Combining Knowledge Management and Business Process Management – A Solution for Information Extraction from Business Process Models Focusing on BPM Challenges

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Abstract. In today's dynamic environment all organizations need up-to-date knowledge for their operations that are based on business processes. Complex organizations use business process management (BPM) tools to model and manage these processes. BPM applications tends to model the organizational processes, together with the required information and other resources needed to perform each activity. BPM yields an overall context, but it is still static.

Our paper presents a solution to extract, organize and preserve knowledge embedded in organizational processes to enrich organizational knowledge base in a systematic and controlled way utilized in the PROKEX project. The proposed solution is to extract the knowledge from information stored in the process model in order to articulate, externalize and transfer it. Our paper focuses on the BPM aspects of the solution as we want to investigate it from the information systems perspective.

The novelty of the solution is based on the connection between process model and corporate knowledge base, where the process structure will be used for building up the knowledge structure. Common form of knowledge base is the ontology, which provides the conceptualization of a certain domain. By using the ontology and combining it with the process models, we connect knowledge management and business process management in a dynamic, systematic and well-controlled solution.

Keywords: semantic business process management, knowledge extraction, knowledge management, knowledge gap.

1 Introduction

Complex organizations model and manage their processes with the help of business process management (BPM) tools. These applications help to describe the organizational processes, together with the required information and other resources needed to perform each activity. BPM yields an overall context, but it tends to be static.

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Project PROKEX proposes a solution to extract, organize and preserve knowledge embedded in organizational processes to enrich organizational knowledge base in a systematic and controlled way, support employees to easily acquire their job role specific knowledge.

Business processes are defined as sequence of activities. From the human resource management view it is required to define unambiguously, who is responsible for the execution of each activity. The RACI matrix (Responsible, Accountable, Consulted, Informed) is used for grouping role types, bridging the organizational model and the process model. We need to acquire knowledge belonging to the job roles, in this sense RACI assigns only job role types to the tasks.

The proposed solution is to extract the knowledge from information stored in the process model in order to articulate, externalize and transfer it. Since the business process models are used for the execution of processes in a workflow engine, another very important source for gathering useful knowledge are real-time instantiations of the business processes, that gives a view on the dynamic knowledge, usually represented in the form of different business rules.

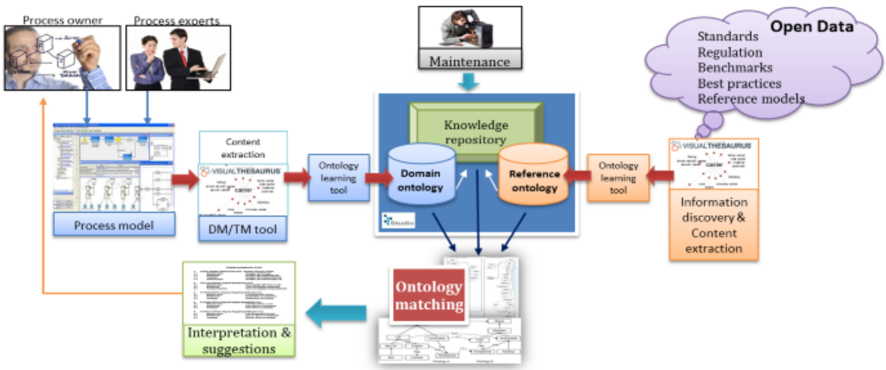

Fig. 1. General overview of Prokex solution http://prokex.netpoitive.hu/

The goal of the paper is to introduce a solution to extract, organize and preserve knowledge embedded in organizational processes in order to enrich organizational knowledge base in a systematic and controlled way; support employees to easily acquire their job role specific knowledge and help to govern and plan the human capital investment (1. Figure).

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2 The State of the Art in SBPM

2.1 Business Process Management

Nowadays business process modeling is an integral part of many organizations to document and redesign complex organizational processes. One of the most promising tendencies in application development today is business process design based software development. Software development methodologies have traditionally been driven by programming and not organizational concepts, leading to a semantic gap between the software system and its operational environment. Business process modeling aligns the business goals and incentives with the IT software design process.

As a forerunner of BPM, in the early 1990s, the idea of Business Process Reengineering (BPR) brought business processes to the center of interest and lifted the subject of design from the supporting IT systems to business processes, to the perspective of business experts. The term is originated from Hammer & Champy's BPR paradigm [1-2].

