which is provided by SMW and displays these query results as a process graph. A new SMW query format transforms the textual query result into a textual representation in the GraphViz DOT language [KN02]. The GraphViz DOT application [GKN06] processes this textual representation in the GraphViz DOT language and creates a corresponding process graph. An example process graph is illustrated in Figure 7.4. Each process step (wiki page) is represented as a standard node in the process graph. The process flow is expressed with edges and additional colored rectangle nodes with symbols representing parallel (green with | |) and multi-choice splits (yellow with +). Exclusive-choices are represented as blue diamond nodes containing the condition and two edges labeled with *true* and *false*. Roles are expressed with red double octagon nodes and connected to corresponding activity. The folder nodes are used for resources similar to roles (see Figure 7.4). For a better view, assigned roles and resources with the same name only appear once in the process graph.

The developed process extension [DLHA09] for Semantic MediaWiki[1] is now part of the Semantic Result Formats (SRF)[2] extension.

This approach serves as a foundation for the wiki-based light-weight maturing of process knowledge approach described in this chapter but does not support graphical editing of the process descriptions. The lack of graphical editing was evaluated as poor in the ACTIVE project (see Section 7.1.4), which resulted in the implementation of a graphical editing functionality in the overall approach presented in Section 7.2.

7.1.2 Process properties

Special process properties have to be defined for our approach. It was necessary to introduce the following properties that we can support most of the *Basic Control-Flow Patterns* [RHAM06]. The property names are selected that they are more or less self-explanatory. If an activity has one successor (sequence pattern) or more successors executed in parallel (parallel-split pattern), the property *has Successor* is used. An activity can have several successors, but only one has to be selected and executed (multi-choice pattern). Therefore we use the property *has OrSuccessor*. To express conditions (exclusive-choice pattern), the properties *has Condition*, *has ConTrueSuccessor* and *has ConFalseSuccessor* are used. In the following, the different predefined properties are explained in detail:

- **has Successor**
  This property links to a proximate activity. If there exists more than one successor activity, a conjunction is displayed in the graph.

- **has OrSuccessor**
  If several possible successor activities exist, this property is used to link to them. A disjunction is displayed in the graph.

- **has Condition**
  This property declares the condition that is used for selecting the successor activity. The condition must be answerable with true or false and can only be used with properties *has ConTrueSuccessor* and *has ConFalseSuccessor*.

[1] A demonstration of the extension can be found at https://km.aifb.kit.edu/projects/process

[2] http://www.mediawiki.org/wiki/Extension:Semantic_Result_Formats

- **has ConTrueSuccessor**
  This property links to the successor activity which should be executed if the condition is true. In the graph, the edge to this activity is labeled with *true*.

- **has ConFalseSuccessor**
  This property links to the successor activity which should be executed, if the condition is false. In the graph, the edge to this activity is labeled with *false*.

In the case that the predefined properties for the different successor relations are mixed, only one successor relation is visualized in the graph and the other successor activities are displayed without an ingoing edge. To express conditions, also properties with *Record* types (see Table 3.3 in Section 3.1.2) can be used. In our implementation, we only allow single value properties, which can be handled easier with editing forms. In addition to these properties which control the sequence of the processes, it is essential that other properties are introduced which describe the activities in detail. In our first version, we have implemented `has Role` and `uses Resource`. These activity description properties can be extended by the users themselves, but are not displayed in the generated graph without further modifications of the code.

- **has Role**
  This property links to the corresponding role, which is responsible for the activity. In the graph the role is displayed in red and is assigned to the activity. It can be switched off, so it is not shown in the graph.

- **uses Resource**
  This property links to the corresponding resources, which is used in the activity. In the graph the resource is displayed as a blue folder and is assigned to the activity. It can be switched off, so it is not shown in the graph.

To display process activity properties in a clearer way on the corresponding wiki page, we suggest to use a template as presented in Figure 7.1. The result with the parsed wiki template is illustrated in Figure 7.3.

The template also uses the logical functions provided by the Parser Functions extension[3] and other templates, namely *Tablerow*, *Tablelongrow*, *Tablesection*, *Resources*, *Roles*, *Successor* and *OrSuccessor*[4] (see Section 3.1.1). In addition, a property *Belongs to process* is used in the template to specify the corresponding process and to set the page category which is the differentiator in the semantic query. For a better usability, we also use the Semantic Forms extension[5] enabling the users to add and edit data

[3] http://www.mediawiki.org/wiki/Extension:ParserFunctions
[4] All templates can be found in the demo wiki, which can be accessed via https://km.aifb.kit.edu/projects/process/index.php/Main_Page
[5] For more details see http://www.mediawiki.org/wiki/Extension:Semantic_Forms

Figure 7.1: Edit mode of example process step *Find Reviewer* including template syntax

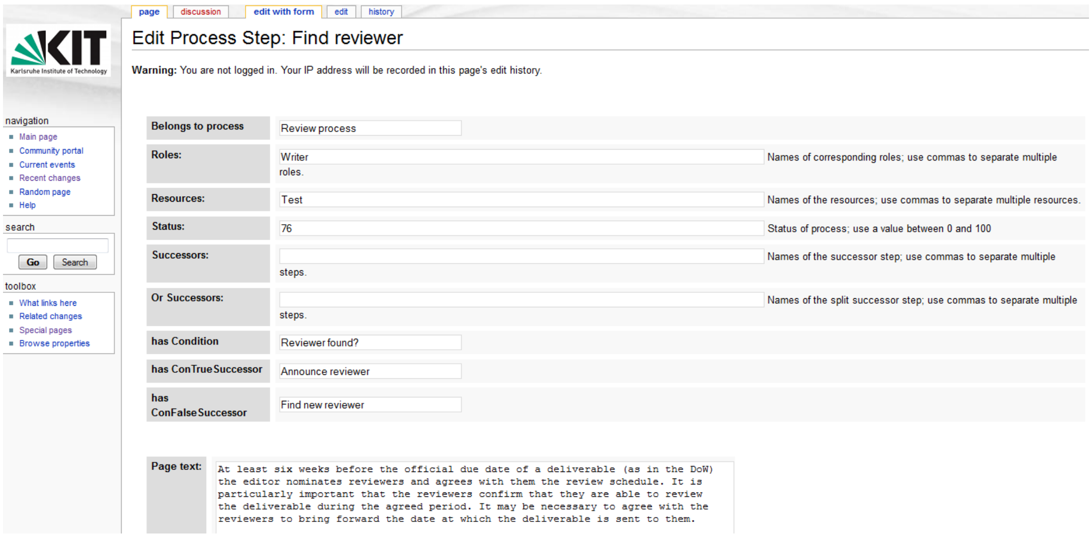


Figure 7.2: Form edit mode of example process step *Find Reviewer* showing the HTML forms

using forms within SMW. An example of editing a wiki page with forms is presented in Figure 7.2. The Semantic Forms extension also provides input forms, which can be used to create new wiki pages or to edit existing wiki pages with forms. Such an input form is also used within the template to allow users to easier add new process steps to the selected process as shown in Figure 7.3. The user simply enters the name of the new process step in the form field. After pressing the *create* or *edit* button, the page is displayed in forms edit mode.

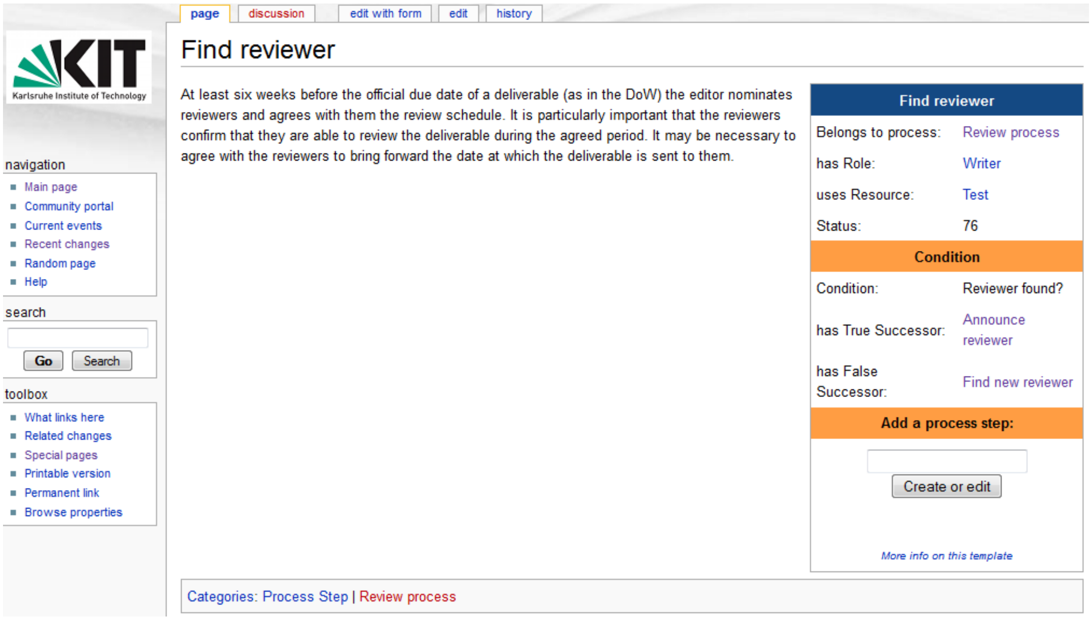


Figure 7.3: Example process step *Find Reviewer* showing the parsed wiki template

7.1.3 Semantic query

With the deployment of this process extension, the standard query formats of SMW, described in Section 3.1.2, are enhanced with a new query format called *process*. The semantic query retrieves all properties presented in section 7.1.2 and transforms the result into a predefined textual representation in the GraphViz DOT language. The query result can be controlled by additional parameters including a first process validation approach:

- **graphsize**
  This parameter specifies the size of the graph image. No value is set by default.

- **showroles**
  If this parameter is set to *yes*, the assigned roles will be displayed in the graph. The default value is *yes*.

- **showresources**
  If this parameter is set to *yes*, the assigned resources will be displayed in the graph. The default value is *no*.

- **graphvalidation**
  If this parameter is set to *yes*, every node which does not have a *has Role* property, will be displayed red in the graph. The default value is *no*.

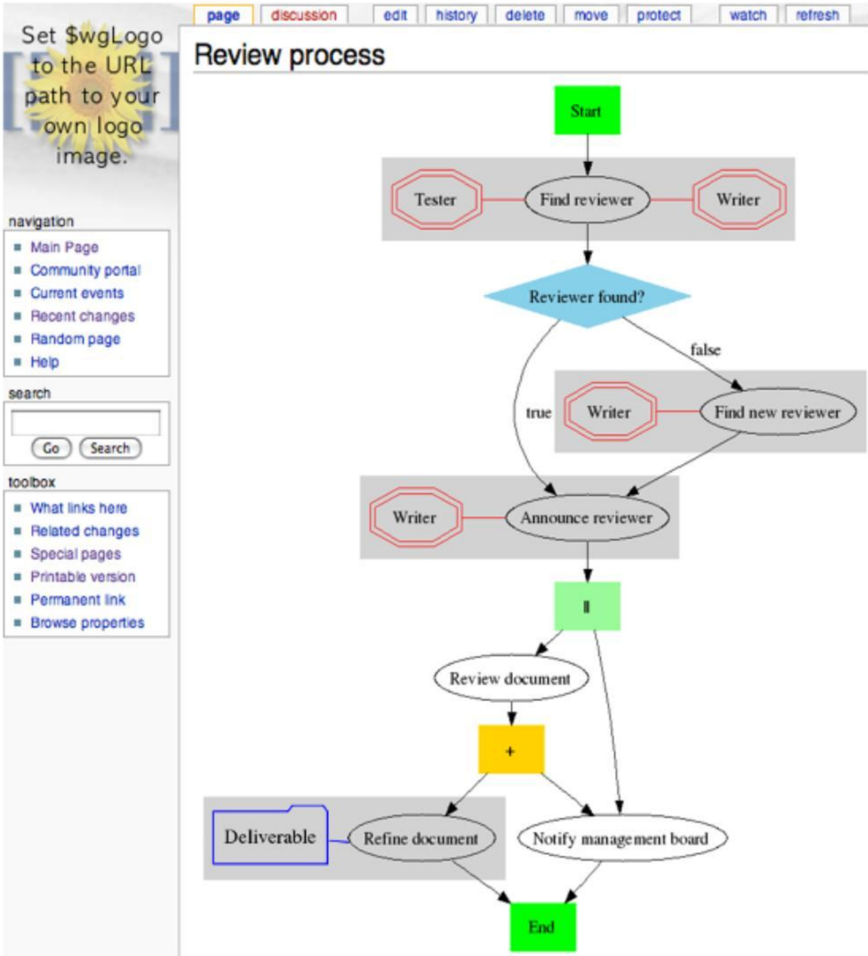


Figure 7.4: Example process graph in the wiki

```
{{#ask: [[Category:Process]] [[Category:{{PAGENAME}}]]
| ?has OrSuccessor=hasorsuccessor
| ?has Successor=hassuccessor
| ?has ConTrueSuccessor=hascontruesuccessor
| ?has ConFalseSuccessor=hasconfalsesuccessor
| ?has Condition=hascondition
| ?has Role=hasrole
| ?uses Resource=usesresource
| format=process | graphvalidation=no
| showroles=yes | showresources=yes}}
```

Wiki Syntax 7.1: Example SMW inline query for displaying processes

An example semantic process query which can create the graph in Figure 7.4 is shown in Wiki Syntax 7.1.

7.1.4 Application of the approach

The SRF process extension was applied within different use cases within the ACTIVE project to support design project knowledge articulation and proposal development. In the following we briefly describe the use cases and summarize the evaluation results.

To visualize different facets of design project knowledge [EJM+10, EDJM10], the process extension was used within the design project visualizer based on SMW. The design project visualizer serves as a one of the front-ends, which is part of a prototype. The design project visualizer is connected to a knowledge base and to a back-end which offers several services such as process mining and extraction functionality. Knowledge stored in the knowledge base as instances of the PSI Upper-Level Ontology [EKM08] was imported into SMW via a connector. With help of the process extension a design project process map was created. For this use case the process extension has been enhanced to show with a discussion icon that there is a corresponding discussion about a process element. This discussion visualization functionality was further extended by adding the number of pro and cons arguments in the process graph. The solution was validated within the ACTIVE project [EDJM10, EDF+11]. The results indicate that design project managers can be supported in performing their typical planning tasks [EDJM10, EDF+11].

The presented extension was also integrated in a SMW proposal development workspace [DGF10] applied in a large consultancy company. In contrast to typical knowledge management settings, the use case did not only focus on the outcome, the final document, but also on the informal process of proposal development. With the extension users were enabled to formalize and visualize the proposal development process by creating wiki pages and connect them with each other. Thus, best practice processes can collaboratively be built. The proposal development workspace was evaluated [DGF10]. Regarding the process extension, the results showed that the visualization of the process is helpful, but consultants require more intuitive process editing functionality. They want to have a graphical interface similar to Microsoft Visio.

