INTEGRATING KNOWLEDGE MODELLING IN BUSINESS PROCESS MANAGEMENT

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ABSTRACT

In this paper we present a new approach for integrating Business Process Management and Knowledge Management. We focus on the modelling of weakly-structured knowledge-intensive business processes. We develop a framework for modelling this type of processes that explicitly considers knowledge-related tasks and knowledge objects and present a workflow tool that is an implementation of our theoretical meta-model. As an example, we sketch one case study, the process for granting full old age pension as it is performed in the Greek Social Security Institution. Finally we briefly describe some related approaches and compare them to our work and draw the main conclusions and further research directions.

1. INTRODUCTION

Business Process Managemnt and Business Process Reengineering (BPR) have been predominant business trends and are now becoming "serious tools" instead of a hype. The focus of BPR is typically on studying and changing a variety of factors, including work flows and processes, information flows and users, management and business practises, and staffing and other resources; see e.g. Hammer and Champy (1993) and Malhotra (1998). However, most BPR efforts have not focused much on knowledge, if at all. This is indeed critical, considering that knowledge is treated more and more as a

principal success factor – or the major driving force behind business success. Moreover, although business process modelling tools and/or workflow management systems support in an adequate manner the modelling and enactment of business processes, they lack any support for knowledge-related activities.

On the front of Knowledge Management efforts, an emphasis is given to the strategic applications of knowledge-related initiatives and a focus on creating the right culture and organisational structure that facilitates knowledge sharing and enables knowledge leveraging; see e.g. Davenport and Prusak (1998). The approaches that focus on knowledge management within the business process level are limited; see e.g. Wiig (1995) who claims that "knowledge-related perspectives need to be part of BPR".

From the above, it becomes clear that an approach that explicitly integrates knowledge management activities into the business process environment is missing.

The present paper attempts to fill this gap by proposing a new framework and a workflow meta-model that treats in an explicit manner knowledge management tasks and knowledge objects, thereby integrating consistently knowledge within business processes. Since the current trend is on supporting business processes that are not rigid, but are flexible and goal-oriented we focus on what we call "weakly-structured" business processes, that are typical of knowledge-intensive companies; see Numi (1998). In addition we develop a business process modelling tool, that extends the formalisms used in most existing business process modelling tools [see Yu and Wright (1997) for a related review], and supports in an integrated manner the modelling of weakly-structured processes and domain knowledge structures. We explicitly model with this tool the weak workflow aspects by allowing underspecified modelling (i.e. rough structure of tasks in the form of a hierarchically ordered set of black-boxes) and late modelling (i.e. complete the specification of a task (maybe a black-box) with more information during run-time).

Finally, we present the application of our approach and the implementation of the modelling tool to a knowledge-intensive business process of the largest Greek Social Security organisation. We have selected the process of granting full old age pension to insured people, which is, to some extend, a straightforward and well-defined business process. Nevertheless it contains critical knowledge and document intensive steps for finding a decision; see Wenger (1998) for similar forms-based knowledge intensive processes. In the case we examine, the steps of the process are often done under uncertainty, they are influenced by many legal regulations, and they are vital for the correct result of the process.

The paper is structured in the following manner. The next section outlines the main elements of our framework, while Section 3 presents in detail our workflow meta-model and the associated process modelling perspectives. Section 4 describes the application of our approach to the social security business process, while section 5 examines some related approaches and compares them to our work. Finally, the last section outlines the conclusions and discuses some directions for further research.

2. MODELLING KNOWLEDGE IN BUSINESS PROCESSES

An analysis of knowledge work shows that knowledge-intensive processes tend to be characterized by dynamic changes of goals, information environment, constraints, and highly individual and ad-hoc communication and collaboration patterns; see e.g. Davenport et al (1996). Moreover, knowledge generation and application plays an important role. Conventional workflow approaches providing a strong structuring mechanism for specification of workflow control are not suited to deal with the ad-hoc effects, frequent exceptions, and common changes in knowledge-intensive work activities; see also Allen (2001) and Macintosh (1999).