It has been common sense to first determine business requirements and then to derive IT implementations, to develop software according to ideal processes as determined by business logic. Business processes have to perform well within ever-changing organizational environments. It can be expected that Business Process Management will only come closer to its promises if it allows for a better automation of the two-way translation between the business level and the software systems.

In order to obtain a full view of the capabilities of BPM, we have to start out from the overview of the BPM lifecycle. Among the vast number of BPM lifecycle models available [3], we chose to build upon the most concise and probably one of the most popular model of van der Aalst.

According to the proposed basic model, the four elements of the BPM Lifecycle are the following:

Process Design: The organizational processes concerning the subject are identified, top level visualization of the processes are laid down. Several modeling standards and tools are aiding this phase, as we will have a deeper look among them in the following sections.

System Configuration: This phase provides a more thorough overview of the processes, ideally taking into consideration all possible aspects required for the implementation of the underlying IT infrastructure. One very important dimension of the configuration is business-IT alignment, and also the synchronization of roles and responsibilities of the organizational structure concerning the processes. This stage has many obstacles in real-life implementations due to the inhomogeneous nature of the IT and organizational architectures of different enterprises.

Process Enactment: Processes are inaugurated in real life circumstances, and form the IT point of view being deployed into Business Process Management Systems/Suites (BPMS), workflow engines or other software instances. Recently, in a state-of-the-art organization, this deployment holds some extent of automation. The current focus of BPM theory is concerned with raising this level of automation in turning electronically modeled processes into effective IT supporting infrastructure.

Diagnosis: In an ever-changing business environment it is inevitable to have appropriate feedback on the operational environment of the processes. Diagnosis activities range from monitoring, analysis of the effectiveness – or other KPIs – of enacted processes, and also after identifying and analyzing possible failures and bottlenecks, the revision of the process design, making BPM a continuous, cyclic function of the organization. This phase has a wide body of literature within the BPM community, it is supported by many diagnostic standards, but it falls out of the scope of our interest.

2.2 BPM and Workflow Management

BPM standards and specifications are based on established BPM theory and are eventually adopted into software and systems. BPM standards and systems are also what Gartner [4-5-6] describes as “BPM-enabling technologies”.

In the industry, there is a growing awareness of the emerging term service-oriented architecture (SOA). BPM is a process-oriented management discipline aided by IT while SOA is an IT architectural paradigm. According to Gartner [6], BPM “organizes people for greater agility” while SOA “organizes technology for greater agility”. Processes in SOA (e.g. linked web services) enable the coordination of distributed systems supporting business processes and should not be confused with business processes.

There is also some confusion between the Workflow Management (WfM) and BPM terms. While often treated synonymously, BPM and workflow are, in fact, two distinct and separate entities. According to one viewpoint, workflow is concerned with the application-specific sequencing of activities via predefined instruction sets, involving either or both automated procedures (software-based) and manual activities (people work) [7]. BPM is concerned with the definition, execution and management of business processes defined independently of any single application. BPM is a superset of workflow, further differentiated by the ability to coordinate activities across multiple applications with fine grain control.

Other research views BPM as a management discipline with Workflow Management supporting it as a technology [8]:

- Business process management is a process-oriented management discipline. It is not a technology;
- Workflow is a flow management technology found in business process management suites and other product categories.

Another viewpoint from academics is that the features stated in WfM according to Georgakopoulos et al. [9] is a subset of BPM defined by van der Aalst [11] with the diagnosis stage of the BPM life cycle as the main difference.

However, in reality, as we have observed, many BPMS are still very much workflow management systems (WfMS) and have not yet matured in the support of the BPM diagnosis, some providers of software tools have updated their products’ names from “WfM” to the more rewarding “BPM” [5].

2.3 Classification of BPM Standards

The most logical way to make sense of the myriad of BPM standards is to categorize them into groups with similar functions and characteristics. For this reason, we propose a cleaner separation of features found in standards addressing the process design and process enactment phase into three clear-cut types of standards:

Graphical Standards: This allows users to express business processes and their possible flows and transitions in a diagrammatic way. Graphical standards are the highest level of expression of business processes.