7.2 Wiki-based light-weight approach

Our methodology for wiki-based light-weight maturing of process descriptions is depicted in Figure 7.5 and enables domain experts without modeling expertise to actively participate in the process modeling task. It starts with textual process de-

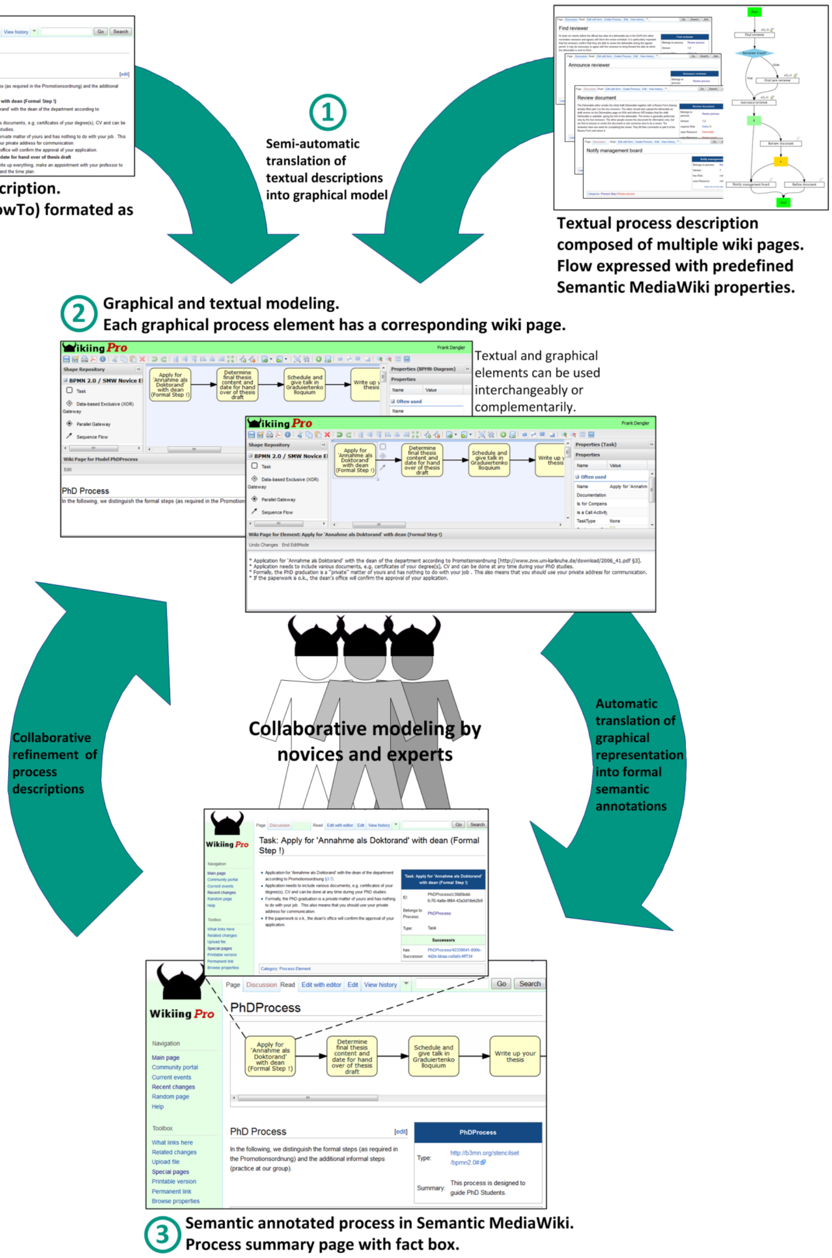


Figure 7.5: Wiki-based light-weight maturing of process descriptions

scriptions, which are either currently created by users as a first idea or previously stored within a wiki and not further refined due to technical limitations. Textual process descriptions can be HowTos, which exist within organizations and are also very prominent within the Web. Examples for such HowTos can be found at WikiHow,[6] a wiki platform where users can collaboratively create, edit, and share textual HowTos. These HowTos are typically structured in a specific format, e.g., numbered lists, bullet lists, and definition lists. Another way to structure wiki pages as a process are the usage of predefined semantic annotations, specifying the process flow. With this approach, multiple wiki pages are connected to a process, which can be visualized for instance with the SRF process extension presented in Section 7.1.

Especially in process description maturing, it is important that existing textual process descriptions, previously stored within the wiki, can be reused. These partly structured, textual process descriptions in form of single and multiple connected wiki pages are semi-automatically translated (Step 1 in Figure 7.5) into graphical representations composed of the supported elements (see Section 7.2.1) and corresponding wiki pages containing describing text. The first technical implementation of the translation is presented in Section 7.4. By translating existing textual descriptions into graphical representations, modeling can be supported and made faster. As explained in Section 6.1, it is difficult for stakeholders to start process modeling from scratch and the translation can reduce the modeling effort. In our approach a full correct translation is desirable, but not necessary. The graphical representation can be seen as a first draft, which can directly be refined by the user initiating the translation and later by the community.

Once the graphical model is transformed or created from scratch, it can be collaboratively refined with additional elements or textual descriptions, depending on the modeling experience and skills of the user (Step 2 in Figure 7.5). Textual and graphical elements can be used interchangeably or complementarily. If users do not know the graphical element, they can describe it in the text of the corresponding wiki page. In addition, the user can enter annotated links to external resources that are required for a given step or task. As soon as the model is saved, it will be stored in the semantic wiki, including the annotated links to external resources (Step 3 in Figure 7.5). Thereby, the graphical process representation is automatically translated into formal semantic annotations. The formal process descriptions are the combined results from the graphics and the annotated text. As a result, the process models are stored in a machine-processable format, which can be exported and reused.

The semantic wiki serves as a process repository, but also offers additional functionality. Versioning functionality is provided which allows for documenting design rationals. The evolution of each process model can be traced back. In addition, edits can be undone by reverting to a previous stored version. Process models and elements can be discussed asynchronously by the users. Everybody can easily comment on the model, which makes modeling and thus Business Process Management (BPM) more responsive. BPM can react quickly and properly to internal and external

[6] http://www.wikihow.com

events [BDJ+11] compared to traditional approaches focusing on "one-shot" process knowledge acquisition.

Typically semantic wikis offer semantic search functionality, which allows querying for the structured process knowledge. Semantic wikis are often used as knowledge bases within organizations. The formalized processes can be connected to these existing knowledge structures with annotated links. These linked process and knowledge structures improve the navigation and retrieval. In addition, semantic queries can be used to detect errors or constraint violations in knowledge bases [Vra10] and respectively in our process model descriptions, for instance a search for the executors of all process activities using a specific confidential document.

7.2.1 Supported graphical elements

A subset of BPMN elements is offered to users supporting all of the *Basic Control-Flow Patterns* introduced in [RHAM06], namely *sequence pattern*, *parallel-split pattern*, *exclusive-choice pattern*, *synchronization pattern*, and *simple-merge pattern*. A task is the basic element of our process. Depending on the granularity level of the process a task can vary from an atomic task, such as *open a web page*, to a task describing a whole sub-process. Within our approach we do not use the BPMN element describing a sub-process. Sub-processes have to be expressed with annotated links between tasks and processes.

Control flow pattern	**Used elements**
Sequence pattern	Simple edge
Parallel-split pattern	Parallel gateway
Exclusive-choice pattern	Data-based exclusive gateway with condition edges
Synchronization pattern	Parallel gateway
Simple-merge pattern	Data-based exclusive gateway

Table 7.1: Mapping of basic control flow pattern to graphical elements

To express the control flow of the process, we use edges in the diagram and two special predefined process elements (gateways). The *Sequence Flow* element defining the execution order is a simple edge. For the parallel-split pattern and synchronization pattern, the *Parallel Gateway* element of BPMN is used. It implicates for the split that all outgoing branches are simultaneously activated. For the synchronization, it waits until all incoming branches are completed before triggering the outgoing flow. The *Data-based Exclusive Gateway* is used to express exclusive-choice pattern and simple-merge pattern. The sequence flow is exactly routed to one of the outgoing branches, when the process splits. The other way round, it waits until one incoming branch is completed. We further support *Conditional Flow* and *Default Flow* for stating conditions, determining the selection of the outgoing branch. An overview of the full mapping can be found in Table 7.1.

7.2.2 Mapping of graphical elements to SMW

As soon as the graphical representation is stored within the semantic wiki, a summary wiki page belonging to the category *Process* is created and the process elements presented in Section 7.2.1 are translated into SMW constructs. Figure 7.6 summarizes this mapping.

Type	Symbol	Mapping
Task		[[Category:Process Element]] [[has Type::Task]] 
Sequence		[[has Successor::<Successor>]]
Parallel Gateway		[[Category:Process Element]] [[has Type::ParallelGateway]]
Data-based Exclusive Gateway		[[Category:Process Element]] [[has Type::Exclusive_Databased_Gateway]]
Condition		[[has ConditionSuccessor::<Successor>;<Condition>]]

Figure 7.6: The mapping of graphical elements to SMW

Every single process step (activity) is represented as a wiki page belonging to the category *Process Element* and linked via the properties *has Type* to the corresponding type (*Task*) and *Belongs to Process* to the corresponding process, represented as wiki pages themselves (process summary pages). If an element has a successor (sequence pattern), it is connected with an edge to the successor element in the diagram. We map this with the additional property *has Successor* on the corresponding wiki page in SMW. For more successors executed in parallel (parallel-split pattern), a Parallel Gateway is used in between the activities, which is represented as a separate wiki page belonging to the category *Process Element* and linked via the properties *has Type* to the corresponding type *ParallelGateway*. An activity can have several successors, but only one has to be selected and executed. Therefore we use the Data-based Exclusive Gateway without conditions, stored as wiki page belonging to the category *Process Element* and linked via the properties *has Type* to the corresponding type *Exclusive_Databased_Gateway*. The Data-based Exclusive Gateway with conditions is used to split based on a condition (exclusive-choice pattern). A condition is stored as a many-valued property.[7] The first value is the id of the successor element and the second value is the condition itself stored as a string value. The different spellings of the *has Type* values result from the Oryx implementation, where CamelCase notation and underline character are used for the different types.

In contrast to the process extension approach presented in Section 7.1, the *has OrSuccessor* property is redundant, because gateway elements are in place to express the multi-choice pattern. The distinction between the synchronization pattern and the simple-merge pattern is realized by using the Parallel Gateway and the Data-based Exclusive Gateway the other way round to merge different branches of a process.

The basic vocabulary used in the semantic wiki is illustrated in Figure 7.7.

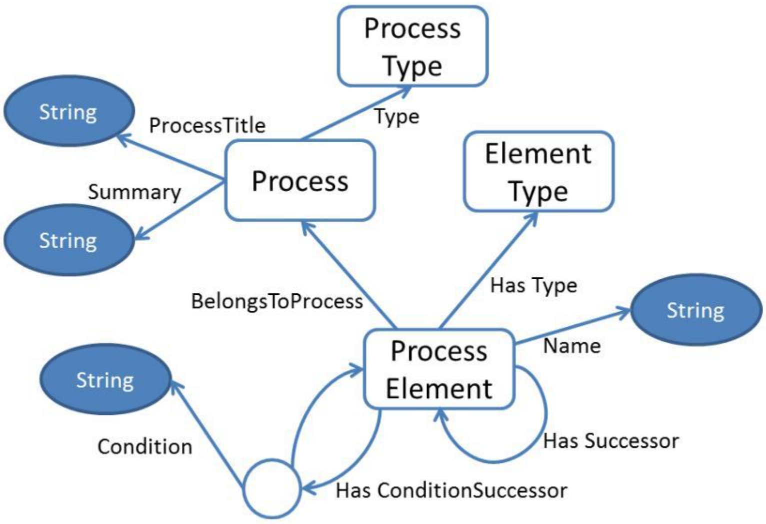


Figure 7.7: Basic wiki process vocabulary

7.2.3 Classification of our approach into the research areas of BPM

Our approach can be classified in the *Design and Analysis* phase of the BPM lifecycle, presented in Section 2.2.2. It support the core task within this phase, namely process

[7]Many-valued properties in SMW are implemented as records, see `http://semantic-mediawiki.org/wiki/Type:Record`.

modeling. In contrast to traditional BPM lifecycle approaches, where the contribution is restricted [BDJ+11], all stakeholders can collaboratively contribute to process modeling, no one is excluded. This is also important for the following phases. For instance, process implementers can be easily integrated in the modeling phase to get feedback for a feasible implementation.

Concerning the six BPM core elements, introduced in Section 2.2.3 the approach can be classified in four of the elements, namely *Methods*, *Information Technology*, *People* and *Culture*. Our approach provides a methodology for the wiki-based maturing of process descriptions that supports the design phase of the BPM lifecycle. This fits in the category *Methods*. As a our approach is also based on a tool, supporting the design activity, it is part of the *Information Technology* element. *People* and organizational *Culture* can also be very important for our approach. People have to share their process knowledge with each other. Without collaboration and a collaboration-friendly environment, maturing of process descriptions is not possible [RB10].

7.2.4 Application of our Approach

The presented approach can be applied on various scenarios. In this section we illustrate how our approach can support the scenarios presented in Chapter 5, namely the process development in an SME and the proposal development process in a large consultancy company.

The process development in an SME described in Section 5.1.3 is supported in different ways. By applying our approach, all stakeholders from the different departments in a company can contribute to the modeling process. The wiki solution can be accessed with a simple browser, typically installed on office computers. Technical barriers, which can occur, when additional software has to be installed cannot emerge. In addition, nobody is excluded due to the lack of modeling expertise. Novices in process modeling can use natural language to describe the process. The stakeholders can work together by discussing and refining the process description. As a result, all activities required to produce the product in mass production can be captured and documented. By using our approach the design rationals do not get lost during the refinement of the models. Changes in the real processes that emerge during executions can directly be adjusted in the model by any user, because everybody can access the wiki solution and refine the process descriptions. As a result, the model-reality divide [SN09] can be reduced.

The business design processes can also be developed by using our approach. The methods and guidelines can collaboratively be defined and refined. Stakeholders can discuss the different stages and milestones. Additional information required for completing a stage can be made available on the corresponding wiki page. Relevant documents describing the business idea and opportunities in different stages can be linked to the steps and filtered with semantic queries. The high-level process can be reused for each new idea and further refined.

The collaborative proposal development scenario described in Section 5.2.3 can also be supported. Since many people with different expertise and roles are involved, everybody can contribute in acquiring the proposal development process descriptions. Depending on the expertise and the available time, proposal team members can thereby alter the process to take advantage of it (e.g., contributing only to parts of the proposal document for which they have the necessary knowledge). Additionally, previous proposal documents can be linked to specific process activities using semantic properties. Thus relevant proposals can be filtered out by using semantic queries. Also less experienced proposal team members can profit from the process wiki, because they can look up and follow the developed processes. The formalized processes can also be used as a basis for the input in a process execution engine, e.g., accessing the RDF export interface via the process execution tool.

7.2.5 Advantages of our approach

Our approach addresses current issues in process modeling. The application implicates various advantages. The combination of graphical representation, natural language, and formal semantics allows collaborative modeling for both novices and experts. Textual and graphical elements can be used interchangeably or complementarily. If the user does not know the graphical representation of a process element, natural language can be used to describe it on the corresponding wiki page.

Standard wiki features can be used for process modeling. Users can discuss the processes and their elements. The versioning functionality allows users to access previous versions and revert to them. Users can automatically be informed about changes in the process model by putting the process wiki pages on their watch list. All these features foster the collaboration between the users. In addition, all design rationals are documented in a way that everybody can access them within the same system.

To get a rich and complete picture of the process, as many stakeholders as possible have to participate in the process modeling task, because the quality of the process description is considered higher, when more stakeholders are involved [HV04]. A wiki-based collaborative process development environment allows including all stakeholders in process modeling. The required organizational and semantic integration are also addressed with our approach; all users can contribute to process modeling and the definition of terms is done in a multitude of small steps, giving each contributor the ability to adapt easily to a common usage of terms [BDJ+11]. The discussion functionality also supports the definition of terms in a collaborative manner. Thus, users can discuss and evolve the meaning of terms.

The semantic wiki acts as a process repository where processes and their process semantics are stored. Process knowledge can be linked, queried and displayed on process pages and on other wiki pages (e.g., what input documents are used, can be made available and processable for computers). In addition, this approach uses an extensible underlying schema. Users can introduce their own properties in the wiki by using the SMW property syntax on the process element wiki page. Structured data can improve the search for processes (e.g., [LSC10]).

7.2.6 Discussion

Another important aspect in a collaborative process development environment is the trade-off between usability, especially for users being novice in process modeling, and expressivity of the used process formalism. The quality of the process descriptions in terms of semantic correctness and required formalisms highly depends on the use case. While a process, which should be automatically executed, must be fully formalized and semantically correct, a process, executed by a human, does not necessarily have to meet such a high standardization and formalism. Novice modelers contributing with their domain knowledge can be involved in both scenarios. As long as only human executed processes such as the methodologies described in Section 5.2.4 are modeled, the expressivity of the process language can be reduced to enhance usability due to two reasons. First, novice users are provided with intuitive means to model processes. Second, novices in process modeling have to read and understand the process descriptions. A process model is hard to understand, if too many elements are used, which are not known to the readers. For automatically executed processes, experts are required in a second step to refine the process descriptions by adding further elements and attributes required for the execution.

Our approach allows including all stakeholders in process modeling, but it is not assured that all stakeholders contribute to process development. Depending on the use case, proper incentives for the knowledge producers have to be provided, which motivate people to contribute [Mar01].

The people in the community are responsible for detecting and correcting errors in process descriptions. This community validation has high potential, especially when natural language is used to describe processes, but it is also very time-consuming. When many people collaboratively contribute, it could be a benefit to introduce a process gardener role similar to a wiki gardener, which is mostly applied in organizations to address proliferation [HT08]. The gardener can be seen as an intermediary [Mar01] or facilitator [Hen05] spending time in polishing the content. Intermediaries have to cope with activities which support knowledge reuse such as abstracting, indexing, authoring and sanitizing [Mar01]. Facilitators support groups in their process modeling effort. While some aspects such as the grammar, the method of the modeling technique, and completeness of the model can be controlled by a tool or the domain expert, only a person with expertise in process modeling can fully translate the elements occurring in reality into model concepts [Hen05]. Thus, the process gardener should be an expert in process modeling.

Renger et al. [RKV08] also suggest to involve a chauffeur or modeler in collaborative modeling to achieve syntactical quality of the model. Such a role is equivalent to our process gardener.

The process gardeners could also benefit from domain expertise, but it is not necessary. If they do not have the knowledge about the domain, the maturing of the model needs (more) iteration steps with the domain experts until the model is accordingly created.