There are several reasons for this:

- The knowledge needed for executing the process is not explicitly described in the workflow model

- Current workflow approaches are not flexible enough to adapt on the fly to changing processes.

In our approach for business process-oriented knowledge management we provide a conceptual framework for modelling knowledge in business processes by focusing on business processes that exhibit two critical characteristics: they are knowledge-intensive and weakly-structured.

These two characteristics of business processes can be described as follows:

- Knowledge-intensive: The processes considered are often complex in general, with many, but conceptually simple, (usually) document-centred activities; at the heart of these processes are few central decision steps which require personal judgment based on experience, a comprehensive knowledge about the given as well as about older, similar cases, access to much specific information in files and forms, manifold legal regulations and standard operating procedures, etc.
- Weakly-structured: The processes under consideration normally consist of many steps performed by many people in different roles, often several departments are involved, sometimes at different locations, etc. Though legal regulations prescribe the departments and/or roles to be involved, the specific sequence of processing steps may vary for specific instances due to particular eventualities, exceptions, or complications. Even if the business process is determined completely, complex, not formally modelled decision processes may be embedded in black boxes, or the process may change during its enactment

Such business processes, have to be analysed from a knowledge management perspective and knowledge management activities should be seamlessly integrated with them. In this paper we use four core tasks of knowledge management which have been identified as essential and important: knowledge generation; knowledge storage; knowledge distribution; and knowledge application.

We follow Mentzas et al (2000) in the treatment of knowledge assets and knowledge objects. We consider that knowledge assets may either tacit or explicit and can be: human, such as a person or a network of people; structural, such as a business process; and market, such a brand name of a product.

In order to explicitly treat knowledge assets some form of knowledge representation as a means of packaging and transferring knowledge has to be used. We define ‘knowledge objects’ as the means of representing knowledge; then the following statement outlines the relation between knowledge assets and knowledge objects: “A knowledge asset creates, stores and / or disseminates knowledge objects”. Some examples: a person is a knowledge asset that may create knowledge objects such as new ideas, learnings, proposals, papers, etc; a community of practice is a knowledge asset that may create knowledge objects such as new ideas, best practices etc; a business process is a knowledge asset that may create and/or store and disseminate knowledge objects such as best practices, company standards, R&D material, etc.

A knowledge object represents the explicit knowledge required in a specific business process. Knowledge objects facilitate and leverage knowledge creation and sharing activities by providing to humans the information they need. Hence a knowledge object has the following characteristics:

- A knowledge object is created and maintained by a knowledge management task (e.g. generate, store, distribute, apply knowledge).
- A knowledge object is used to search, organise and disseminate knowledge content.
- A knowledge object acts as a catalyst, enabling the fusion of knowledge flows between people, with knowledge content discovery and retrieval, through technology.
- A knowledge object facilitates the knowledge transfer from person to person, or from information to person.

3. INTEGRATING KNOWLEDGE TASKS AND KNOWLEDGE OBJECTS IN BUSINESS PROCESSES

In order to model knowledge-related tasks and knowledge objects within weakly-structured business processes on a conceptual level, we construct a workflow meta-model that emphasises the coherence between them. The proposed meta-model is depicted in Figure 1.

A knowledge-intensive business process is defined in a workflow model. The workflow model consists of tasks and their interdependencies. Each of these tasks can be decomposed into (sub)tasks, which in turn can represent a whole workflow.