Graphical standards allow users to express the information flow, decision points and the roles of business processes in a diagrammatic way. Graphical standards are currently the most human-readable and easiest to comprehend without prior technical training. Unified Modeling Language activity diagrams – UML AD [12], Business Process Model and Notation - BPMN [13], Event-driven Process Chains – EPC [14], Role-Activity Diagrams (RADs) Petri-nets and flow charts are common techniques used to model business processes graphically [15].

These techniques range from common notations (e.g. flow charts) to standards (e.g. BPMN). And of the standards, UML AD and BPMN are currently the two most expressive, easiest for integration with the interchange and execution level, and possibly the most influential in the near future. For this reason, we will focus more on UML AD and BPMN, followed by a brief description of the other graphical business process modeling techniques.

Execution Standards: It computerizes the deployment and automation of business processes. Execution standards enable business process designs to be deployed in BPMS and their instances executed by the BPMS engine. There are currently two prominent execution standards: BPML and BPEL (Business Process Execution Language). Of the two, BPEL is more widely adopted in several prominent software suites (e.g. IBM Websphere, BEA AquaLogic BPM Suite, SAP Netweaver, etc.) even though BPML can better address business process semantics.

Interchange Standards: It facilitates portability of data, e.g. the portability of business process designs in different graphical standards across BPMS; different execution standards across disparate BPMS, and the context-less translation of graphical standards to execution standards and vice versa.

As mentioned earlier, interchange standards are needed to translate graphical standards to execution standards; and to exchange business process models between different BPMS's [16]. Some practitioners thought these interchange standards as "the link between business and IT", but we do not agree with this assertion because an interchange standard is a translator from a graphical standard to an execution standard [17]. There are currently two prominent interchange standards: Business Process Definition Metamodel (BPDM) by OMG and XML Process Definition Language (XPDL) by the WfMC.

2.4 Semantic Interoperability and Process Ontologies

2.4.1 Semantic Business Process Management

The main challenge in Business Process Management is the continuous, two-way translation between the business requirements view on the process space and the actual process space, constituted by the IT systems and resources. Semantic Business Process Management (SBPM) is a new approach of increasing the level of automation in the translation between these two levels, and is currently driven by major players from the BPM and Semantic Web Services domain [18].

Business Process Management is the approach of managing the execution of IT supported business operations from the managerial process view. BPM should provide a uniform representation of a process at a semantic level, which would be accessible to intelligent queries or for compliance checks [19]. It is expected, that the BPM notation should cover every aspect of the characterized processes available at the managerial level.

Semantic process management was created with the purpose to overcome the obstacles of standard BPM techniques, and also to incorporate its principles with semantic technologies, primary with the ontology-based development. Hepp at. al, along with Koschmider and Oberweis identified the challenge in traditional process management, that it only contributes models for the business experts and managerial level, completely lacking or only marginally addressing technical details of implementation. This way process models are inadequate for automatic machine processing, working implementations are only possible after further supplementary transformation [20-21]. The main focus of semantic process management is consequently the narrowing of the gap between the business and IT views of organizational phenomenon with the utilization of semantic technologies such as ontologies, reasoning mechanisms and semantic web services. Hepp et al. did not demonstrate concrete applications, only introduced a theoretical framework.

There is a considerable advance in the past decade in the domain of SBPM, many experimental projects have been concluded successfully. The unambiguous and rapid alignment between process models and IT solutions is targeted by the SUPER project, one of the most extensive R+D project under the FP7 initiative of the European Union (Semantics Utilised for Process Management within and between Enterprises) [22]. Another result of this effort is the development of the Web Service Modeling Ontology (WSMO) [23], as well as the Semantic Business Process Execution Language (SBPEL). Gábor and Szabó extends the standard BPM life cycle to SBPM life cycle and gives examples to existing applications to the phases [24].

Several approaches have been discussed to enhance both the act of creating conceptual models as well as the execution of the models by using semantic schema in the area of business process management [20]. The paradigm of current SBPM research is to provide as much compatibility to existing tools and standards as possible. This means, that processes behind of a business model should be represented in terms of SBPM environment, and it should be possible to create executable processes configured within an SBPM environment.