By introducing a process gardener, the quality of the process description can be improved, but the introduction of a process gardener can also generate additional costs. Traditional modeling practices, where internal or external business process consultants conduct workshops and generate the process models, are also time and cost intensive. The expected time and cost savings, which can result from the usage of the collaborative tool, could be used to employ process gardeners, which can be engaged in more process modeling activities in the wiki at the same time. Special semantic queries can be formulated to detect errors within process models similar to the validation of a knowledge base presented in [Vra10]. For instance, a query asking for all process steps and their corresponding role can point the user to process steps, which have no assigned role.

Another challenge is the integration of sub-models, different perspectives and changes created in parallel to speed up the process [RKV08]. Within our approach for wiki-based maturing of process descriptions everybody has access to all processes which can foster a shared understanding and reduce the integration effort. It is also possible to use the provided discussion functionality to clarify integration issues during modeling.

The translation of existing textual descriptions into graphical models is a current research area. Many different approaches have been proposed (e.g. [GKC07, FMP11, GSB11]). As the focus of this thesis is on the collaborative maturing, the translation of textual descriptions does not play such an important role. Currently, we only support basic translation of structured textual process descriptions (see Section 7.4), which is sufficient for our approach. The textual descriptions are automatically translated to display a graphical representation of the process to the user in the graphical interface. Our translation can be seen as a first draft, which can directly be refined by the user. The user must confirm the model by actively saving the new created graphical representation. Thus, users can correct errors in the translation, which reduces the claim of a fully correct translation compared to automatic translation approaches without user interactions. Nevertheless, our approach can benefit, if better translation algorithms and solutions are incorporated.

Finally, a lot of knowledge is lost if only the abstract graphical model is retained, which is the result of traditional process workshops in organizations. All the natural language descriptions, discussions, and different previous versions contain additional knowledge about a process, which is relevant for humans to better understand the process. The wiki-based collaborative solution can help to avoid this, but they have to be applied in an early phase of the development of process descriptions [HV04].

It can be beneficial for users involved in the process maturing activity if a wiki already exists within an organization. Our wiki-based process maturing approach can be easily implemented into an existing wiki. The new created process descriptions can then be linked to the knowledge already existing in the wiki.

7.3 Implementation of Wikiing Pro

The Semantic Result Formats process extension described in Section 7.1 serves as a foundation for our development. To support our approach with a tool, we developed a wiki-based graphical process editor. We selected Semantic MediaWiki (SMW) introduced in Section 3.1 as the wiki component. SMW already provides the required collaboration functionality for wiki-based maturing of process description. In addition, it serves as a background semantic knowledge base used to store the process knowledge, including flow information and functional process knowledge. Unfortunately, the basic SMW only allows textual editing and does not provide graphical editing functionality. Furthermore, the process extension for SMW described in Section 7.1 only supports the translation of predefined SMW properties, annotated within the wiki page, into a process graph. The other way round, graphical editing of the process model, is not provided. To enhance SMW with graphical editing capabilities, we integrate a graphical process editor.

For our implementation we selected the Oryx process editor, described in Section 3.2, as the graphical process editor component. Oryx basically provides the modeling functionality required to support our approach. In addition, it is an open source project, which allows us to access and modify the source code for our purpose. As stated above we only use a small subset of BPMN constructs for our approach. Therefore the stencil set extension functionality of Oryx is used to reduce the amount of available modeling constructs. The stencil set extension of Oryx can be further used to add additional element properties.

SMW was extended to be compatible with the Oryx graphical editor, so that data can be exchanged between both. Three new SMW API calls have been added to access, translate and store process descriptions. In addition, the Oryx graphical editor has been complemented to display and edit wiki pages seamlessly from within its interface; as a consequence, users can directly access the corresponding wiki page within the process editor. The wiki text entered in the Oryx interface is rendered by using the parse method provided by the SMW API. Thus the whole SMW syntax can also be used within the graphical interface including categories and properties. SMW

ASK queries are executed and the results are displayed as well. Both the originally entered text as well as the parsed wiki text are temporarily stored within the data model of the Oryx process editor as additional hidden properties.

Even though technically the process editor runs on a separate Tomcat server, the SMW authentication is also used to control the access on the process model within the process editor, providing a seamless experience between the two different components.

7.3.1 The graphical process editor interface

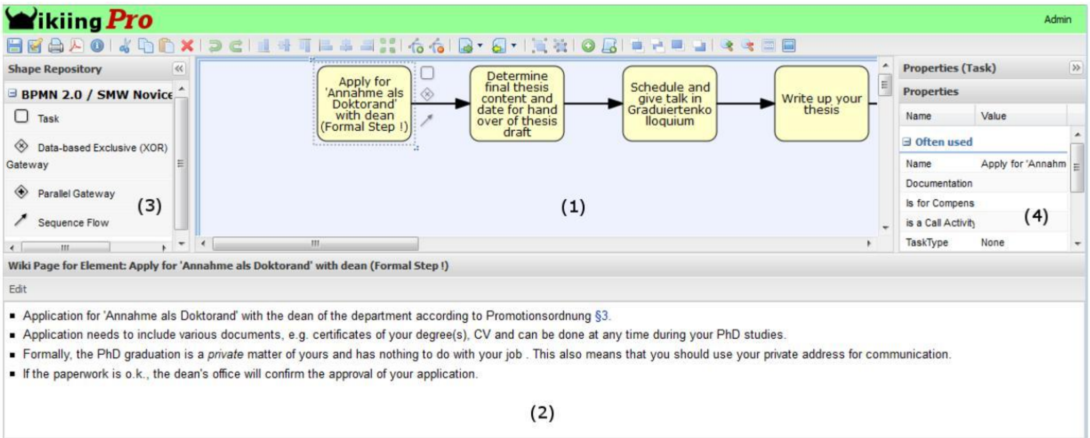


Figure 7.8: SMW process editor screen shot

As can be seen in Figure 7.8, the process editor interface consists of four different regions. While the (1) graphical representation is displayed in the middle, the (2) corresponding wiki page is showed in the bottom of the editor. The available (3) process elements (listed in Figure 7.6) are presented in the left region of the editor, namely *tasks*, *sequence flow*, *parallel gateway*, and *data-based exclusive gateway*. The (4) corresponding properties of the process elements respectively the process canvas are displayed in the right region in the property window, depending on the selected element(s). The property window originates from the Oryx implementation. Only the condition property is used, other available properties are ignored within the current SMW integration as they are not required.

Users can easily add process elements to the process description by selecting and dragging a process element from the left region and dropping it on the process diagram in the middle. After the first element is added to the process diagram, new successor elements can also be added by using the context menu of the existing element. If a new process is created or a new element is added to the graphical representation, the user can click on the *create wiki page* button to access the edit mode of the newly created wiki page. Once the user has finished to modify the wiki text, the modification can be saved by clicking the *end edit mode* button or discharged by clicking the *cancel* button. If the user selects another process element before ending the edit mode, a dialog box appears where the user can select if the modifications should be saved or discharged. As a result, the modifications cannot get lost as it was the case during the evaluation with the students (see Section 8.2). The process data are only stored within SMW, when the user saves the process description by clicking on the *save* or *save as*[8] icon in the process editor menu.

7.3.2 The SMW backend

SMW is used as the backend knowledge base for the graphical process editor interface. Once the process is saved, the process is transferred to SMW via the newly developed API. Only logged-in SMW users can store processes. A valid access cookie is required. The graphical representation (SVG) and the serialized data (JSON object) including the formalized model and the wiki text belonging to each process element are committed to SMW. The data are further processed within SMW by creating or updating wiki pages. For each process a process summary page with the process name as its title is created, containing the graphical representation in SVG format, a fact box and the textual description with semantic annotations. As a consequence, each process has a unique name in SMW.

The process elements are stored as subpages to the process summary page. The process element wiki pages contain the textual descriptions and a fact box showing a selection of the stored properties (see Figure 7.10). The unique id of the process element is used as the subpage title. This allows using same process element name twice or more times within a process.

The elements are mapped as described in Section 7.2.2. The categories are assigned using predefined templates. The process and element properties are translated into SMW properties and stored as SMW properties with their corresponding value. Thus, all properties are also available and accessible in SMW. As a result, all the process properties can be queried and exported without extending SMW, because the basic functionality provided by SMW is reused.

Links to the corresponding wiki pages are automatically added to the SVG figure, which enable the user to navigate through the process in the wiki.

[8]The *save as* icon have to be used, if a user wants to store an existing process description under a new name.

7.3.3 The SMW user interface

SMW does not only serve as semantic knowledge base in the backend, but also offers the wiki interface to the user. Templates including semantic queries are used on the process wiki pages to present the most important properties and their values in a fact box. These templates can be enhanced to show additional properties. Each graphical representation is displayed on a process summary page. An example summary page is presented in Figure 7.9. This summary page also contains the textual descriptions. The figure is stored in SVG format including the links to the subpages of process elements. A fact box consisting of a summary description and the type of the process language is also included in the basic process summary page template.

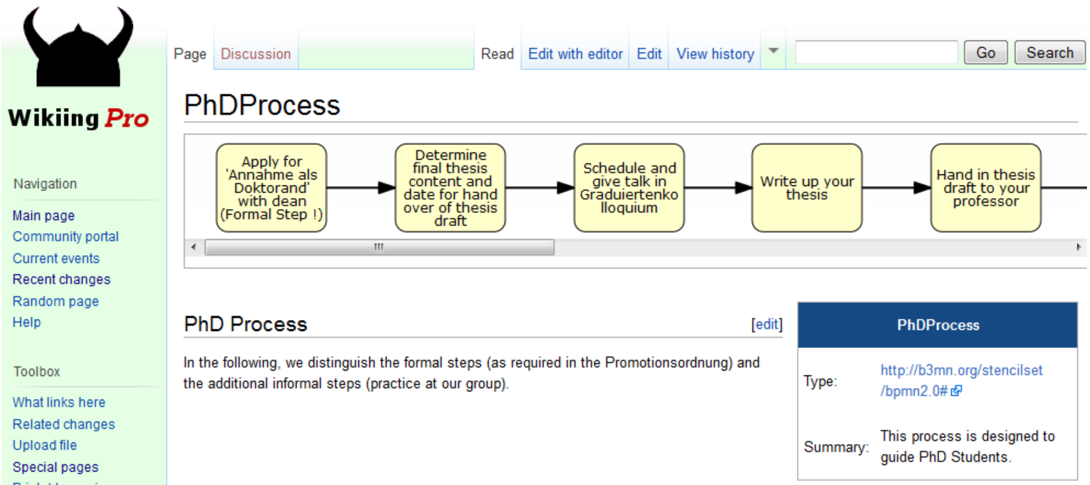


Figure 7.9: Example process in SMW (process summary page with fact box)

The textual descriptions of process elements are displayed on the process element pages. A template is also used to display process element properties and their values in a fact box as shown in Figure 7.10. The template can also be extended to show additional properties and their values.

If a user clicks on the standard edit tab, the viewed wiki page is displayed in the standard textual edit mode as shown in Figure 7.11. The process semantics including successor relations and describing properties can only be edited in the graphical mode and are hidden in the standard edit mode. The user can only modify the textual descriptions and the included semantic annotations additionally added in the textual description by the users.

A new MediaWiki tab *Edit with editor* has been added to the process wiki for editing existing processes. The tab automatically appears on all pages belonging to the categories *Process* and *Process Element* as shown in Figure 7.9 and in Figure 7.10. If the

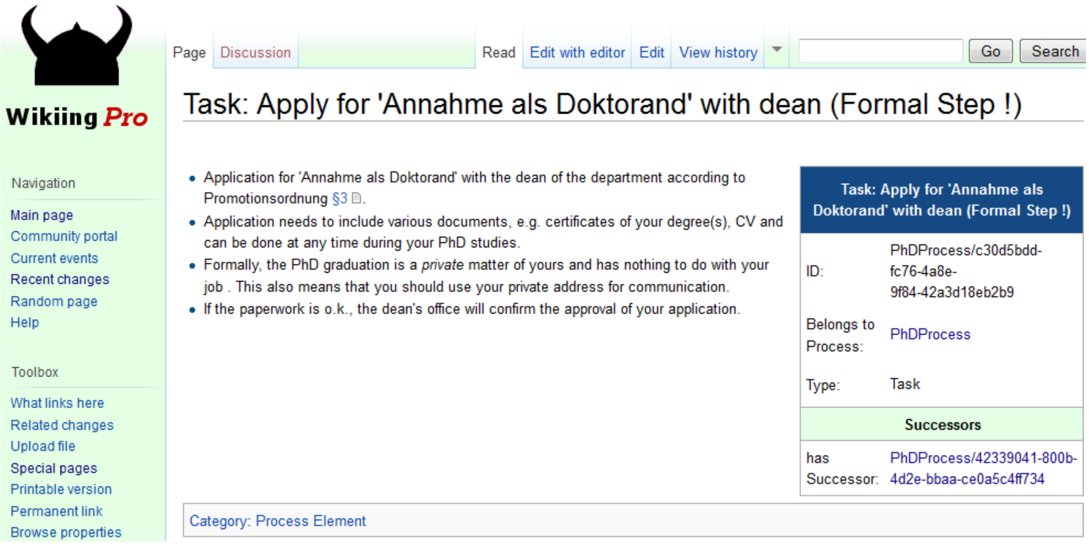


Figure 7.10: Example task in SMW (element wiki page with fact box)

Figure 7.11: Example textual description of a task in SMW edit mode – process semantic is not shown to the user; it can only be changed in the graphical edit mode

user clicks on *Edit with editor* tab, the graphical process editor with the process model is opened in a new browser tab. The users can then browse or update the process in the graphical interface.

An additional MediaWiki tab *Create Process* has also been added to the process wiki for creating a new graphical representation from textual process descriptions as explained in Section 7.4. The tab automatically appears on all wiki pages belonging to the main namespace. The main page and pages belonging to the categories *Process* or *Process Element* are excluded as they are already part of a structured process description. As shown in Figure 7.12, a *Create Process* tab is displayed on a wiki page containing an example HowTo. By clicking on this tab, the graphical editor interface is displayed and the process described with text on a single wiki page or on multiple wiki pages connected with predefined semantic annotations is transformed into an editable graphical representation. First an internal semantic query is executed asking for process elements belonging to the selected wiki page. If the query returns a result, the multiple wiki page transformation (see Section 7.4.2) is performed otherwise the single wiki page transformation (see Section 7.4.1) is executed.

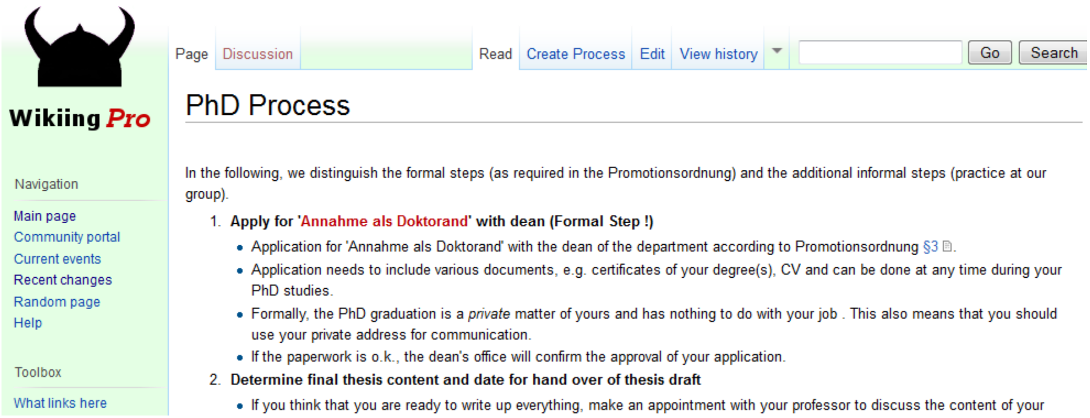


Figure 7.12: Example HowTo in SMW with *Create Process* tab

7.4 Transformation of existing textual processes

In traditional (semantic) wikis, processes are stored either as a textual description or images on a single wiki page or they can also be expressed by connecting various wiki pages like in the approach presented in Section 7.1. The single page process descriptions are usually simple HowTos, structured as a numbered list, bullet items or definition items. The single page process description can also contain a process graphic, representing an informal process description created in an external tool (e.g., a Microsoft Visio or Powerpoint graphic stored as picture). In this thesis we concentrate on the textual descriptions and exclude these graphical informal process descriptions, but there are approaches to automatically inferring formal process models from informal business process diagrams [MDS+10].

The interlinking of multiple wiki pages can define a single process (by describing single tasks or sub-processes on their own pages, and then interlinking these). A way to specify such a process, by using predefined Semantic Properties to express flow relations, is described in Section 7.1. With our wiki-based approach, we support both ways of transforming wiki pages into graphically editable process descriptions – single and multi wiki page transformations. As the process descriptions which consist of multiple wiki pages are more structured, this transformation is preferred. Predefined properties also allow for *parallel* and *exclusive split*, which is currently not supported in single page translation.