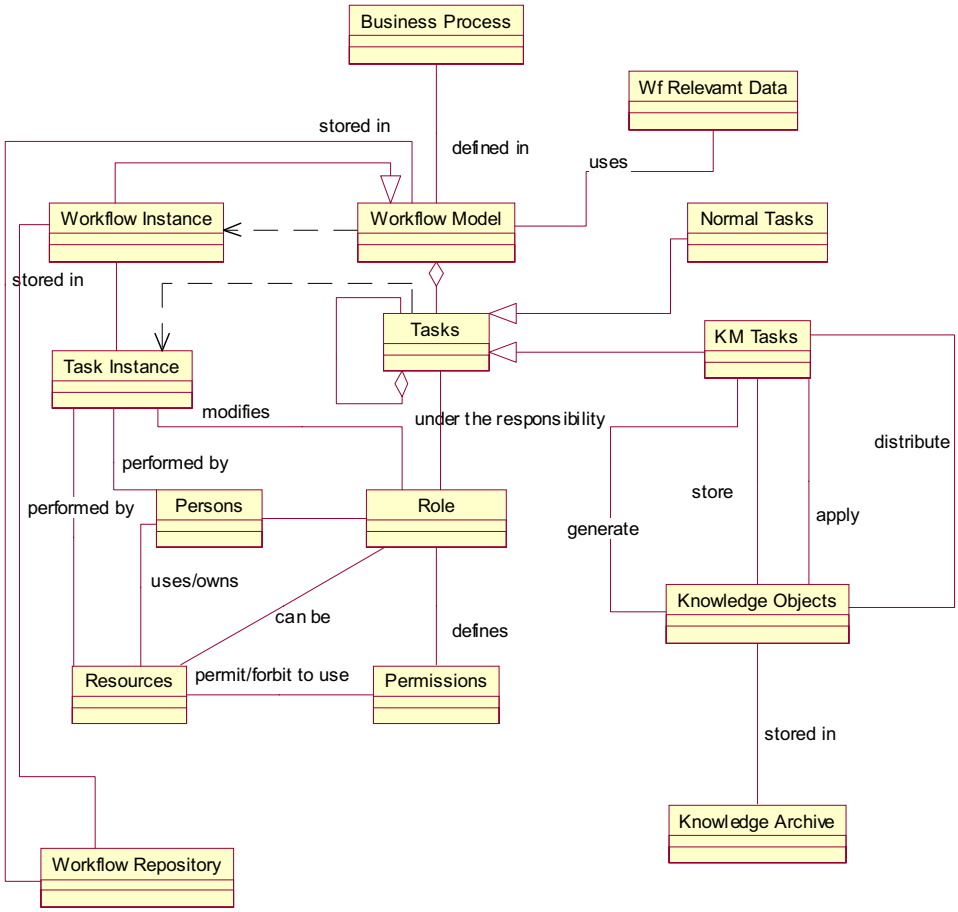

Figure 1: Workflow meta-model using UML notation

We distinguish two types of tasks in the workflow model:

- Normal tasks (from now on they will be called Tasks), which describe the structured work in a business process and
- Knowledge Management tasks (they will be called KM Tasks), which describe work associated with the generation, storage, application and distribution of knowledge in the business process.

Both Tasks and KM Tasks of the workflow model are assigned to Roles during modelling. Each of these roles has a set of permissions associated regarding the usage of the organisation's resources (tools, applications, etc.).

A detailed planning of the work to be done in knowledge-intensive business processes is quite difficult to be achieved in advance. To deal with this observation, in our approach under-specified modelling is allowed. The workflow model can include tasks not completely specified in form of a hierarchically ordered set of black boxes. The specification of such tasks can be completed during run-time with more detailed information.

During enactment time, the workflow model is instantiated. The workflow instance consists of the instances of the Tasks and KM Tasks. A Task Instance is a copy of the task model plus a reference to it and is under the responsibility of an organisational entity. The actual performer of a task can either be human (employees) or software and they are matched to the roles of the model so that the appropriate actor is selected to perform a specific task.

Modelling modifications can be made to a running Task-instance. Any possible modifications influences only new Task-instances, but since the changes of the model are getting logged to the workflow audit repository they can be proposed to running instances.

The proposed workflow model is an extension of the reference workflow model proposed by the Workflow Management Coalition. Like the reference workflow model it captures the fundamental elements of the workflow paradigm and their relationships:

- What tasks are performed in the workflow process (task specification perspective)
- Who performs the specified task (organisational perspective)
- In which order these tasks are executed (process logic perspective)
- What data are consumed, produced or exchanged between tasks (data perspective)

We extended this model in order to include Knowledge Management tasks that support knowledge-intensive business processes. Therefore, we use another perspective, the knowledge perspective, which captures the tasks in the process that are associated with the generation, storage, application and distribution of knowledge. These persepctives are more detailed described in the following sub-sections.