During the phases of development and implementation, conceptual models are used to support the requirements engineering process. Furthermore, conceptual models facilitate tasks such as the exploration, negotiation, documentation, and validation of requirements. This allows exploring and correcting possible errors at an early stage [25]. Conceptual modeling captures the semantics of an application through the use of a formal notation, but the descriptions resulting from conceptual modeling are intended to be used by humans and not machines. The conceptual foundations of these approaches show several similarities, but the actual realizations on various technical platforms are not discussed in detail. The realization of the alignment of conceptual models and semantic schema on a technical level needs to be elaborated in details. Our approach tries to provide a feasible implementation pattern based on the extension of process ontologies to resolve this issue.

2.4.2 Process Ontology

Ontologies are state-of-the-art constructs to represent rich and complex knowledge about things, their properties, groups of things, and relations between things. The use of web-based ontologies and their contribution to business innovation has received a lot of attention in the past years [26]. Ontologies provide the means to freely describe different aspects of a business domain, basically provide the semantics and they can describe both the semantics of the modeling language constructs as well as the semantics of model instances [27]. With web-based semantic schema such as the Web Ontology Language (OWL) [28], the creation and the use of specific models can be improved, furthermore the implicit semantics being contained in the models can be partly articulated and used for processing.

Apart from the representation of business domains, ontologies are utilized in many other practical areas of software development from 3D construct definition to software localization and internationalization. The generation, processing and visualization of ontologies are supported by an extensive set of tools and frameworks. This general but formalized representation can also be used for describing the concepts of a business process. We attempt to undertake this task and provide an extension for the standard ontology definition in the form of an annotation scheme to enable ontologies to cover all the major aspects of business process definition. From now on, we refer to ontologies as process ontologies [29-30].

According to our current knowledge, process ontologies have no precise definition in academic literature. Some refer to it simply as a conceptual description framework of processes [30]. In this interpretation process ontologies are abstract and general. Contrary, task ontologies determine a smaller subset of the process space, the sequence of activities in a given process [31].

In our approach, a formal process ontology is a domain ontology built upon the knowledge domain of processes. Ontology definition is the key element in turning process models into working software, providing a visual and textual representation of the processes, data, information, resources, collaborations and other measurements. We are primarily interested in the automatic generation of workflow systems based on BPM defined ontologies, while preserving the capability of discussion with non-technical users. The core paradigm of our approach is to represent the business incentives extended with all the implementation details of processes using ontology languages and to employ machine reasoning for the automated or at least semi-automated translation. We discuss how to establish the links between model elements and ontology concepts in order to realize reusability. Automatic generation of workflow processes allows us to redeploy processes in a flexible manner whenever business requirements change. This method also permits interoperability between different implementation frameworks supporting the process ontology annotation scheme.

2.5 Ontology Languages

In the context of our research, process models as process knowledge resources can be disseminated through the Web. The Semantic Web domain has given us standards such as RDF and OWL to support the semantic interpretation. The knowledge representation of process models needs to be transformed into those Semantic Web standards.

The Web can be viewed as a large distributed repository for the process models. However, distributed models are originally from different autonomous systems and stored in various schemas. Technologies facilitating interoperability of heterogeneous models such as ontology and semantic annotation, are required when organizing the knowledge in such a repository.

The OWL Web Ontology Language [27] is designed for use by applications that need to process the content of information instead of just presenting information to humans. OWL facilitates greater machine interpretability of Web content than that supported by XML, RDF, and RDF Schema (RDF-S) by providing additional vocabulary along with a formal semantics.

OWL-S is an ontology of services that provides users and agents with the possibility to discover, invoke, compose, and monitor Web resources offering particular services and having particular properties [32]. The motivations of the applications of OWL-S are automatic Web services discovery, automatic Web services invocation and automatic Web service composition and interoperation.

3 Prokex BPM Component Overview

In this section we provide a short overview of the modeling components utilized during the PROKEX project to obtain the necessary knowledge of the observed organizations. We have conducted process audits at several organizations: government agencies, profit-oriented companies and companies of the financial sector.

Our inspection concentrated on a small number of business processes. It was not our aim to build a complete process map of these organizations, but to acquire enough information to validate our approach in diverse circumstances.

3.1 Use Case: “Food Safety Inspection – Sampling” Process

Based on the challenges of the common agricultural policy and the demand for a consistent management of professional policy, the Agricultural Management has been rearranged. Another goal of the reform has been to provide an access to the necessary information for the farmers faster than before, and to make administration more efficient. Accordingly, all the agricultural administrative departments, which had been independent before, were integrated on 1 January 2007.