For the positioning of the process elements, we selected the automatic layout algorithms provided by GraphViz DOT [KN02], but also other automatic layout algorithms can be used (e.g., [See97, KKLS09]).

7.4.1 Single wiki page transforming

Simple HowTos, like in WikiHow, are usually formatted as numbered lists. MediaWiki supports to format wiki text as number lists. MediaWiki syntax allows building ordered lists by using the hash character (#) at the beginning of subsequent lines as already described in Section 3.1.1. We parse the wiki text of such a single HowTo page with our extension for the transformation. Regular expressions are used to identify the hash character at the beginning of a line, similar to the approach presented in [VGR11]. If a text line matches this pattern, we create a task element and display the text in our first version either as the name of the process step or on the corresponding wiki page, if it is longer than 80 chars, otherwise the text would not fit into the graphical task element. Our extension also identifies bullet lists and definition items, included in the numbered list. The bullet or definition items are directly displayed as part of the corresponding wiki page. The sequence of the task elements is created out of the sequence of the numbered list items. If a wiki page consists of multiple numbered lists, all numbered lists are transformed into task elements, but the different lists are not connected.

To arrange the elements in the graphical representation, we use existing graph layout algorithms provided with GraphViz DOT [KN02]. A textual description of the graph is created in the GraphViz DOT language and transformed into a graph with DOT. In a next step, the coordinates of the graph elements are used as coordinates of the process elements.

A HowTo can look like the numbered list shown in Figure 7.12. The graphical transformation of this textual process description is illustrated in Figure 7.8. Upon saving the page, the enumeration will be replaced with the process summary page as shown in Figure 7.9 and the subpages for the elements are created.

7.4.2 Multi wiki page transforming

A process can be described on multiple wiki pages. To detect such a process, the single wiki pages have to be connected to each other with predefined properties. For our approach we use the predefined properties specified in Section 7.1 to express the process flow. By taking these predefined properties as connectors between the wiki pages, we also assume that each wiki page represents a process step (activity) and is thus mapped to a task element in the graphical model. In addition, wiki pages representing a process step must be linked to an identifier. In our case, we use the property *Belongs to Process*. This property is used within the internal semantic query, retrieving all wiki pages belonging to a specific process and their flow properties. For each property *has Successor* an edge (*Sequence Flow* element) is created between the subject and object of the property. If a task has multiple successor properties, a *Parallel Gateway* element is included, from where the edges go to the multiple successor tasks. The *Data-based Exclusive Gateway* is used for each *has OrSuccessor* property and their condition properties. If a condition flow is specified using the properties *has Condition*, *has ConTrueSuccessor* and *has ConFalseSuccessor*, a *Data-based Exclusive Gateway* is drawn and the outgoing edges are labeled with *True* and *False* in the graphical representation. The value of the *has Condition* property is inserted into the wiki page of the *Data-based Exclusive Gateway* element. Even if the process is not connected semantically correct with the predefined properties (e.g. *has Successor* and *has OrSuccessor* on the same wiki page), the graphical representation is created according to the expressed model.

The content of each wiki page defining the process activities is also included in the wiki page of the corresponding process element, thus describing the activity.

The layout of the graphical representation is also generated with GraphViz DOT [KN02]. The predefined SMW properties are translated into the GraphViz DOT language and transformed into a graph with DOT according to the approach presented in Section 7.1. The coordinates of the graph elements are also used as coordinates of the process elements.

When the user saves the transformed graphical representation of the process description, the process in the new structure is stored in the wiki. The previous process summary page is replaced with the new one and the process elements are stored as corresponding subpages. To avoid duplicates, a redirect link is inserted on each previous element of the process description to the corresponding new process step subpage. With these redirects in place we can assure minimal negative impact due to the transformation and allow all existing links to continue working.

7.5 Comparison of our tools with existing solutions

Our approach can also be compared against the requirements presented in Section 6.1 and with other solutions. Table 7.2 shows the result of the comparison of our tools with the different wiki-based tools for maturing of process descriptions from Table 6.1. A filled out circle ● indicates that a tool fully satisfies the requirement. If it only supports a part, a half-filled circle is used ◑. An empty circle ○ indicates that the tool does not meet the requirement.

Approach	R1: Natural language support for novice users	R2: Intuitive graphical rendering and editing of processes	R3: Collaboration support	R4: Definition of a common language	R5: Structured process documentation support	R6: Automated translation of text into structured process description	R7: Mechanisms for process description validation
SMW+BPEL [HBV09]	●	○	◑	◑	●	○	○
MRM wiki [FTD10]	●	○	●	◑	◑	○	○
KnowWe extension [HRBP10]	●	●	◑	◑	◑	○	○
BP-MoKi [FGR+11]	●	●	●	●	●	○	◑
SRF Process extension	●	○	●	◑	●	○	○
Wikiing Pro	●	●	●	◑	●	◑	○

Table 7.2: Comparison of our approach with existing approaches using the derived requirements presented in Section 6.1

The SRF Process extension presented in Section 7.1 was our first approach to support wiki-based maturing of process description. As it was one of the first wiki-based approaches, showing that processes can be created by connecting wiki pages, it does not satisfy the requirements from the two current research streams, namely automated translation of text into graphical descriptions and mechanisms for process description validation. As the extension does also not provide a graphical editing interface, it is on the same level as the SMW+BPEL and the MRM wiki solution. The application in the ACTIVE project use cases (see Section 7.1.4) showed that it can be used to visualize processes, but it is not the appropriate solution for editing processes due to the lack of a graphical editing interface.

As a consequence, we further extended our first approach and implemented Wikiing Pro, the wiki-based process editor. It further supports intuitive graphical editing of processes and automatic translation of existing textual process descriptions into graphical representations. By providing intuitive graphical editing functionality, Wikiing Pro can compete with the KnowWE extension and with BP-MoKi. In contrast to the KnowWE extension, Wikiing Pro offers full collaboration structured process documentation support. Compared with BP-MoKi, Wikiing Pro only basically supports the definition of a common terminology as no explicit ontology creation support is offered by the Wikiing Pro tool. Wikiing Pro is the only tool partially offering an automatic translation of textual descriptions into graphical representation.

The SRF Process extension approach offers some automatic validation mechanism to detect tasks with unassigned roles by coloring them red. As this validation functionality is very limited we do not count it as supported in our comparison.

Currently, the Wikiing Pro tool does not offer automatic validation support, but it allows the user to formulate SMW queries, which can be used to detect errors or constraint violations in the process models (e.g., an empty cell in the result table for assigned roles indicates that a role assignment is missing). Those queries can also be written for the SMW+BPEL and SRF Process extension using their concept and property names. As BP-MoKi stores the semantic annotations in a separate knowledge base, SMW queries cannot be used for that reason.

Part III

Evaluation and Conclusion

Chapter 8

Evaluation

In this chapter we evaluate the Wikiing Pro tool presented in Section 7.3 in two different scenarios, namely a pre-evaluation with ten students and a real enterprise evaluation with three users.

We first introduce questionnaires assessing usability in Section 8.1. We briefly present the Computer System Usability Questionnaire (CSUQ) and the System Usability Scale (SUS), which we used for our two studies.

The first study, described in Section 8.2, was conducted with ten students. They had to model three existing textual descriptions each with the Wikiing Pro tool (see Section 7.3) and rate our system with an extended CSUQ. The results were used to get a first impression about the usability of the tool and to implement some of the suggestions from the students.

Subsequent to the further development of the tool, we performed a second evaluation within a real enterprise use case, which is presented in Section 8.3. The innovation and business development department was involved in the evaluation of the as-is state. In total 25 processes were modeled with the Wikiing Pro tool by the participants. At the end the usability of the Wikiing Pro tool was analyzed with an extended SUS questionnaire. Parts of this chapter are based on [DV11].

8.1 Usability evaluation

Usability is defined by ISO 9241 as the "extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use." [ISO98]. Usability is assessed by a set of users completing a set of tasks solving realistic problems with the system of interest. Usability evaluation is conducted to measure how the new product performs compared to own previous versions or competitors' products. Subjective and objective quantitative data in the context of real use cases can be gathered during usability tests by researchers. While objective data measures the performance of the participants, the opinions or attitudes of the participants are typically classified as subjective data [Lew95].

Over the years, various questionnaires such as Computer System Usability Questionnaire (CSUQ) [Lew95], Microsoft's Product Reaction Card (MPRC) [BM02b], Questionnaire for User Interface Satisfaction (QUIS) [CDN88], and System Usability Scale (SUS) [Bro96] have been created for assessing the user perceived usability of systems [TS04].

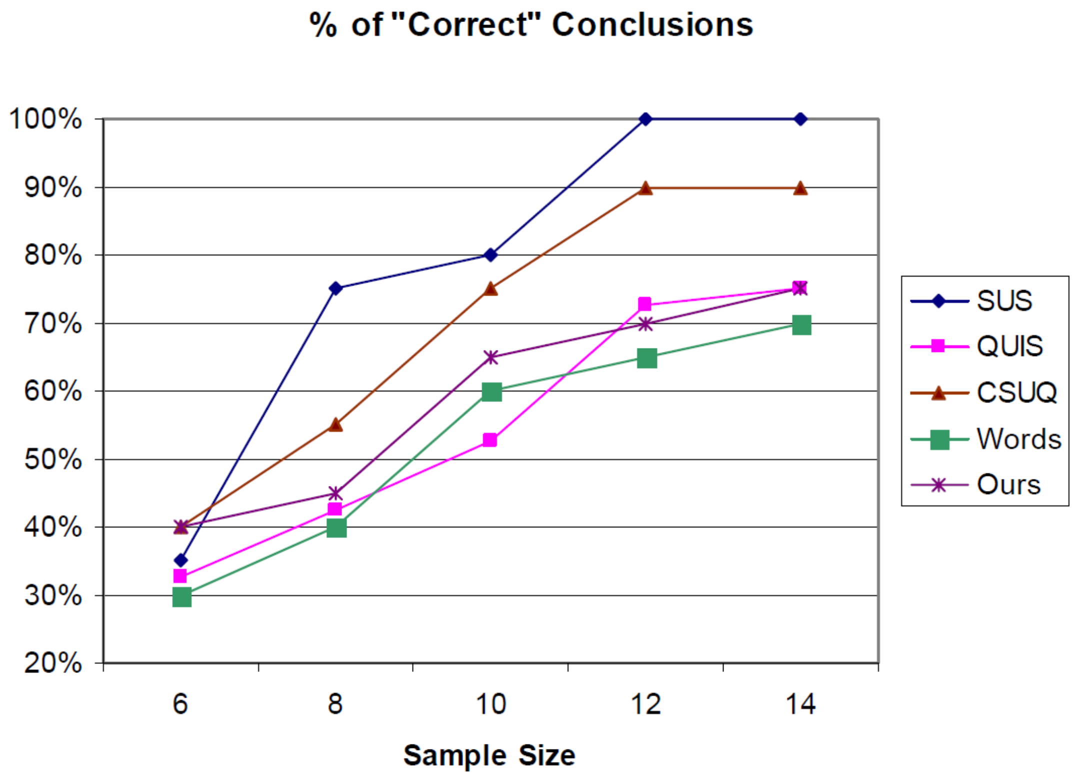


Figure 8.1: Comparison of the significance of the different usability questionnaires based on the percentage of correct t-tests of random sub-samples of various sizes (Source: [TS04])

Typically, only a small number of participants are involved in a usability test, which led Tullis and Stetson [TS04] to analyze the effectiveness of four standard usability questionnaires, namely CSUQ, QUIS, SUS, and MPRC and their own questionnaire according to their significance with the focus on Web sites. They set up a study with 123 of their employees, who had to complete two tasks on different Web sites and rank the usability with one of the questionnaires randomly assigned to them. They further analyzed how significant the results are, if the study had been done with randomly selected sub-samples of the data. Their results, illustrated in Figure 8.1, show that CSUQ and SUS have a higher accuracy with an increasing sample size than the other questionnaires. All questionnaires start with an accuracy of 30-40% at a sample size of six. The accuracy of SUS goes up to about 75% at a sample size of eight. The accuracy of CSUQ climbs to 75% at a sample size of ten.

As a consequence, we selected these two approaches for our experiments. For the first evaluation with students (see Section 8.2), we used CSUQ, because it contains more questions than SUS. Thus potentially leading to more detailed feedback valuable for the improvement of our system in an early stage of development and preparing the application in the company scenario. As we conducted the first evaluation with a sample size of ten participants, we assume on the basis of the comparison of the questionnaires above that our evaluation has an accuracy of 75%.

As the usability evaluation within the company took place in a setting where we expected fewer participants, we selected SUS, because the accuracy increases quicker than for other approaches. As time is a limited resource in enterprises, it is often important to have a questionnaire, which does not require vast effort and expense to fill out [Bro96]. SUS better suits to our industry use case because it contains fewer questions than CSUQ and does not require so much effort to complete.

8.1.1 Computer System Usability Questionnaire (CSUQ)

The Computer System Usability Questionnaire (CSUQ) was developed by Lewis [Lew95]. It is based on the Post-Study System Usability Questionnaire (PSSUQ) [Lew92] originally started with 18 items in a different order. An additional item was later added by Lewis to address all systems characteristics. The PSSUQ was slightly revised to the CSUQ to use it in a nonlabaratory setting. The CSUQ contains 19 statements and users have to rate them from 1 to 7, where 1 is *strongly agree* and 7 is *strongly disagree*. The list of questions can be found in Table 8.1.

Lewis conducted a factor analysis and found three factors, namely *System Usefulness*, *Information Quality*, and *Interface Quality*. He further calculated the reliability for all factors including the overall scale of the questionnaire. The results indicated acceptable scale reliability. The validity and sensitivity were also tested. He conclude that the factors are stable and that the questionnaire can be used to assess user satisfaction with a system in a nonlaboratory setting [Lew95]. The CSUQ score can be calculated as illustrated in Table 8.2

For our evaluation with students in Section 8.2 we used this questionnaire as part of our evaluation to gather detailed feedback about the usability of the Wikiing Pro system. We turned the rating scale that 7 is *strongly agree* and 1 is *strongly disagree*, which changes the result in the way that higher values are better than smaller ones as such a rating scale was more intuitive for our test persons.

1. Overall, I am satisfied with how easy it is to use this system.
2. It is simple to use this system.
3. I can effectively complete my work using this system.
4. I am able to complete my work quickly using this system.
5. I am able to efficiently complete my work using this system.
6. I feel comfortable using this system.
7. It was easy to learn to use this system.
8. I believe I became productive quickly using this system.
9. The system gives error messages that clearly tell me how to fix problems.
10. Whenever I make a mistake using the system, I recover easily and quickly.
11. The information (such as on-line help, on-screen messages, and other documentation) provided with this system is clear.
12. It is easy to find the information I need.
13. The information provided with the system is easy to understand.
14. The information is effective in helping me complete my work.
15. The organization of information on the system screens is clear.
16. The interface of this system is pleasant.
17. I like using the interface of this system.
18. This system has all the functions and capabilities I expect it to have.
19. Overall, I am satisfied with this system.

Table 8.1: The questions of the CSUQ (Source: [Lew95])

Score name	**Average the responses to**
Overall	Items 1-19
System Usefulness	Items 1-8
Information Quality	Items 9-15
Interface Quality	Items 16-18

Table 8.2: Rules for calculating CSUQ Scores (Source: [Lew95])

8.1.2 System Usability Scale (SUS)

Another questionnaire, the System Usability Scale (SUS), was created by Brooke [Bro96] resulting in a global view of subjective usability. His intention was the development of a simple, "quick and dirty" questionnaire allowing inexpensive assessments of usability in industrial systems evaluation. In contrast to the CSUQ, the SUS has only a ten questions. The user has to rate each item with a 5 point scale, where 5 is *strongly agree* and 1 is *strongly disagree*. The list of questions can be found in Table 8.3.

The SUS score, which ranges from 0 to 100 can be calculated as follows. The item score range from 0 to 4 which means that for items 1,3,5,7, and 9 the score is the scale position minus 1 as these items are positive questions. For items 2,4,6,8 and 10 the score is 5 minus the scale position as these items are negative questions. The thus

1. I think that I would like to use this system frequently
2. I found the system unnecessarily complex
3. I thought the system was easy to use
4. I think that I would need the support of a technical person to be able to use this system
5. I found the various functions in this system were well integrated
6. I thought there was too much inconsistency in this system
7. I would imagine that most people would learn to use this system very quickly
8. I found the system very cumbersome to use
9. I felt very confident using the system
10. I needed to learn a lot of things before I could get going with this system

Table 8.3: The questions of the SUS (Source: [Bro96])

calculated score of each item is summed and the result is multiplied with 2.5 [Bro96]. An example is shown in Table 8.4.