3.1 Task specification perspective

The task specification perspective deals with the static dimension of workflow modelling, i.e. the specification of the tasks forming the business process. In this perspective the workflow tasks and their decomposition within a workflow model are provided. Each task in the workflow model can be characterised either as a normal task or a KM task related with the creation, storage, application or distribution of knowledge. A workflow task can consist of several (sub)tasks. The (sub)tasks of a workflow model are one level of decomposition. Each (sub)task in turn can be further decomposed. This recursively can result into an arbitrary deep decomposition hierarchy.

3.2 Organisational perspective

The content of the organisational perspective is twofold. First, it provides specification constructs for the definition of an organisation structure. Using this capability, users can be registered and described in more detail by user attributes. Furthermore, relationships between users like a supervisor relationship can be specified. Second, the organization perspective deals with the assignment of users to workflows at runtime. Assigning specific persons or resources to a workflow task denotes that this task should be performed by these actors.

Although feasible in principle, this solution is pretty inflexible. When one workflow performer changes their status, all assignments to workflow tasks have to be reviewed to check whether they are still valid or not. For example, after an employee has left the company, all assignments that directly

reference that person have to be updated. Checking assignments for validity is a very time-consuming task and also might cause severe integrity violations. To overcome the drawbacks stemming from the static assignments of workflow performers, the concept of Role is introduced in our model as proposed by the Workflow Management Coalition; see WfMC (1995). Role definitions are attached to workflow tasks expressing that these tasks can be executed by persons, or software agents that are able to play the specific roles. This kind of assignment is flexible enough since it is resistant to changes in the organisation.

In our approach, the organisational structure is modelled in terms of organisational units, positions, persons that fill these positions and resources, as well as relationships between these elements. This typical organisational model is extended with the use of the role that is used to refer to the performer of the real task.

3.3 Data perspective

This perspective focuses on what data objects are used within the workflow models. Every task requires a data object as an input and produces a data object as an output. A Knowledge object can be seen as a Data object with more attributes necessary for its manipulation by KM Tasks.

3.4 Process logic perspective

The process logic perspective is the heart of the workflow model. It ties together the first three perspectives describing the control and data flow between the workflow tasks.

In this perspective, active nodes (tasks) and passive nodes (events) are linked to form an Event-driven Process Chain (EPC). EPCs are extended by links to other relevant entities contributed by the other perspectives. In this way, tasks can be connected to input and output data that are located in the data perspective to model the data flow between different tasks.

In our approach, we model the control flow of the business process in the EPC model using sequences, splitters and joiners and more complex branching (loops). With the sequence flow element, it is possible to link two activities sequentially. More interesting are the split-join constructions that allow a workflow path to split into multiple parallel branches. It can be specified that such parallel branches all have to be executed at the same time (and-split), that only one (xor-split) or some (or-split) of these branches have to be executed. The loop flow element allows one or more tasks to be repeated until a condition is met.

3.5 Knowledge perspective

A knowledge perspective is essential in order to stress the link between business processes and knowledge management. Like the process logic perspective, it ties together the task specification, the organisational and the data perspective: KM Tasks performed by persons or software agents handling knowledge objects. However, the knowledge perspective can be seen as a sub-set of process logic since KM Tasks are part of the whole business process.

The knowledge perspective essentially describes the content of knowledge objects by reference to (ontological) concepts. Different concepts are connected by links (which may bear additional attributes related to their respective semantics) and are grouped into views.

4. AN APPLICATION EXAMPLE

Below we present an application of our approach in a specific weakly-structured knowledge-intensive business process. In order to demonstrate the practicality of our approach we have developed a

modelling tool that incorporates the theoretical aspects of our framework. We developed the tool as an integration of the commercial tool MS Visio 2000® and CognoVision®. CognoVision® is a document-based knowledge archive that creates a logical encapsulation of information objects (documents, web pages, etc), manages meta-data and the attributes of these information objects and allows for structured views and intelligent semantic links among the information objects. In our development, Visio symbols become objects in CognoVision and all the necessary information for the enactment of the workflow model are stored in the form of object attributes and links between them.