The application of an integrated “from the soil to the table” approach and view was implemented, covering each element of the food chain, including feed production and marketing, the primary production, processing, storing, transporting and marketing of food. With the consistent and complete surveillance of the whole chain kept in one hand, the highest level of food safety could be implemented.

In our use case, we demonstrate the Prokex BPM component via the “Food safety inspection – Sampling” process. The sampling process starts by the pre-set timing and task breakdown, and it includes the preparation of sampling, execution described by specific regulations, shipping of samples to accredited laboratories, related documentation. The sampling process ends at the point when the samples are arriving to the laboratories.

The main process of sampling is simple but complex as well, because of the small differences depending on the scope of the sampling. Depending on the goal of the investigation and the parameters of sampling, different portions, methods, devices and documentations have to be used, on top of it the goals and parameters may also change in line with some high-risk events in the food chain.

The domain of food safety is a strongly regulated environment: EU legislation, national legislation and organizational regulations are deeply described, thereby causing strong difficulty for the sampling staff to have always fully updated and actual information.

Nevertheless sampling is a critical phase in the whole process as if the sampling is not happening fully in line with regulations and documentation is not complete and accurate, even though laboratories may provide a prefect work and results from a scientific standpoint the results may not be relevant and useful from a food safety and control standpoint.

Challenges we face and plan to provide a solution by PROKEX:

- Sampling staff doesn’t always have fully updated knowledge about sampling requirement details;
- Related regulation and documentation is very long and detailed;
- Because of the different sources and form of Information, documentation is not well structured to enable staff members to easily find relevant pieces of information;
- Sampling staff often works based on routines learned from the past even if the related process has been changed in the meantime.

By analyzing the tasks and implementing a structured knowledge base in PROKEX sampling staff will receive a useful tool for easily retrieving relevant knowledge related to the specific process they are actually running.

3.2 Modeling Environment

The business process models have been implemented using the BOC ADONIS modeling platform. The main application area of ADONIS is Business Process Management. We have selected this modeling platform because of its popularity in modeling practice. However, our approach is principally transferable to other semi-formal modeling languages.

ADONIS is a graph-structured Business Process Management language. The integral model element is the activity. The ADONIS modeling platform is a business meta-modeling tool with components such as modeling, analysis, simulation, evaluation, process costing, documentation, staff management, and import-export. Its main feature is its method independence.

The RACI model support for identifying roles within the processes and associate them with the process activities has a built-in support for EPC in Adonis.

3.3 Initial Modeling of the Processes

The basis of our multi-dimensional approach is a general control-flow oriented business process model. The process modeling starts with the close observation of an existing, real-life process at the given organization. We conducted interviews with all of the stakeholders of the company, reviewed the process development meetings and materials prepared during the actual project. We also inspected the underlying IT infrastructure.

The ever-recurring problem of capturing processes is the level of granularity. Setting this appropriate level can be thought of as an optimization problem in itself. If a process model is too superficial, it will not contain enough information to draw conclusions, conduct redesign or utilize it in any other ways. A modeling architecture with unnecessarily frittered details or a model with inhomogeneous granularity results in a confusing process architecture, and consumes unnecessary resources to create, maintain and manage. Ternai et al. collects the parameters have to be set in order to use a process model as a base of semantic transformations [33], we used those guidelines in this work, too.

Throughout our work, the level of granularity in modeling a process is set to grant the ability to attach corresponding concepts like roles or information objects to the model. In the sampling process it means, that we have modeled the main tasks, and identified the relevant information required to those tasks. At this point, the information is unstructured, and has various, heterogeneous sources.

3.4 Complementary Modeling Layers

After finalizing the basic process flow, the specific activities within the process model have to be aligned with roles and responsibilities. We capture a view of the inner stakeholders of the organization. We start by collecting all the roles that are related to the given process, and gradually examine, which roles have any relation with a given activity. This task is carried out on the theoretical ground of the RACI responsibility matrix. We determine, which are the explicit roles being played by which stakeholder at the level of a given activity. More precisely, we define according to the RACI, which role is Responsible for the performing of the activity, which role is Accountable for it, which are the roles needed to be Consulted during the execution of the activity, and who to be Informed about the advance, obstacles, completion or other information related to the given activity.