Question	**Rating**	**Item Score**
1	1	0
2	1	4
3	2	1
4	2	3
5	3	2
6	3	2
7	4	3
8	4	1
9	5	4
10	5	0
Sum		20
Score		50

Table 8.4: SUS score calculation example

For our evaluation within a real industry use case (see Section 8.3) we use this questionnaire to assess usability. A study by Finstad [Fin06], who conducted SUS with native English and non-native English speakers, indicates that an international English-speaking audience can have problems with understanding the unmodified SUS, especially in an automated Web tool. As a consequence, we translated the ten SUS questions into German, because all of our study participants were native German speakers.

8.2 Pre-evaluation with students

The first usability test of the wiki-based graphical process editor was conducted with ten students from different fields (computer science, economics, teaching), who were at the end of their studies. They were asked to model processes with our Wikiing Pro tool as part of the experiment. The goal of this evaluation was that we wanted to get a first impression about the usability of the Wikiing Pro tool used for process modeling. Since the tests were done in an early phase of the development, we expected to identify bugs as a side effect of the usability test. We did not provide the full functionality of the Wikiing Pro tool presented in Chapter 7 to the students. The automatic translation of textual descriptions into graphical representations was not available during the experiment. As a result the students had to create the process descriptions manually. We wanted to exclude the case that the students only use the translation functionality without modifying textual or graphical descriptions to get better feedback about the manual modeling with the tool.

The usability test was conducted as follows. First, the students had to model process descriptions. After modeling the processes, the students had to fill out a questionnaire containing questions about previous experiences and about the usability of the tool.

The students had different experience levels in using Semantic MediaWiki (SMW) and in modeling processes. Only five students had ever modeled a process before, one was uncertain. Four from these five students had already used a process modeling tool. Only four students have ever used Semantic MediaWiki before, for purposes independent of process modeling.

We used simple textual process descriptions with additional properties described in the text and with less than two splits. We selected four textual process descriptions specifying internal HowTos of the university institute AIFB and eight public available service process descriptions (GR01, GR02, GR03, GR04, GR05, IT01, IT02, and IT04) from the COCKPIT Project [KKKP10]. The internal HowTos were originally stored in the institute wiki and structured as numbered lists including bullet items. The service process descriptions from the COCKPIT project were structured as tables, containing the task name, a brief description, the task duration, required roles, possible next tasks, inputs, and outputs.

The students received a brief introduction of 20 minutes of the structure of the evaluation and the basic functionality of Wikiing Pro, which includes the drag and drop functionality of graphical process elements, the creation and editing of wiki pages within the graphical interface, an example how to annotate links in SMW to formalize process properties, and how to save processes in the wiki.

After this introduction, the processes were assigned to each student that each process were modeled at least by three students. Then the students were asked to model without any further hint. The results can be found in our evaluation wiki.[1]

The students modeled the same processes in different ways at different abstraction levels. While all students used task and sequence flows, only four students used the gateway elements. Conditions were modeled correctly by the students. They were sometimes expressed in the textual description, in the graphical representation, or in both representations. Two students used the color property of the nodes to differentiate between steps categorized as formal and optional, which was stated in the textual description. The same two students also modeled inputs and outputs as task elements in a different color. Another student used the task type property, available for each task element, and specified if a task is a service or if it is executed by a human. A SMW template for additional process parameters such as duration, inputs and outputs, was created and used by one of the students during the modeling task.

Additional semantic annotations were introduced by half of the students. Inputs, outputs, roles and task durations were specified with semantic annotations in the wiki text. However, the students used different names for annotating, resulting in uncontrolled growth of the SMW properties. Furthermore, the specific types of the semantic annotations were not set by the students. As a result, each duration value was misinterpreted as a wiki page and not as a data type. This can probably be traced back to the fact that the students did not know how to set types in SMW, because of their limited experiences with the tool.

At the end, each student had to fill out a web-based Computer System Usability Questionnaire (CSUQ) [Lew95], by rating 19 statements from 1 to 7 with respect to our tool, where 7 is *strongly agree* and 1 is *strongly disagree* (see Section 8.1.1). In addition, the questionnaire was extended with questions about previous process modeling experiences and free text questions about most positive and negative aspects. The full questionnaire can be found in Appendix A. The results of the CSUQ are shown in Table 8.5, where *N* is the number of responses, *AVG* is the average value, *DEV* is the deviation value, *MED* is the median, *MAX* is the maximum, and *MIN* is the minimum.

The overall assessment of the students about the usability of the tool was positive. They appreciated that the system was easy-to-use and were satisfied with the system. Only one person ranked it with a negative score. The evaluation results also show that the students could easily use the system and were immediately able to complete the requested task, the modeling of the three processes. Most students felt comfortable using the system and stated in the questionnaire that they became pro-

[1] The evaluation wiki can be accessed via `http://oryx.f-dengler.de` (Username: ProcessTester – Password: active!)

Question	N	AVG	DEV	MED	MAX	MIN
Overall, I am satisfied with how easy it is to use this system	10	5,30	1,35	6	7	2
It was simple to use this system	10	5,50	1,43	6	7	2
I can effectively complete my work using this system	10	5,60	1,28	6	7	3
I am able to complete my work quickly using this system	9	4,67	1,49	5	7	2
I am able to efficiently complete my work using this system	10	5,50	0,81	5,5	7	4
I feel comfortable using this system	10	5,20	1,47	6	7	3
It was easy to learn to use this system	10	5,40	1,74	6	7	1
I believe I became productive quickly using this system	9	5,56	1,34	6	7	3
The system gives error messages that clearly tell me how to fix problems	6	3,00	1,91	2,5	6	1
Whenever I make a mistake using the system, I recover easily and quickly	10	5,50	1,36	6	7	3
The information (such as online help, on-screen messages, and other documentation) provided with this system is clear	8	4,63	1,87	4,5	7	2
It is easy to find the information I needed	9	5,11	1,66	6	7	2
The information provided for the system is easy to understand	9	5,44	1,95	6	7	1
The information is effective in helping me complete the tasks and scenarios	9	5,33	1,63	6	7	2
The organization of information on the system screens is clear	10	5,20	1,60	6	7	2
The interface of this system is pleasant	10	5,90	1,58	6,5	7	2
I like using the interface of this system	10	5,90	0,94	6	7	4
This system has all the functions and capabilities I expect it to have	6	5,50	1,38	5,5	7	3
Overall, I am satisfied with this system	10	5,40	1,02	5,5	7	3

Table 8.5: CSUQ student evaluation results, where *N* is the number of responses, *AVG* is the average value, *DEV* is the deviation value, *MED* is the median, *MAX* is the maximum, and *MIN* is the minimum

ductive fast. The students enjoyed to use the interface and found it pleasant. The reverting functionality helped them to easily recover from modeling and interaction errors. Only the quality of the error messages was ranked negative in average. As we had only implemented generic error messages which were not self-explaining, we expected this rating.

As a few students complained that some the questions are hard to answer, some of the questions were not answered by all students.

We further calculated the overall score and the three factor scores for *System Use-*

Student	Overall	System Usefulness	Information Quality	Interface Quality
1	5,75	5,88	5,00	6,33
2	2,67	3,00	2,00	3,00
3	5,16	4,88	5,29	5,67
4	5,41	4,50	6,17	7,00
5	5,82	6,00	5,33	6,50
6	4,72	5,13	3,71	6,50
7	4,63	5,38	3,71	4,67
8	6,65	6,38	7,00	6,67
9	6,42	6,50	6,29	6,67
10	6,00	6,00	6,00	6,00

Table 8.6: CSUQ single student evaluation score

fulness, *Information Quality*, and *Interface Quality* for all students as illustrated in Table 8.6. The single results of the score values show that the score for interface quality was always higher or equal than the overall score. The systems usefulness was also ranked higher in 80% of the cases than the overall feedback. The score for information quality did poorly in most cases. This result is also reflected in the average score values presented in Table 8.7

Score name	Score
Overall	5,24
System Usefulness	5,34
Information Quality	4,89
Interface Quality	5,77

Table 8.7: CSUQ average student evaluation score

The students criticized that all information entered as wiki text was deleted when they clicked on another task while the wiki text editor was not closed using the *end edit mode* button. In addition they recommended that the system should provide duplication of pages within the modeler, in order to enable faster modeling of similar processes. Some students needed more time in the beginning to get familiar with the wiki syntax. As a positive aspect most of the students explicitly mentioned the intuitive usage. It was stated that it was easy to handle, because the user interface was perceived as simple and clear. The user interface was positively mentioned for not being overloaded with unnecessary features. Once a process is modeled, most students found that the system is very useful, because it can be easily understood and provides a user-friendly interface, which does not require additional knowledge to use it.

8.2.1 Discussion of results

According to the study from Tullis and Stetson [TS04] a number of 10 test persons results in an accuracy of 75% (see also Section 8.1). For our pre-evaluation such a setting was sufficient to obtain a first impression about the usability of our tool.

For this evaluation we decided that the students had to model existing textual process descriptions instead of leaving it to the students what processes they want to model. The advantage of such as setting was that we were able to compare the same processes with each other and with the textual process descriptions, too.

The students only got a brief introduction tutorial about the usage of Wikiing Pro. Most of the students had never used Semantic MediaWiki before. In the brief introduction tutorial, only the basic SMW functionality was explained. As a consequence, the students had to act on their own initiative, which was explicitly mentioned by one student in the interview; the trialists stated that he learned how to do use the tool either through explanation of other people, try and error or through looking at other processes, which were already in the wiki.

As we were able to compare the original textual descriptions with the modeling results of the students, we could also test if the processes are modeled syntactically correct. The tests illustrate that the models can be understood by experts, but the models for the same process description can differ. As two students used task nodes in different colors to model inputs and outputs, the models created by these students are not semantically correct. Inputs and outputs cannot be modeled with task elements, but experts can interpret these models correct due to the different colors for the elements used by the students. As our approach is based on the wiki principals (see Section 2.5.1), it is designed for collaborative process modeling. Other users could iteratively improve those process descriptions and correct the errors. This assumption also motivates the introduction of a process gardener as suggested in Section 7.2.6.

A SMW template was created and used by one of the students to reduce the effort for adding additional process parameters such as duration, inputs, and outputs to individual process steps. The usage of BPMN task types, which can be set in the property window of the graphical interface, by another student shows that he thought outside the box and identified and used helpful additional functionality, which was not introduced to them. Both cases further indicate that users are able to extend our tool to cover their needs.

The use of different names for SMW properties by the students show that we have to suggest to the people involved in modeling that they have to define a common terminology together before they start with modeling. Consequently, we added the point in our introduction presentation, which we used for further usability tests (see Section 8.3), as a common terminology collaboratively defined by the process modeling group can improve the search functionality when common semantic properties are used within semantic queries.

This pre-evaluation also shows that our tool can be used intuitively by process modeling novices who do not have previous experience with it. They used the standard features explained to them, which are sufficient to create basic process descriptions, which can be understood and refined by other users. Additional functionality provided by SMW such as setting types of SMW properties was not used by our test persons. Both observations also supports the claim, that experts in process modeling and wiki usage are additionally required to correct and refine process models for better reuse.

8.2.2 Conclusion

We acknowledge that our study bears certain limitations. First, only ten students were involved in our evaluation, but since all of them had no or only little experience with modeling processes, we can assume based on our findings and their feedback that the basic operation of the tool is accessible to novices. Second, different process descriptions can be created for the same process, which can also include errors. Our approach is designed for collaborative process modeling. Consequently, it can be assumed that in most cases the errors are corrected by other users iteratively and processes are improved collaboratively as it happens within wikis, for instance with Wikipedia articles.

The results are favorable and indicate that the tool can be used intuitively without any previous experience in process modeling. The tool provided the functionality needed to complete the assigned tasks. As the quality of the error messages was ranked negatively in average, we improved them in the second release, which was subject to the company use case. Additionally we added a pop-up window, where the users have to confirm if they want to save the modifications in the wiki text or discharge them. It automatically appears if the user selects a new element while editing the wiki text.

The overall results looked promising. The integration of natural language and graphical elements was widely used. Four students used additional features provided by the graphical interface and SMW, such as coloring graphical elements or the usage of templates. The use of such features was not expected by the evaluators, but shows that users can creatively extend the system to cover their needs.

8.3 Evaluation within an enterprise setting

Following the feedback from the pre-evaluation, we fixed the wiki text edit bug in our tool and modified the tool introduction presentation for the second usability evaluation within an SME. The evaluation was conducted with the innovation and business development department.

The evaluation was structured in three phases. First, we analyzed process descriptions created and used in the department, asked the employees about their experience with process modeling and let them rate their frequently used tool with SUS questionnaire. In the second phase we introduced Wikiing Pro and conducted a three-month test, where people developed process descriptions with it. Finally, we asked the participants to evaluate the Wikiing Pro tool.

8.3.1 Analysis of existing process descriptions and modeling tools

The current processes descriptions used within the innovation and business department have already been described in Section 5.1.4. The processes are represented either as full textual descriptions or as a mixture of graphical and textual descriptions. The level of detail also varies between the different graphical and textual process descriptions and also between the elements used within process descriptions. The descriptions were created with Microsoft Word, Powerpoint and Visio.

Before we introduced our Wikiing Pro tool within the department, we asked the people to fill out a questionnaire assessing the current modeling expertise, the used tools for process modeling, and their usability. The questionnaire was developed in German language to avoid misunderstandings and thus influencing the results (see also Section 8.1.2). It was structured as follows.

In the first part, we asked the people to provide the amount of process models, to which they have contributed and what process modeling language they have used before. In the second part the people had to rate their most frequently used tool for process modeling with help of a SUS questionnaire [Bro96] translated into German (see Section 8.1.2). Additional questions about the most positive and negative aspects of the rated tool and improvement suggestions complement the SUS rating section. The full questionnaire can be found in Appendix A.

Eleven people were invited to participate in the survey. At the end, six people had completed our questionnaire. The participants had contributed to a various amount of process descriptions ranging from 1 to 20 as shown in Table 8.8.

They also used different tools to create the process descriptions as illustrated in Table 8.8. A full circle ● indicates that the participant used the type of modeling tool before. An empty circle ○ indicates that the tool was not used. While most of the participants used standard office software, only one person had used a professional process modeling tool to create process descriptions. Participant 1 only used a graphical tool for developing process descriptions such as Microsoft Powerpoint and Visio. Participant 2 describes the processes with Microsoft Word. All three others used both textual and graphical tool. While Participant 3 created user stories as EPCs, all other participants used Visio and Powerpoint as graphical tool in combination with Microsoft Word as a text writing tool.

The participants further explained that the graphical tool was used to create a visual overview of the process and the detailed task descriptions are documented in natural language with Microsoft Word.

Participant	**Number of processes, to which the participant had contributed**	**Graphical tool (e.g., Microsoft Visio or Powerpoint)**	**Text editor (e.g., Microsoft Word)**	**Professional process modeling tool (e.g., ARIS)**
Participant 1	10	●	○	○
Participant 2	1	○	●	○
Participant 3	20	●	○	●
Participant 4	5	●	●	○
Participant 5	1	●	●	○
Participant 6	3	●	●	○
Sum	**40**	**5**	**4**	**1**

Table 8.8: Previous experience with process modeling. A full circle ● indicates that the participant used the type of modeling tool before. An empty circle ○ indicates that the tool was not used.

We further asked for the modeling languages, which the participants had used to create their process descriptions. The results are illustrated in Table 8.9. A full circle ● indicates that the participant used the modeling language. An empty circle ○ indicates that the language was not used.

The responses from the participants show that only two of them know that they had used a process modeling language. These two participants both had used BPMN and EPC. One of them also modeled process descriptions with UML. The other four participants could not specify the process modeling language, which they had used to create their process descriptions. They did not know it, which indicates that they do not have experiences with process languages.

Participant	BPMN - Business Process Modeling Annotation	EPC - Event-driven Process Chain	UML - Unified Modeling Language	Petri nets	YAWL - Yet Another Workflow Language	Not known
Participant 1	○	○	○	○	○	●
Participant 2	○	○	○	○	○	●
Participant 3	●	●	●	○	○	○
Participant 4	○	○	○	○	○	●
Participant 5	○	○	○	○	○	●
Participant 6	●	●	○	○	○	○
Sum	**2**	**2**	**1**	**0**	**0**	**4**

Table 8.9: Process modeling languages used by the participants for their process descriptions. A full circle ● indicates that the participant used the modeling language. An empty circle ○ indicates that the language was not used.

The participants also had to rate the process modeling tool they had used so far with the SUS questionnaire. The results are used later to compare them with the Wikiing Pro evaluation results. The score values of the different participants are presented in Table 8.10. The detailed results according to the German version of the questionnaire can be found in Table A.1 in Appendix A.

The comparison of the different score values shows that participants, who can specify the process modeling language, rate existing process modeling tools with a comparatively lower score.