In the following, we describe how our approach and the associated tool have been used in the specific case. We tested our approach in an organisation from the social security sector: the Greek Social Security Institute (IKA), which is the largest insurance institution in Greece. Having as its primary purpose the protection of the insured persons, IKA offers an extensive range of services to them, like insurance, benefits, pensions and interstate social security. Currently, IKA provides health care to 5.500.000 insured persons including the members of their family and pays out pensions to 1.000.000 pensioners approximately. The Institute's income is derived from contributions of both workers and employers and from governmental funding.

4.1 Description of the business process

The business process that was examined and modelled with our tool is the granting of full old age pension. The significance of the pension process lies in the large number of beneficiaries that currently amounts to 1.000.000 persons and increase at an annual rate of 10%. In addition, the pension granting process requires a deep knowledge of the relevant legislation; first for making the decision whether the insured person is entitled to receive a pension; and second for calculating the amount of pension.

It is quite common that for one specific case more that one legal regulation may be relevant, and it is a matter of knowledge and experience to identify all these regulations and then choose the most appropriate one. If it is the case that the insured member can establish a pension right under more than one regulation, the different pension amounts are calculated and the highest one is chosen. In addition, the pension granting process -as part of a normal administrative workflow - contains some central, knowledge and document intensive steps for coming to a decision whether the insured person is entitled to receive a pension or not and to calculate the correct amount of the pension. These steps must be legally checkable, they are often done with uncertainty, based on the experience of the relevant regulations the employees have and they are vital for the correct result of the process.

The process begins with the submission of the application form by the insured person and the collection of all the supplementary documentation, which constitutes the retirement folder. The retirement folder is submitted by the insured person to any of IKA's branches and then it is forwarded to the one being responsible for acting upon it. The pension folder is being checked at the department of pensions or the department of payments. The insured person is entitled to pension when he/she fulfils the prerequisite conditions (e.g., minimum number of working days and age) for the specific type of pension and category to which he/she belongs. The decision regarding the entitlement to a pension is made on the basis of the employment and personal data of the insured person. This decision is based also on the current legal regulations, which are differentiated according to the pension type, the category of the insured person and other factors. Having established that the minimum prerequisite conditions are met, a decision of approval is issued, which mentions all the information related to the granting and the calculation of the pension. If the insured person is not entitled to a pension, a decision of rejection is issued.

4.2 Task specification

The first thing to do when developing the workflow model for the selected business process is to define which tasks are involved in the business process and decompose them into subtasks. Starting

from some generic tasks that roughly describe the business process, the workflow developer defines the decomposition into more detailed subtasks which in turn can represent a whole workflow. This decomposition continuous until the desired level of details is obtained. Thus, a tree containing tasks and subtasks is formed. The links between tasks and subtasks depict no temporal logic, just the task decomposition. In this tree, both normal and KM tasks are depicted.

4.3 Process logic

Having specified the tasks involved in the business process as well as their decomposition into more detailed subtasks, the next thing to do is to connect these tasks using control flow elements (sequence, and, or, xor, etc) forming the process chain. The input or output of each task -in the form of data or knowledge objects- is linked to the task along with the workflow participant that is in charge of performing the specific task. In Figure 2 we show the process chain for the "Granting of full old age pension" business process.