This knowledge is the basis of the PROKEX project's proposed outcome, namely to be able to present the knowledge items required by a person in a given role, or in a broader perspective, in a given position.

There are two additional modeling dimensions that play an important part in enriching process information. Many organizations have a well-structured IT infrastructure map, and in a higher-level process model, IT architecture elements are assigned to the process model at activity level. Modeling tools incorporate sub-models of the company's IT infrastructure. In this sub-model we define the major systems, tools or resources, which are going to play an active role in our processes.

Documents are also essential artifacts of business processes, different documents serving different roles are being created, transferred, and utilized as a source of knowledge and information. These documents have to be taken into account throughout the complete BPM lifecycle, and this way also incorporated to the complex process models.

In the sampling process it means, that we have identified the main roles in the process, and assigned them to the tasks, and to the RACI matrix. We have modeled the IT system model and investigated the unstructured information gathered in the previous step.

3.5 Complex Process Model

As a last step of capturing the inspected processes, we undertake a 360 degree semantic annotation. In other words, we supplement the models with every available, explicit knowledge items at activity level.

This action is carried out in three levels:

- Domain experts and practitioners provide direct, structured knowledge items at the level of activities;
- As a second layer, an accurate, thorough description of the activity is recorded which can be treated as unstructured information;
- The third layer relies on related documentation: guidelines, official procedures, best-practices, related legislation, etc.

Concerning the modeling implementation of the semantic annotation, the first level knowledge items can be directly placed in Adonis EPC process models as information objects. The information contained in underlying, non-structured form most undergo a semantic transformation to identify the knowledge elements or concept groups.

We are preserving the level of granularity set forth in our initial process models. It has to remain unchanged, since this granularity applies to all other modeling dimensions as well.

In the sampling process, structured information was provided by domain experts, and we modeled that as 'Information objects' connecting them to activated in the process model. All the information gathered via process meetings was populated to the description attribute to the relevant activities; this is layer two. And in the third layer, we have investigated the regulations and connected them to the activities as well.

3.6 Multidimensional Process Knowledge–Process Coupling via Semantic Transformations

The resulting complex process models contain interconnected, multi-dimensional information on the following areas of the recorded processes:

- process structure, process hierarchy
- organizational structure, roles and responsibilities at activity level
- mapped explicit knowledge

- IT architecture
- document structure

In order to make use of this holistic process-space, we need to apply semantic transformations to the models. We are aiming to provide a machine-readable representation for further utilization in the form of ontologies.

Since the complex process models hold both process knowledge and domain knowledge, we have to conduct these transformations respectively.

Process ontology instances can be created automatically by XSLT transition. The process model hierarchy is represented in OWL format, and the additional structure of interconnected elements can also be transferred following a semantic annotation scheme. As far as our knowledge extends, there are no industry standards expressing the full requirements of such a process structure annotation, but an ad-hoc processing of such a markup is possible [34]. The PROKEX project intends to develop a reference architecture satisfying some aspects of automatic processing.

The creation of domain ontology also holds several challenges. The above described first level structured knowledge can be easily transformed into OWL ontologies, but the underlying levels need further elaboration. We are striving to provide automatic ways to create ontology knowledge elements or concept groups by means of applying text-mining techniques, but some extent of domain expert knowledge seems to be inevitable for transforming unstructured knowledge from the recorded processes. Another article under the PROKEX project tackles this issue in details "Process-based Knowledge Extraction in a Public Administrative Authority: A Text Mining Approach" is to create an ontology from the originating SBPM. [10]

4 Conclusion

Our approach proposes a solution to extract, organize and preserve knowledge embedded in organizational processes to enrich organizational knowledge base in a systematic and controlled way, support employees to easily acquire their job role specific knowledge. We have identified the requirements in the business process modeling level to be able to use the process model as a base of creating a domain ontology from the information in it.

Our overall aim is to create a supporting infrastructure capable to conduct multi-dimensional queries especially for the purpose to support employees to easily acquire their job role specific knowledge.

The novelty of the solution is based on the connection between process model and corporate knowledge base, where the process structure will be used for building up the knowledge structure. The whole solution can be fully understood by investigating the articles to be written from project Prokex and its text-mining part. We focused on the business process modeling challenges of the solution.

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