Five participants have also provided feedback on the negative aspects of the tools they used. It was often stated that the tools in use had not been designed for process modeling. Only simple processes can be documented with Microsoft Word typically in form of task lists. The missing integration with other applications and the lack of collaboration support were other aspects that were rated negatively. The graphical tool provides a good overview, but lacks the possibility to add explanations to single process steps. In contrast, Microsoft Word can be used describe the tasks in detail, but it lacks a graphical overview of the process.

All participants mentioned as the only positive aspect that the existing standard office tools are easy to use. People are familiar with these tools and already know

Question	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5	Participant 6
I think that I would like to use this system frequently	1	3	2	4	3	1
I found the system unnecessarily complex	3	3	1	3	3	2
I thought the system was easy to use	2	3	1	3	3	2
I think that I would need the support of a technical person to be able to use this system	3	2	2	1	4	3
I found the various functions in this system were well integrated	1	1	1	3	2	3
I thought there was too much inconsistency in this system	2	3	2	4	3	2
I would imagine that most people would learn to use this system very quickly	3	3	2	2	3	2
I found the system very cumbersome to use	2	2	2	2	4	3
I felt very confident using the system	2	3	2	3	3	3
I needed to learn a lot of things before I could get going with this system	3	3	3	3	3	1
Sum	22	26	18	28	31	22
Score value	**55**	**65**	**45**	**70**	**77,5**	**55**

Table 8.10: SUS score calculation for the different tools used by the participants to model processes

how to work with them.

The test persons were also asked to name additional functionality, which they expect from the future process modeling tools. Collaboration support and integration with other systems were mentioned each by two people. An intuitive usability and pleasant representation also for new employees was considered beneficial. In addition, time required for the creation of process models should be reduced by the tool through the use of list and formulas.

8.3.2 Application of Wikiing Pro

For our field test, we set up a running instance of our Wikiing Pro tool on one of the internal servers of the company. In a second step, a meeting was scheduled where the Wikiing Pro tool was introduced to the employees in the department. This included the wiki and the semantic wiki concepts and their basic functionality. Links to further information, such as the full MediaWiki and Semantic MediaWiki syntax, were additionally provided within the presentation. A detailed manual about the usage of Wikiing Pro was referred to. It was explained how new processes can be created using drag-and-drop functionality, and how wiki pages can be edited within the graphical interface. Subsequent to the meeting, user accounts were created and credentials were sent to each participant.

The test phase was conducted for a period of three month from May to July 2011. 11 people were invited, but only four people actively contributed. They created a total of 24 process descriptions in total. Sub-processes, which graphically describe a process step in more details, were also included within these 24 process descriptions. In total eight sub-processes were modeled. Seven of them belong to the same main process and one of them belongs to another main process. Consequently, 16 processes were developed without using a sub-process hierarchy. Process numbers 1, 2, 4, 5, 8, 9 and 18 are all sub-processes of number 17. Process number 10 is a sub-process of number 12. Overall, 474 process elements were used within the 24 process descriptions. Each process consists of at least 7 process elements and has at most 38 elements. An overview of the modeling elements is presented in Table 8.11, where *N* is the number of used elements, *AVG* is the average value, *MAX* is the maximum, and *MIN* is the minimum number.

Element Type	**N**	**AVG**	**MAX**	**MIN**
Task	182	7,58	18	2
Sequence Flow	232	9,67	20	2
Exclusive Databased Gateway	33	1,38	6	0
Parallel Gateway	15	0,63	2	0
Data Object	5	0,21	5	0
Association Undirected	5	0,21	5	0
Start None Event	1	0,04	1	0
End None Event	1	0,04	1	0
Overall	**474**	**19,75**	**-**	**-**

Table 8.11: Number of different process elements modeled by the test persons,where *N* is the number of used elements, *AVG* is the average value, *MAX* is the maximum, and *MIN* is the minimum number.

The analysis of the developed process descriptions shows that a process description contains approximately 20 graphical elements in average. Each process description has at least two task elements and two sequence flow elements. In average, approximately eight task elements and ten sequence flow elements were incorporated in the process descriptions. The number of sequence flow elements includes the 26 condition successors modeled within the process descriptions of process number 8, 17, 18, 20, 21, 22, and 24.

The results also show that additional BPMN elements were used within the graphical representation. This was possible due to the modular implementation approach of the Oryx process editor (see Section 3.2) which allows users to enable and disable stencil set extensions, used to limit the number of modeling elements[2]. While one of the trailists added a start and an end element to a process description, another one used the *Data Object* element and undirected associations to connect the data object elements to other elements. The numbers of process elements are presented for each process in Table 8.12.

In addition to the number of process elements, we also analyzed the number of used properties and wiki text contributions for each process description. The results are illustrated in Table 8.13. While a full circle ● indicates that properties or wiki text were used on the process summary page, an empty circle ○ indicates that properties or wiki text were not used.

The analysis of the process descriptions shows that semantic properties are used on approximately half of the process summary pages and additional wiki text was entered in 75% of the process summary pages. Semantic properties were also used on process element pages. In average, 3,25 element pages of a process contain at least one additional semantic property. A textual descriptions was created on 3,63 element pages per process. All additional properties and wiki text were only used on task element pages, except in process number 22. In this process, semantic properties and wiki text were also entered in two exclusive databased gateway elements to further describe the decision conditions. As a result, 47% of the task elements contain a textual description. The developers of the process descriptions of process numbers 6, 14, and 23 used different colors to differentiate tasks and roles. The meanings of the different colors were stated on the process summary page for process numbers 14 and 23. The responsibilities were also expressed with semantic properties on each task element page. Only in process number 17 the user used a SMW ask query to display all process instances which are subprocesses of this process.

Conditions were not always modeled correctly in the graphical representation. In the processes with number 8, 11, and 18 condition expressions had been entered but the condition types were not set in the property window. In process number 20 condition types were set, but not labeled. Taking these conditions without labes into account the amount of condition flows in the statistics would increase from 26 to 43.

Additional BPMN elements, namely *data object*, *association undirected*, *start none event*, and *end none event*, were used within the process descriptions of process numbers 11 and 21. However, the additional elements were not used in a syntactically correct fashion according to the BPMN standard. In the description of process number 11, where the modeler introduced start and end events, an end event is missing, which results in an incorrect model. In process number 21, data objects had been used, but they are connected to gateways, which is also not correct according the BPMN standard. All other process descriptions are modeled syntactically correct.

The descriptions of process numbers 3, 11, 17, and 18 were collaboratively created

[2] The number of process elements was limited to reduce the complexity for novice users

Process	Task	Sequence Flow	Exclusive Databased Gateway	Parallel Gateway	Data Object	Association Undirected	Start None Event	End None Event	Sum
Process 1	6	6	0	2	0	0	0	0	**14**
Process 2	3	2	0	0	0	0	0	0	**5**
Process 3	14	16	2	0	0	0	0	0	**32**
Process 4	5	4	0	0	0	0	0	0	**9**
Process 5	3	8	2	2	0	0	0	0	**15**
Process 6	10	13	4	0	0	0	0	0	**27**
Process 7	6	5	0	0	0	0	0	0	**11**
Process 8	12	20	6	0	0	0	0	0	**38**
Process 9	3	3	0	1	0	0	0	0	**7**
Process 10	12	10	0	0	0	0	0	0	**22**
Process 11	4	13	3	0	0	0	1	1	**22**
Process 12	7	6	0	1	0	0	0	0	**14**
Process 13	4	3	0	0	0	0	0	0	**7**
Process 14	18	19	0	1	0	0	0	0	**38**
Process 15	4	3	0	0	0	0	0	0	**7**
Process 16	4	3	0	0	0	0	0	0	**7**
Process 17	11	16	2	2	0	0	0	0	**31**
Process 18	9	18	4	2	0	0	0	0	**33**
Process 19	4	4	1	0	0	0	0	0	**9**
Process 20	11	14	2	0	0	0	0	0	**27**
Process 21	2	10	5	0	5	5	0	0	**27**
Process 22	11	14	1	2	0	0	0	0	**28**
Process 23	14	16	0	2	0	0	0	0	**32**
Process 24	5	6	1	0	0	0	0	0	**12**
Sum	**182**	**232**	**33**	**15**	**5**	**5**	**1**	**1**	**474**

Table 8.12: Numbers of different process elements for each process.

by the users as shown in Table 8.14. Each process description was edited 5,79 times in average.

Our participants did not use the discussion functionality provided by Wikiing Pro in form of additional discussion pages to each wiki page. Consequently we cannot draw any conclusion about the usage characteristics of the discussion functionality.

Process	Properties on process summary page	Additional text on process summary page	Elements with additional properties	Elements with wiki text
Process 1	●	●	2	0
Process 2	●	●	3	1
Process 3	○	○	1	3
Process 4	●	●	1	2
Process 5	●	●	1	1
Process 6	○	○	0	1
Process 7	○	●	0	1
Process 8	●	●	0	0
Process 9	●	●	2	0
Process 10	●	●	0	0
Process 11	○	●	3	6
Process 12	●	●	2	3
Process 13	○	○	3	3
Process 14	●	●	17	17
Process 15	○	○	3	3
Process 16	○	●	0	4
Process 17	●	●	6	3
Process 18	●	●	1	2
Process 19	○	●	1	3
Process 20	●	●	4	5
Process 21	○	●	0	1
Process 22	○	○	9	9
Process 23	●	●	14	14
Process 24	○	○	5	5
Sum	**13**	**18**	**78**	**87**
Average	**0,54**	**0,75**	**3,25**	**3,63**

Table 8.13: Numbers of used properties and textual descriptions on process summary page and element pages. A full circle ● indicates that properties or wiki text were used on the process summary page. An empty circle ○ indicates that they were not used.

Process	Edits	Users
Process 1	8	1
Process 2	3	1
Process 3	2	2
Process 4	4	1
Process 5	8	1
Process 6	10	1
Process 7	6	1
Process 8	3	1
Process 9	4	1
Process 10	6	1
Process 11	22	2
Process 12	2	1
Process 13	2	1
Process 14	2	1
Process 15	1	1
Process 16	1	1
Process 17	28	2
Process 18	11	2
Process 19	1	1
Process 20	5	1
Process 21	1	1
Process 22	5	1
Process 23	1	1
Process 24	3	1
Average	**5,79**	
Collaboratively created processes		**4**

Table 8.14: Numbers of edits and collaboratively created process descriptions.

8.3.3 Evaluation of Wikiing Pro tool

After the field test, we asked the test persons to fill out a questionnaire assessing the number of process descriptions, where they have contributed to, their expertise with wikis and semantic wikis, and the usability of the Wikiing Pro tool. The questionnaire was also developed in German language to avoid misunderstandings (see also Section 8.1.2). It was structured as follows:

In the first part, we asked the people to provide the amount of process descriptions, to which they have contributed and to rate their experience with wikis and semantic wikis. In the second part the test persons had to assess the usability of Wikiing Pro with help of a SUS questionnaire [Bro96] translated into German (see Section 8.1.2). Additional questions about the most positive and negative aspects of the tool and improvement suggestions complement the SUS rating section. The full questionnaire can be found in Appendix B.

Six members of the innovation and business develop department, who participated in the pre-evaluation study, were invited to participate in the survey. We received three replies. The participants had contributed to a number of process descriptions ranging from 2 to 20, as shown in Table 8.15.

Participant 1	**Participant 2**	**Participant 3**
5	2	20

Table 8.15: Number of process descriptions to which the participant had contributed

As the sum of 27 contributions to process descriptions is higher than the number of 24 existing process descriptions in the Wikiing Pro tool (see Section 8.3.2), we can infer that some of the participants worked collaboratively on the same process descriptions. We further asked three questions about the previous experience with wikis. The results can be found in Table 8.16.

Participant	**Have you ever viewed wiki content**	**Have you ever edited a wiki article**	**Have you ever used the discussion functionality**
Participant 1	●	●	●
Participant 2	●	○	○
Participant 3	●	○	○
Sum	**3**	**1**	**1**

Table 8.16: Previous experience with wiki. A full circle ● indicates that the participant answered *Yes*. An empty circle ○ indicates that the question was answered with *No*.

As we can see, only Participant 1 had previous experience with wikis. This participant edited more than 50 wiki articles and used the discussion functionality. All others only read wiki articles. The test persons had to answer an additional question, referring to the use of Wikipedia. With this question we wanted to check, whether our participants know what wikis are. All test persons answered the question with *Yes* and also the question, if they have ever viewed wiki content.

To get additional feedback about the previous usage of semantic wikis, we inquired for the users' experiences with semantic wikis. The results are presented in Table 8.17.

Participant	**Have you ever used a semantic wiki**	**Have you ever semantically annotated wiki article**	**Have you ever specified an (ASK) query**
Participant 1	●	●	●
Participant 2	●	○	○
Participant 3	○	○	○
Sum	**2**	**1**	**1**

Table 8.17: Previous experience with semantic wiki. A full circle ● indicates that the participant answered *Yes*. An empty circle ○ indicates that the question was answered with *No*

While Participant 1 was very familiar with semantic wikis because he/she used semantic wikis for 48 months, and semantically annotated more than 50 wiki articles, Participant 3 had no previous experiences with semantic wikis. Participant 2 stated that he/she used semantic wikis for 10 months, but had no experiences with semantic annotations and formulating queries.

The interviewees also had to rate the Wikiing Pro tool with the SUS questionnaire. The score values of the different participants are presented in Table 8.18. The detailed results in the German version can be found in Table B.1 in Appendix B.

The average SUS score value is 57,5. This is a slightly higher value than the average SUS score value of 55 of the pre-evaluation in the innovation and business development department (see Table 8.10 in Section 8.3.1). As the Wikiing Pro tool was compared to standard office software, which is highly intuitive to end users, the slightly higher value is a good result.

While Participant 1 did not notice any negative aspects, the other test persons mentioned the following. As negative aspects the other participants stated that the overall design is not so attractive. The process modeling window in the graphical editing interface and in the wiki were perceived as too small. The condition labels are imprecise concerning the location in the process diagram. Other negative aspects were identified in the usage of semantic annotations provided by SMW. They can be error-prone

Question	Participant 1	Participant 2	Participant 3
I think that I would like to use this system frequently	4	2	4
I found the system unnecessarily complex	4	0	3
I thought the system was easy to use	3	1	3
I think that I would need the support of a technical person to be able to use this system	2	1	0
I found the various functions in this system were well integrated	4	2	3
I thought there was too much inconsistency in this system	4	2	2
I would imagine that most people would learn to use this system very quickly	3	0	3
I found the system very cumbersome to use	4	0	3
I felt very confident using the system	0	2	3
I needed to learn a lot of things before I could get going with this system	4	3	0
Sum	32	13	24
Score value	**80**	**32,5**	**60**

Table 8.18: SUS score calculation for Wikiing Pro tool

concerning name spelling. Novices require a lot of time to learn how to safely handle semantic annotations and queries on wiki pages.

As positive aspects two of the test persons mentioned the good integration of process editing functionality with the semantic wiki, and the intuitive usability. Additional information to process elements can be easily integrated on the corresponding wiki page without overloading the graphical representation. Small process descriptions can be created quickly and easily refined. Another participant appraised the Software as a Service (SaaS) approach, which allows for accessing the tool via a Web browser, and the search functionality as very helpful.

It was also mentioned by one participant that the usability of the system heavily depends on previous knowledge and experience with semantic wikis, especially when it comes to the syntax for formatting and annotating text, and formulate queries. If this knowledge is available, the participant thinks that people can work with the system very well. Another participant suggested hiding the wiki functionality behind a more intuitive interface.

The test persons further recommended enhancing the import and exporting functionality, to integrate social networks, and to reduce the functionality to the basics, but the test persons did not further specify what explicit functionality they require or they would prefer to reduce. One participant specified that the graphical representation can be enhanced by allowing the user to select between an overview and zoom view. In addition it would be helpful when semantic annotation can be predefined within the system and the users can then select from a list during process modeling. Such a feature could eliminate the spelling errors, which can occur when people have to enter the property names manually.

8.3.4 Discussion of the results

In this section, we discuss the findings from our evaluation within the company field study. We started our enterprise study with eleven persons. However, only six persons participated in the pre-evaluation study and only four people from the innovation and business development department modeled processes with the Wikiing Pro tool. The post-evaluation questionnaire was only filled-out by three participants in the end. According to the study from Tullis and Stetson [TS04] such an amount of test persons results in an accuracy of less than 35% (see also Section 8.1). As we used an enhanced questionnaire, where the participants had to provide more detailed feedback, and we could analyze the development of the created process models, we can generalize some of the results. In the following, we first want to discuss our analysis of the created process models. In a second step, we review the survey results.

The modeling of user-defined conditions required two user inputs: the condition label, and the condition type. The analysis of the process descriptions showed that users forget to set the type (process numbers 8, 11, and 18) or the condition label (process numbers 20 and 21). This indicates that an easier setting of conditions could reduce such errors on process descriptions. An improved solution would automatically set the property *ConditionType* of a sequence flow element from *Standard* to *Conditional Flow*, if a condition label is entered.