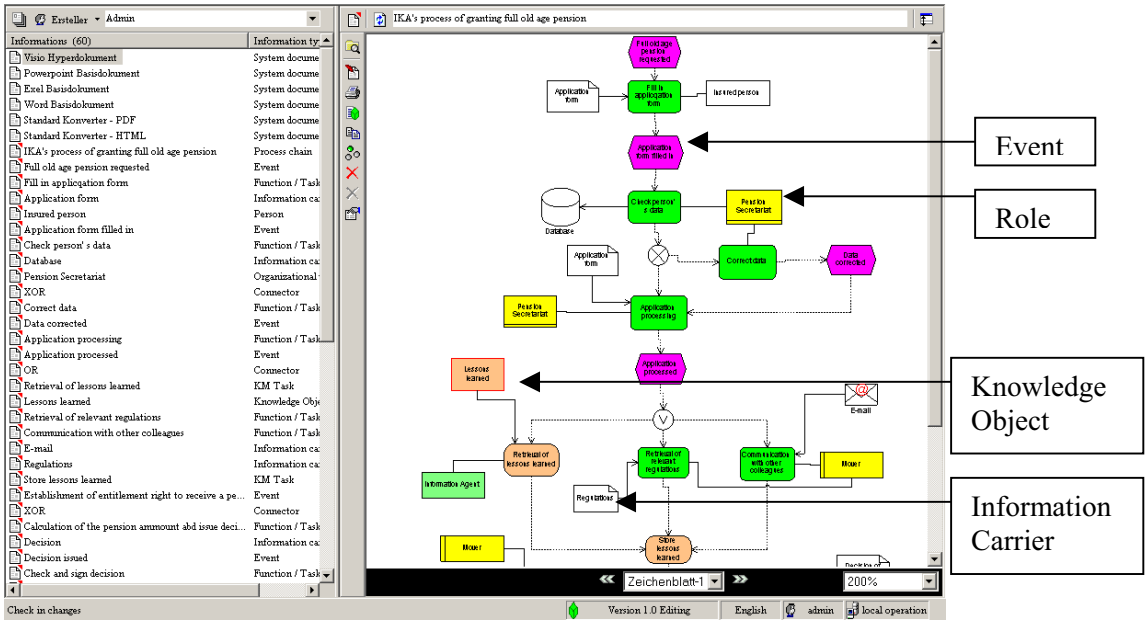

Figure 2. Process logic for the business process of IKA

5. RELATED WORK

Our work is an approach for integrating knowledge in business process management proposing a theoretical framework, a meta-model and an associated tool for modelling business processes enhanced with knowledge management activities.

To the best of our knowledge, in the area of Knowledge Management only few approaches have explicitly acknowledged the relation between knowledge management and business processes. And even fewer approaches have tried to develop a systematic method to integrate knowledge management activities into the business processes.

The CommonKADS methodology [see Schreiber et al (1999)] focuses on the development of knowledge systems as tools to support knowledge intensive tasks. Knowledge management itself is seen as a meta-level activity that acts on the knowledge object level. This meta-level activity consists of a cyclic exertion of three main activities: conceptualise (identify knowledge, analyse strengths/weaknesses), reflect (identify improvements, plan changes) and act (implement changes, monitor improvements). The knowledge object level is defined by three objects: (1) agents as persons or software that possess (2) knowledge assets and participate in (3) business processes. The knowledge

management cycle is presented with seven activities covering the complete life cycle of knowledge within the organization: Identify, plan, acquire and/or develop, distribute, foster the application, control and maintain, dispose. The emphasis is on the value and process view of knowledge management. However, the method could not show how to integrate these knowledge management activities within the business processes

The importance of the combination of business processes with knowledge management tasks is also underscored by the knowledge value chain approach proposed by Weggeman (1998). His knowledge value chain is a continuously repeated process which is composed of six knowledge management tasks on the operational level: identify the required knowledge, document the available knowledge, develop, share, apply and evaluate knowledge. These tasks are linked to the strategic level (Mission, Vision, Goals, Strategy) and the business process named primary process such as order handling, for instance. Nevertheless, his approach does not provide a well developed method of how to integrate the mentioned knowledge management activities into the primary process either.