The use of additional BPMN elements within the process descriptions by two users implies that they tested further functionality of the Wikiing Pro tool, which was not explained during the introduction session. Unfortunately, the graphical process descriptions of these two processes are not modeled correctly. This indicates that our reduced selection of the modeling elements supporting the Basic Control- Flow Patterns [RHAM06], namely *tasks*, *sequence flow*, *parallel gateway*, and *data-based exclusive gateway* are likely to be a meaningful choice for novice users, because our test persons, who had introduced additional elements, did not use them syntactically correct. Further detailed studies should be conducted to prove this result with a larger test group. We were able to analyze the development of process descriptions through the complete revision history of each wiki page being part of the process descriptions. We gained detailed results about the modeling behavior for each process descriptions and showed that the users worked collaboratively on some process descriptions. We could not check if the created process descriptions represent how the work is performed in reality.

We conducted the field test within a team located at the same venue, which allows our study participants to exchange information about process descriptions in face-to-face meetings. This setting could be an explanation, why our trialists did not use the discussion functionality provided by the Wikiing Pro tool. A further evaluation with a virtual team, distributed over different location should be performed to see how the discussion functionality is used and how it affects the modeling of process descriptions.

The average SUS score value of the Wikiing Pro tool is slightly higher than the average SUS score of the previous used standard office tools for process modeling such as Microsoft Word, Powerpoint and Visio. Our users are very familiar with standard office tools. Semantic wikis in contrast were very new to most of the test persons. Thus, the slightly higher average score of the Wikiing Pro tool can be seen as a positive result.

Only Participant 1 had previous experience with semantic annotations and queries. In contrast Participant 3 had no experience with semantic wikis and Participant 2 had never used the annotation and query syntax. The SUS score value of Participant 1 is very high. Although Participant 3 had fewer experiences with semantic wikis than Participant 2, the SUS score value of Participant 3 is higher than the one of Participant 2. In combination with the number of process descriptions (see Table 8.15), to which the participants had contributed, we can conclude that the usability of Wikking Pro tool is affected by the level of expertise with semantic wikis. As the Wikiing Pro tool is built on Semantic MediaWiki, it employs all functionality provided by SMW. Consequently, users having previous experiences with SMW can work better with our tool.

The additional user comments about positive and negative aspects were also very helpful and corroborate that the usability of the Wikiing Pro tool heavily depends of the previous knowledge and experience with semantic wikis, which is currently minimal in enterprises. For those enterprise users it should be simpler to add semantic annotations or additional training sessions should be conducted explaining the annotation and query syntax in more detail.

8.3.5 Conclusion

The evaluation of the Wikiing Pro tool within an enterprise was divided in three phases. First, the participants had to answer a pre-evaluation questionnaire. After that a field test was conducted, where users had to model their processes with the new tool. Finally, the users were asked to fill-out a post-evaluation questionnaire.

Eleven trialists were invited to the pre-evaluation questionnaire, which was filled-out by six persons. At the end, four modeled processes with the Wikiing Pro tool and three of them answered the post-evaluation questionnaire. Although the number of participants is very low, we can derive the following conclusions:

The evaluation showed that the test persons were able to model their process descriptions with the Wikiing Pro tool and some of these process descriptions were created collaboratively within the tool. The number of the selected BPMN elements was sufficient for those processes. In the two cases where more BPMN elements were used the additional elements were not applied syntactically not correct. This indicates that these users had problems with using too many BPMN elements.

Compared to traditional modeling tools, Wikiing Pro provides additional features such as the enhanced search functionality, which was explicitly emphasized by the test persons as useful for process modeling.

Overall we have preliminarily showed that the Wikiing Pro tool can be used for process development and therefore provides valuable support. However, in order to have clearer insights on this, more long-term field studies are required with our approach.

Chapter 9

Conclusion and Future Work

In this thesis, we outlined a new wiki-based approach for maturing process descriptions. By combining techniques from the area of business process management and knowledge management in a novel way, we present an adequate process modeling tool, allowing both novices and experts to develop process descriptions with natural language, graphical representation, and formal semantic annotations.

In this chapter, we first summarize the contributions of this thesis including the research questions in Section 9.1. Second, we present an outlook on future work in Section 9.2 that is based on open questions that are raised in the context of this thesis. Finally, we conclude in Section 9.3.

9.1 Summary

In Chapter 1 we introduced informal knowledge-intensive processes, which are performed by knowledge workers. We motivated that enterprises have to capture and document these processes in order to better understand, share, and optimize them.

Based on this motivation, we presented the main research questions we addressed in this thesis. In summary, these are the following hypotheses:

Hypothesis 1: *Traditional process modeling tools are inadequate for documenting and modeling informal, knowledge-intensive processes.*

Hypothesis 2: *Adequate tools have to support textual and graphical descriptions, collaboration, and structured documentation.*

Hypothesis 3: *The wiki-based approach for maturing of process description can be used intuitively by novices in process modeling and experts*

In order to address the first hypothesis, we elaborated other approaches and tools supporting process modeling and analyzed their strengths and weaknesses in Chapter 4. First, we presented top-down methods for process modeling that all suggest to do interview-based, "one-shot" process-knowledge acquisition and to use "traditional", centralized modeling tools. However, these methods and tools are not adequate when dealing with informal, frequently changing, knowledge-intensive processes as they neither support the decentralized collection of process knowledge nor their evolution with light-weight technologies. In contrast to these top-down methods, Social Software, especially wiki-based solutions, are presented, that can support collaborative process modeling in a bottom-up manner. Consequently, Social Software approaches better support the development of process descriptions from informal, knowledge-intensive processes. To show that these solutions are also not adequate for modeling informal, knowledge-intensive processes, we described the current process modeling situation in small and medium enterprises and methodology descriptions in a large consulting company and illustrated that these process descriptions can be categorized as documentations of informal, knowledge-intensive processes in Chapter 5.

To find an appropriate solution to support people in collaboratively making informal process knowledge explicit, we gathered requirements for the maturing of process descriptions in Chapter 6. We analyzed existing literature to collect the requirements for enabling both novice users as well as process modeling experts to capture process descriptions and cooperate together. The requirements served on the one hand as a comparison framework for existing wiki-based solution and on the other hand as a foundation for our approach. In a further step, we mapped the requirements to the example scenarios presented in Chapter 5 and showed that support for natural language and graphical descriptions, collaboration, and structured documentation is required. By mapping these requirements, we addressed the second hypothesis.

In Chapter 7 we presented a wiki-based approach based on the derived requirements that allows both novices and experts to develop process descriptions. The developed tool supports the capturing of stories and natural language process descriptions, rendering and editing of graphical representations, and generation of formal models from the graphical representations, which can be exported with a well-defined semantics and used for further processing and validation. It provides users with means to intuitively model processes graphically with basic (but widely used) process elements and thus enables users to develop process knowledge by using graphical descriptions, natural language, and formal semantic annotations. We evaluated our approach within two scenarios in Chapter 8. First, we tested the intuitive usability with students, who were novices in process modeling. We then applied our approach within a real enterprise use case. The results indicated that our wiki-based approach for maturing process descriptions can be used intuitively by novices in process modeling, which confirms the third hypothesis.

In summary, we have shown that traditional process modeling tools are inadequate for documenting informal process knowledge. Furthermore we derived requirements for wiki-based, light-weight maturing of process descriptions, which support the development of informal, knowledge-intensive process descriptions by providing support for natural language and graphical descriptions, collaboration, and structured documentation. To provide adequate support, we developed a new wiki-based approach for maturing of process description. The evaluation of our approach indicated, that novices users can intuitively use our approach.

9.2 Future Work

There are several directions in which our approach can be extended. First, long-term usability studies can be conducted to get better insight on how our approach can be used in different company environments. Advantages of long-term studies are described in Section 9.2.1. Second, more sophisticated approaches for the translation of textual process descriptions into graphical representations can be integrated within our presented approach (Section 9.2.2). Finally, automated validation support can be used within our approach to detect and correct errors in process descriptions. Such extensions are discussed in Section 9.2.3.

9.2.1 Long-term usability study in several companies

In this thesis we evaluated our approach with students and within a company. Long-term studies with more participants should be conducted to get better insights on how people work with the tool. As most development, adjustment and refinement of process descriptions are interminable tasks, long-term studies with the duration of at least a year can provide evidences about the number of adjustments and refinements of process descriptions within a company.

The collaboration feature can be evaluated within distributed teams, to see how often the discussion functionality is used. Furthermore, use case criteria can be derived by applying our approach in many different companies. The thus gained results can be used to tailor our approach so that it fits better to the single use cases. For instance, often used properties can be incorporated directly in the property editor area within the graphical interface.

9.2.2 More sophisticated translation of textual process descriptions

The translation of textual descriptions into graphical representations can be improved by implementing a more sophisticated identification of process steps. In our approach we currently rely on pre-structured text (numbered lists). Additional mechanisms, which identify conditions, parallel splits, and exclusive splits, can help to create more structured process descriptions. This would require natural language processing and text mining techniques, as used for example in the approaches from Ghose et al. [GKC07] or Friedrich et al. [FMP11].

Within our approach, people can use textual descriptions and graphical elements interchangeable or complementary. It can happen that the textual and graphical descriptions are inconsistent. With an enhanced translation implementation such inconsistencies can be detected. Such an implementation would be a first step for validation mechanisms, which are discussed in the following section.

9.2.3 Automated process description validation support

Currently, our approach does not offer automatic validation support, but it enables the user to formulate queries within Semantic MediaWiki, which can be used to detect errors or constraint violations in the process models. Approaches for the automated validation of process models and their integration within our solution are subject to future work. In the semantic business process management research area, different validation mechanisms have been proposed such as the approaches from Weber et al. [WHM08] or the validation functionality of BP-MoKi [FGR+11]. However, these approaches only inform the human modeler that a process is incorrect, but do not suggest actual fixes for the detected bugs. In this context, an important future topic is also the development of approaches which detect errors and give recommendations to the user on how to fix them.

9.3 Conclusion

In this thesis we developed a wiki-based approach that can better cope with the maturing of process descriptions of informal, knowledge-intensive processes. Our solution supports both novices and experts in capturing of stories and natural language process descriptions, rendering and editing of graphical representations, and generation of formal models from the graphical representations, which can be exported with a well-defined semantics and used for further processing and validation.

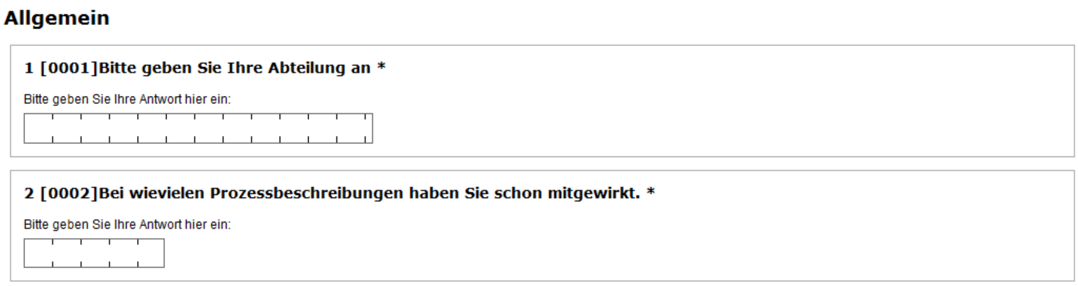
Part IV

Appendix

Appendix A

Company use case pre-evalution questionnaire

A.1 Questionaire


Allgemein

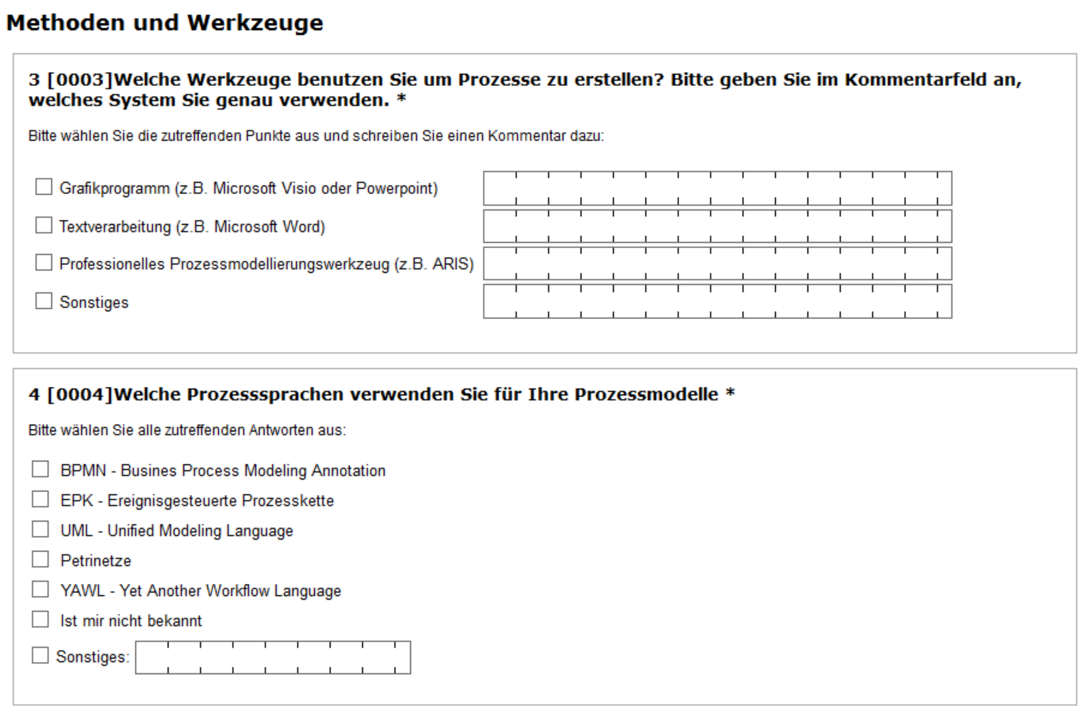
1 [0001]Bitte geben Sie Ihre Abteilung an *

Bitte geben Sie Ihre Antwort hier ein:

2 [0002]Bei wievielen Prozessbeschreibungen haben Sie schon mitgewirkt. *

Bitte geben Sie Ihre Antwort hier ein:

Figure A.1: Pre-evaluation questionnaire – Questiongroup 1



Methoden und Werkzeuge

3 [0003]Welche Werkzeuge benutzen Sie um Prozesse zu erstellen? Bitte geben Sie im Kommentarfeld an, welches System Sie genau verwenden. *

Bitte wählen Sie die zutreffenden Punkte aus und schreiben Sie einen Kommentar dazu:

- ☐ Grafikprogramm (z.B. Microsoft Visio oder Powerpoint)
- ☐ Textverarbeitung (z.B. Microsoft Word)
- ☐ Professionelles Prozessmodellierungswerkzeug (z.B. ARIS)
- ☐ Sonstiges

4 [0004]Welche Prozesssprachen verwenden Sie für Ihre Prozessmodelle *

Bitte wählen Sie alle zutreffenden Antworten aus:

- ☐ BPMN - Busines Process Modeling Annotation
- ☐ EPK - Ereignisgesteuerte Prozesskette
- ☐ UML - Unified Modeling Language
- ☐ Petrinetze
- ☐ YAWL - Yet Another Workflow Language
- ☐ Ist mir nicht bekannt
- ☐ Sonstiges:

Figure A.2: Pre-evaluation questionnaire – Questiongroup 2

5 [0005]Bitte spezifizieren Sie, welches System Sie für welche konkreten Prozessmodellierungsaufgaben benutzen. *

Beantworten Sie diese Frage nur, wenn folgende Bedingungen erfüllt sind:

°

------- Scenario 1 -------

Die Antwort war bei Frage '3 [0003]' (Welche Werkzeuge benutzen Sie um Prozesse zu erstellen? Bitte geben Sie im Kommentarfeld an, welches System Sie genau verwenden.)

------- oder Scenario 2 -------

Die Antwort war bei Frage '3 [0003]' (Welche Werkzeuge benutzen Sie um Prozesse zu erstellen? Bitte geben Sie im Kommentarfeld an, welches System Sie genau verwenden.)

------- oder Scenario 3 -------

Die Antwort war bei Frage '3 [0003]' (Welche Werkzeuge benutzen Sie um Prozesse zu erstellen? Bitte geben Sie im Kommentarfeld an, welches System Sie genau verwenden.)

------- oder Scenario 4 -------

Die Antwort war bei Frage '3 [0003]' (Welche Werkzeuge benutzen Sie um Prozesse zu erstellen? Bitte geben Sie im Kommentarfeld an, welches System Sie genau verwenden.)

------- oder Scenario 5 -------

Die Antwort war bei Frage '3 [0003]' (Welche Werkzeuge benutzen Sie um Prozesse zu erstellen? Bitte geben Sie im Kommentarfeld an, welches System Sie genau verwenden.)

------- oder Scenario 6 -------

Die Antwort war bei Frage '3 [0003]' (Welche Werkzeuge benutzen Sie um Prozesse zu erstellen? Bitte geben Sie im Kommentarfeld an, welches System Sie genau verwenden.)

------- oder Scenario 7 -------

Die Antwort war bei Frage '3 [0003]' (Welche Werkzeuge benutzen Sie um Prozesse zu erstellen? Bitte geben Sie im Kommentarfeld an, welches System Sie genau verwenden.)

------- oder Scenario 8 -------

Die Antwort war bei Frage '3 [0003]' (Welche Werkzeuge benutzen Sie um Prozesse zu erstellen? Bitte geben Sie im Kommentarfeld an, welches System Sie genau verwenden.)

------- oder Scenario 9 -------

Die Antwort war bei Frage '3 [0003]' (Welche Werkzeuge benutzen Sie um Prozesse zu erstellen? Bitte geben Sie im Kommentarfeld an, welches System Sie genau verwenden.)

------- oder Scenario 10 -------

Die Antwort war bei Frage '3 [0003]' (Welche Werkzeuge benutzen Sie um Prozesse zu erstellen? Bitte geben Sie im Kommentarfeld an, welches System Sie genau verwenden.)

------- oder Scenario 11 -------

Die Antwort war bei Frage '3 [0003]' (Welche Werkzeuge benutzen Sie um Prozesse zu erstellen? Bitte geben Sie im Kommentarfeld an, welches System Sie genau verwenden.)

Bitte geben Sie Ihre Antwort hier ein:

Benutzbarkeit

6 [0006]Wie viele Monate benutzen Sie schon das von Ihnen am häufigsten verwendete System? *

Bitte geben Sie Ihre Antwort hier ein:

Figure A.3: Pre-evaluation questionnaire – Questiongroup 3

7 [0007]Bitte bewerten Sie das am häufigsten von Ihnen verwendete System mit den folgenden Fragen, wobei 1 für Sie stimmen nicht zu/widersprechen und 5 für Sie stimmen voll zu steht. Falls Sie mehrere Systeme gleich häufig benutzen, bilden Sie bitte einen Mittelwert.

*

Bitte wählen Sie die zutreffende Antwort für jeden Punkt aus:

	1 - Widerspeche/stimme nicht zu	2	3	4	5 - Stimme voll zu
Ich könnte mir vorstellen, das System häufig zu benutzen	○	○	○	○	○
Das System ist unnötig komplex	○	○	○	○	○
Das System ist einfach zu handhaben	○	○	○	○	○
Ich denke, dass ich Hilfe vom technischen Support brauchen würde, um die Möglichkeiten des System voll auszuschöpfen.	○	○	○	○	○
Die verschiedenen Funktionen des Systems sind gut integriert	○	○	○	○	○
Ich finde, dass es zu viele Inkonsistenzen im System gibt.	○	○	○	○	○
Ich kann mir vorstellen, dass die meisten Personen den Umgang mit dem System schnell erlernen würden	○	○	○	○	○
Das System ist umständlich zu bedienen	○	○	○	○	○
Ich fühlte mich sicher im Umgang mit dem System	○	○	○	○	○
Ich mußte mir erst viele Dinge anlernen, bevor ich mit dem System zurecht kam	○	○	○	○	○

Figure A.4: Pre-evaluation questionnaire – Questiongroup 4

8 [0008]Bitte erläutern Sie die negativen Aspekte bei der Verwendung der jetzigen Methoden und Werkzeuge:

Bitte geben Sie Ihre Antwort hier ein:

9 [0009]Bitte erläutern Sie die positiven Aspekte bei der Verwendung der jetzigen Methoden und Werkzeuge:

Bitte geben Sie Ihre Antwort hier ein:

10 [0010]Haben Sie noch zusätzliche Kommentare zur Bewertung

Bitte geben Sie Ihre Antwort hier ein:

Figure A.5: Pre-evaluation questionnaire – Questiongroup 5

11 [0011]Welche zusätzlichen Funktionen würden Sie sich für die Prozessmodellierung von Ihrem jetzigen System wünschen? *

Bitte geben Sie Ihre Antwort hier ein:

Figure A.6: Pre-evaluation questionnaire – Questiongroup 6

A.2 SUS survey results

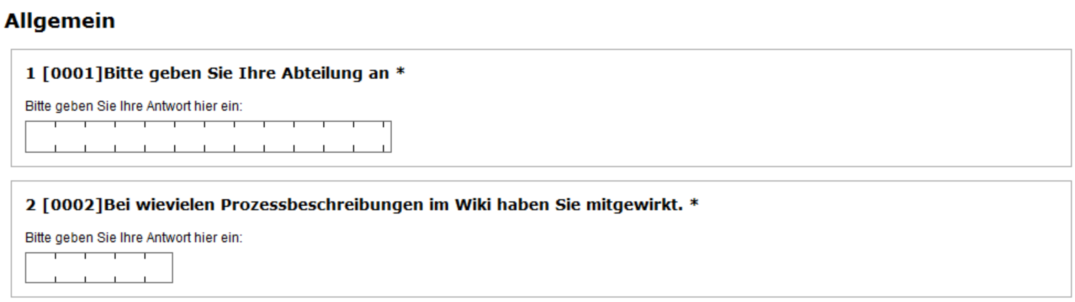
Question	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5	Participant 6
Ich könnte mir vorstellen, das System häufig zu benutzen	2	4	3	5	4	2
Das System ist unnötig komplex	2	2	4	2	2	3
Das System ist einfach zu handhaben	3	4	2	4	4	3
Ich denke, dass ich Hilfe vom technischen Support brauchen würde, um die Möglichkeiten des System voll auszuschöpfen	2	3	3	4	1	2
Die verschiedenen Funktionen des Systems sind gut integriert	2	2	2	4	3	4
Ich finde, dass es zu viele Inkonsistenzen im System gibt.	3	2	3	1	2	3
Ich kann mir vorstellen, dass die meisten Personen den Umgang mit dem System schnell erlernen würden	4	4	3	3	4	3
Das System ist umständlich zu bedienen	3	3	3	3	1	2
Ich fühlte mich sicher im Umgang mit dem System	3	4	3	4	4	4
Ich musste mir erst viele Dinge anlernen, bevor ich mit dem System zurecht kam	2	2	2	2	2	4

Table A.1: SUS results per participant of pre-evaluation

Appendix B

Company use case post-evalution questionnaire

B.1 Questionaire



Allgemein

1 [0001]Bitte geben Sie Ihre Abteilung an *

Bitte geben Sie Ihre Antwort hier ein:

2 [0002]Bei wievielen Prozessbeschreibungen im Wiki haben Sie mitgewirkt. *

Bitte geben Sie Ihre Antwort hier ein:

Figure B.1: Post-evaluation questionnaire – Questiongroup 1

Wiki Expertise

3 [0003]Wie gut kennen Sie sich mit Wikis aus *

Bitte wählen Sie die zutreffende Antwort für jeden Punkt aus:

	Ja	Unsicher	Nein
Haben Sie zuvor schon Informationen aus einem Wiki bezogen?	○	○	○
Haben Sie zuvor schon Text in einem Wiki-Artikel editiert?	○	○	○
Haben Sie zovor schon einmal die Diskussionsfunktionalität benutzt	○	○	○

4 [0004]Wieviele Wiki-Artikel haben Sie schon editiert? *

Beantworten Sie diese Frage nur, wenn folgende Bedingungen erfüllt sind:
° Die Antwort war 'Ja' bei Frage '3 [0003]' (Wie gut kennen Sie sich mit Wikis aus (Haben Sie zuvor schon Text in einem Wiki-Artikel editiert?))

Bitte wählen Sie nur eine der folgenden Antworten aus:

○ 1-2
○ 3-10
○ 10-50
○ mehr als 50

Figure B.2: Post-evaluation questionnaire – Questiongroup 2

5 [0005]Wieviele Monate arbeiten Sie schon mit Wikis? *

Beantworten Sie diese Frage nur, wenn folgende Bedingungen erfüllt sind:
°

-------- Scenario 1 --------

Die Antwort war 'Ja' bei Frage '3 [0003]' (Wie gut kennen Sie sich mit Wikis aus (Haben Sie zuvor schon Informationen aus einem Wiki bezogen?))

-------- oder Scenario 2 --------

Die Antwort war 'Ja' bei Frage '3 [0003]' (Wie gut kennen Sie sich mit Wikis aus (Haben Sie zuvor schon Text in einem Wiki-Artikel editiert?))

-------- oder Scenario 3 --------

Die Antwort war 'Ja' bei Frage '3 [0003]' (Wie gut kennen Sie sich mit Wikis aus (Haben Sie zovor schon einmal die Diskussionsfunktionalität benutzt))

Bitte geben Sie Ihre Antwort hier ein:

Figure B.3: Post-evaluation questionnaire – Questiongroup 3

Semantic Wiki Expertise

6 [0006]Haben Sie schon einmal Wikipedia benutzt? *

Bitte wählen Sie nur eine der folgenden Antworten aus:

- ○ Ja
- ○ Nein

7 [0007]Wie gut kennen Sie sich mit Semantischen Wikis aus? *

Bitte wählen Sie die zutreffende Antwort für jeden Punkt aus:

	Ja	Unsicher	Nein
Haben Sie zuvor schon ein semantisches Wiki benutzt?	○	○	○
Haben Sie zuvor schon Text in einem Wiki-Artikel semantisch annotiert?	○	○	○
Haben Sie zovor schon einmal eine Abfrage (ASK query) gestellt?	○	○	○

8 [0008]Wieviele Wiki-Artikel haben Sie semantisch annotiert? *

Beantworten Sie diese Frage nur, wenn folgende Bedingungen erfüllt sind:
° Die Antwort war 'Ja' bei Frage '7 [0007]' (Wie gut kennen Sie sich mit Semantischen Wikis aus? (Haben Sie zuvor schon Text in einem Wiki-Artikel semantisch annotiert?))

Bitte wählen Sie nur eine der folgenden Antworten aus:

- ○ 1-2
- ○ 3-10
- ○ 10-50
- ○ mehr als 50

Figure B.4: Post-evaluation questionnaire – Questiongroup 4

9 [0009]Wieviele Monate arbeiten Sie schon mit semantischen Wikis? *

Beantworten Sie diese Frage nur, wenn folgende Bedingungen erfüllt sind:
°

-------- Scenario 1 --------

Die Antwort war 'Ja' bei Frage '7 [0007]' (Wie gut kennen Sie sich mit Semantischen Wikis aus? (Haben Sie zuvor schon ein semantisches Wiki benutzt?))

-------- oder Scenario 2 --------

Die Antwort war 'Ja' bei Frage '7 [0007]' (Wie gut kennen Sie sich mit Semantischen Wikis aus? (Haben Sie zuvor schon Text in einem Wiki-Artikel semantisch annotiert?))

-------- oder Scenario 3 --------

Die Antwort war 'Ja' bei Frage '7 [0007]' (Wie gut kennen Sie sich mit Semantischen Wikis aus? (Haben Sie zovor schon einmal eine Abfrage (ASK query) gestellt?))

Bitte geben Sie Ihre Antwort hier ein:

Figure B.5: Post-evaluation questionnaire – Questiongroup 5

Benutzbarkeit

10 [0010]Bitte bewerten Sie das System Wikiing Pro mit den folgenden Fragen, wobei 1 für Sie stimmen nicht zu/widersprechen und 5 für Sie stimmen voll zu steht.

*

Bitte wählen Sie die zutreffende Antwort für jeden Punkt aus:

	1 - stimme nicht zu	2	3	4	5 - stimme voll zu
Ich könnte mir vorstellen, das System häufig zu benutzen	○	○	○	○	○
Das System ist unnötig komplex	○	○	○	○	○
Das System ist einfach zu handhaben	○	○	○	○	○
Ich denke, dass ich Hilfe vom technischen Support brauchen würde, um die Möglichkeiten des System voll auszuschöpfen.	○	○	○	○	○
Die verschiedenen Funktionen des Systems sind gut integriert	○	○	○	○	○
Ich finde, dass es zu viele Inkonsistenzen im System gibt.	○	○	○	○	○
Ich kann mir vorstellen, dass die meisten Personen den Umgang mit dem System schnell erlernen würden	○	○	○	○	○
Das System ist umständlich zu bedienen	○	○	○	○	○
Ich fühlte mich sicher im Umgang mit dem System	○	○	○	○	○
Ich mußte mir erst viele Dinge anlernen, bevor ich mit dem System zurecht kam	○	○	○	○	○

Figure B.6: Post-evaluation questionnaire – Questiongroup 6

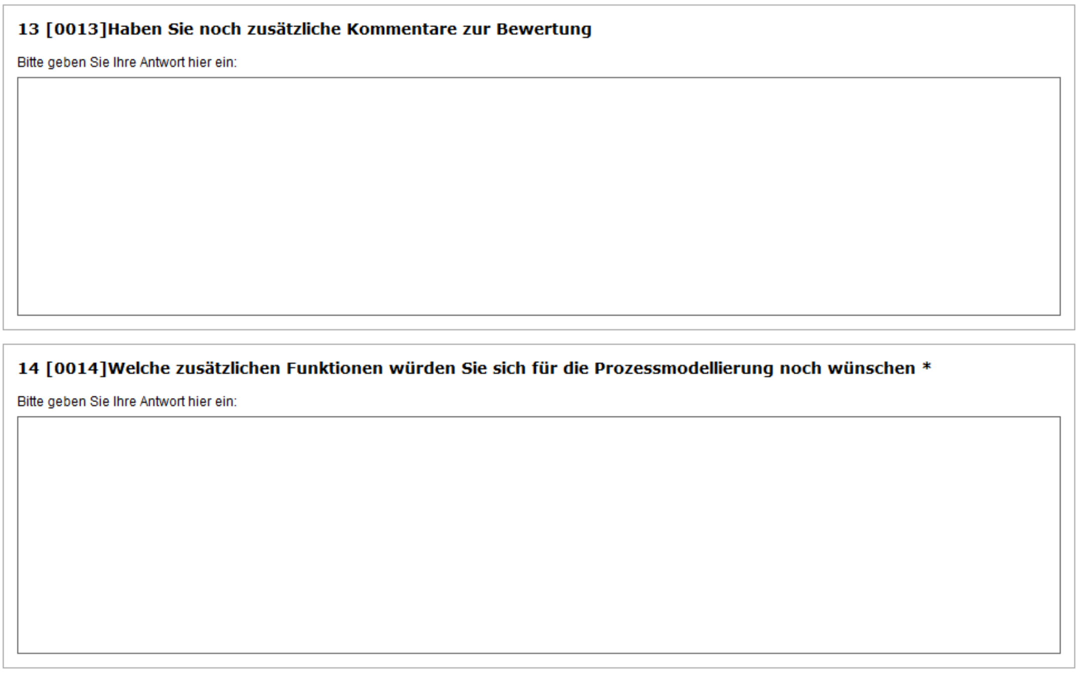
11 [0011]Bitte erläutern Sie die negativen Aspekte bei der Verwendung von Wikiing Pro:

Bitte geben Sie Ihre Antwort hier ein:

12 [0012]Bitte erläutern Sie die positiven Aspekte bei der Verwendung von Wikiing Pro:

Bitte geben Sie Ihre Antwort hier ein:

Figure B.7: Post-evaluation questionnaire – Questiongroup 7



13 [0013]Haben Sie noch zusätzliche Kommentare zur Bewertung

Bitte geben Sie Ihre Antwort hier ein:

14 [0014]Welche zusätzlichen Funktionen würden Sie sich für die Prozessmodellierung noch wünschen *

Bitte geben Sie Ihre Antwort hier ein:

Figure B.8: Post-evaluation questionnaire – Questiongroup 8

B.2 SUS survey results

Question	Participant 1	Participant 2	Participant 3
Ich könnte mir vorstellen, das System häufig zu benutzen	5	3	5
Das System ist unnötig komplex	1	5	2
Das System ist einfach zu handhaben	4	2	4
Ich denke, dass ich Hilfe vom technischen Support brauchen würde, um die Möglichkeiten des System voll auszuschöpfen	3	4	5
Die verschiedenen Funktionen des Systems sind gut integriert	5	3	4
Ich finde, dass es zu viele Inkonsistenzen im System gibt	1	3	3
Ich kann mir vorstellen, dass die meisten Personen den Umgang mit dem System schnell erlernen würden	4	1	4
Das System ist umstÃd'ndlich zu bedienen	1	5	2
Ich fühlte mich sicher im Umgang mit dem System	1	3	4
Ich musste mir erst viele Dinge anlernen, bevor ich mit dem System zurecht kam	1	2	5

Table B.1: SUS results per participant of post-evaluation

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