The links between the design of business processes and knowledge management are also stressed by Heisig (2000). He presents an approach to analyse the business process from a knowledge management perspective and tries to integrate knowledge management activities into daily business. Starting from the selection of the business area and business process, every task –which is considered to be a knowledge processing task- is assessed through its function and contribution to the core activities of knowledge management (i.e. generate, store, distribute, apply knowledge) resulting in a knowledge activity profile which shows the level of support provided by the operational task towards the core process of knowledge management. The business process is improved by closing identified gaps and by sequencing the core task of knowledge management

The approach of Probst et al. (1998) specifies eight building blocks to manage knowledge: knowledge goals, knowledge identification, acquisition, development, sharing, utilization, retention and assessment. Knowledge is considered to be a resource used in the business process. The idea of building blocks for knowledge management has been proposed by Wiig (1995) with examples of building blocks for knowledge creation and dissemination. While Wiig (1995) emphasizes the connection of these building blocks with the redesign of business processes, the approach of Probst et.al. (1998) does not provide any suggestions of how to integrate the proposed building blocks into the business processes.

The model-based knowledge management approach proposed by Allweyer (1998) adds a new perspective to the modelling of existing business processes, especially of knowledge-intensive processes. Knowledge management activities are considered as an integral part of existing business processes. The four level architecture of business process management is adopted for knowledge management and the method is renamed knowledge process redesign. The approach aims to the description of required and used knowledge as well as generated and documented knowledge. Knowledge is understood as information in context with value for the owner of this information which allows him to act. The approach claims to support the structuring of knowledge into categories and the construction of a knowledge map to locate who knows what inside the organization. Easy-to-understand pictograms are proposed to help users describe the use of documented and tacit knowledge within their business processes. The approach does not make explicit how to integrate the knowledge management activities into business processes and does not provide any criteria to analyse and improve the knowledge processing within the business process.

An approach of a model-based design of knowledge-oriented processes proposes a reference model for knowledge management; see Warnecke et al (1998). The reference model consists of an object model with system elements and activities, a process model and an implementation model. The two most important elements of the object model are (1) knowledge defined as a specialization of information or sub-class of the object class information and (2) knowledge sources separated in person-independent and person-bound sources. The definition of five basic knowledge management activities - identify, make explicit, distribute, apply and store - with two to four sub-activities implies no sequencing.

Nonetheless, experience shows that there is a certain sequence, starting with the identification and ending with the storage of relevant experience. The lack of emphasis on the importance of the sequencing of the basic knowledge management activities overlooks the fact that one important weakness in existing business processes is the lack of connectivity between these basic activities. A possible barrier for the application of the reference model is the translation of real world tasks into the specific notation of the model. This might lead to additional effort and misunderstandings between the modelling expert and the process owner. The redesign is carried out by contrasting the current process with the reference model. The relevant criteria for the design are not explicitly stated in this approach.

The idea of Business Process oriented Knowledge Management is also a main topic of the EU project PROMOTE (see Karagiannis et al (2000)) which has similar analysis goals and methods. Their method consists of five steps: Strategic Decisions - the Awareness phase, Knowledge Management Process (KMP) Analysis, KMP and Oranisation Memory (OM) Modelling, Specification and Implementation, Evaluation and Continuous Optimisation.A Knowledge Builder is developed allowing users to model KMPs describing the knowledge flow in the business process. Business Process models are used to define when to access the OM, and KMP processes are used to define how to access the OM. However, KM activities and BP tasks are not explicitly integrated in the modelling phase.

6. CONCLUSIONS AND FURTHER WORK

The present paper describes a novel approach for integrating knowledge tasks and knowledge objects within business process models. This integration is achieved by explicitly incorporating knowledge tasks and knowledge objects into the business process model. The knowledge tasks deal with the creation, storage, distribution and application of knowledge required for achieving the goal of the business process. The paper also presented a workflow modelling tool that is enhanced with the perspectives of the modelling approach and supports the modelling of weakly-structured business processes by allowing underspecified modelling -with the use of black-boxes instead of fully specified tasks- and late modelling (i.e. append additional modelling of a task during run-time).

We believe that there are two main directions for further research work in this area. The first refers to the realisation of a workflow engine that adopts the perspectives of our modelling approach and facilitates the enactment of the business models. The second refers to the development of context-aware knowledge agents that will co-operate with the workflow engine and modelled information needs, in order to proactively offer relevant information from a process-oriented structured archive to the user in charge of a certain task.

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