Workflow and knowledge management:

Approaching an integration

Jin Lai Yushun Fan
Department of Automation, Tsinghua University, Beijing 100084, China
laijin00@mails.tsinghua.edu.cn fan@cims.tsinghua.edu.cn

[Abstract]

As in a famous saying: “Knowledge comes from practice and should return to practice“, knowledge is closely related to business process where it is used and created. In this part, WFMS (Workflow management system), as a system for business process definition, execution and management, plays an import role in KM (knowledge management): a big knowledge consumer and an important knowledge provider. But now the standard workflow technology has very few knowledge considerations. In this paper, after analyzing the relation among knowledge and WFMS, a new architecture for their integration is proposed. Considering the implementation of this architecture, one of the key points, the extended workflow model is studied.

[Keywords]

Workflow, WFMS, knowledge management, knowledge model, KM.

1. Introduction

The two lasting contributions of business process reengineering (BPR) are an emphasis on business processes and the recognition of the importance of knowledge and its management to an organization. The former orientation finds an expression in workflow management system (WFMS), which completely defines, manages and executes structured business processes, workflows, so as to make sure that the right tasks are executed at the right time by the right people using the right tools. Concerning the latter orientation, knowledge management (KM) is proposed and studied in order to improve the organization’s knowledge infrastructure and to bring the right knowledge to right people in the right form at the right time. [1]

Actually business process and knowledge are both indispensable elements of an organization, and moreover, these two orientations are closely correlated. To workflow’s aspect, some complex business processes rely on intensive information exchange with the company’s environment, such as design process, decision making and some office processes, and the knowledge workers would like the workflow management system to automatically and even proactively offer the relevant knowledge in the right format and at the right time. Although WFMS is becoming more and more related with other application systems, such as the workflow management systems used in the EAI (Enterprise Application Integration) platforms (Weblogic 2.1, Tibico for example), in current standard WFMS approaches the considerations of supplying knowledge for knowledge intensive task (KIT) are still very few. To knowledge management’s aspect, knowledge itself is defined as “ the whole body of data and information that people bring to bear to practical use in action, in order to carry out tasks and create new information”[1]. In short, knowledge is information made actionable. In this part, knowledge

management (KM) has a process focus. Knowledge creation, sharing, use and evaluation are all carried out in organizations' daily business processes, and on the other hand, knowledge is embedded in routines, processes as well as norms, thus WFMS can be and should be an important dynamic knowledge resource for KM. Although WFMS is already used in some knowledge management system such as Microsoft's Exchange 2000, it is mostly used as an aid for automating the processes needed for knowledge management itself such as document examination and approval, and because the workflow model has no knowledge elements, WFMS is not really integrated with knowledge. Thus although WFMS has a good framework for real-time knowledge capture and dissemination, its ability is not full recognized.

In order to resolve the problem mentioned above, we propose a new architecture for an integration of WFMS and KM, where conventional workflow is extended with knowledge specifications to support context-aware knowledge supply and real-time knowledge collection**,** and two intelligent agents are proposed to help knowledge supplying and capturing. And an important part of this architecture, the extended workflow model will also be discussed. Our design in this part is used for optimizing our workflow management system, CIMFLOW (http://www.simflow.net).

This paper will be organized as follows: in section 2, we will discuss the relation of workflow and knowledge from two aspects: a concept point of view and a system point of view; in section 3, after analyzing the limitations of current WFMS and knowledge management system, a new integration architecture is addressed; in section 4, the extended workflow model to support this architecture is proposed; and in section 5 some related work is listed; and in the final section, there will be a summary and a proposal to the future research.

2. Workflow and knowledge

As is mentioned workflow and knowledge are closely interrelated, but how? This section will discuss this problem in two aspects: in view of fundamental concepts, what's the relation between knowledge model and workflow model; in view of system construction, including what type of business process is associated to knowledge management, what kind of role WFMS will play in knowledge management and what knowledge is related to WFMS.

2.1 Knowledge model and workflow

What is knowledge? In CommonKADS, one of the leading methodologies to support structured knowledge management and engineering, knowledge is defined as " the whole body of data and information that people bring to bear to practical use in action in order to carry out tasks and create new information". There may be some other definitions, but most of them agree that: 1) Knowledge attaches purpose and competence to information; 2) Knowledge is potential to generate action. According to these characteristics, a knowledge model is put forward by CommonKADS and widely adopted. This model has three parts: domain knowledge, inference knowledge and task knowledge. Each part is called a knowledge category. The domain knowledge means the domain-specific static knowledge and information. And its description is somewhat comparable to a "data model" or "object model", which may include three types of constructions: concepts, relations and rules. And the inference knowledge

describes the basic inference steps that can be made in domain knowledge and applied by tasks. Substantially an inference is an atomic reasoning action. And the tasks knowledge describes the goals a task pursues and how these goals can be realized through its decomposition into subtasks and (ultimately) inferences.

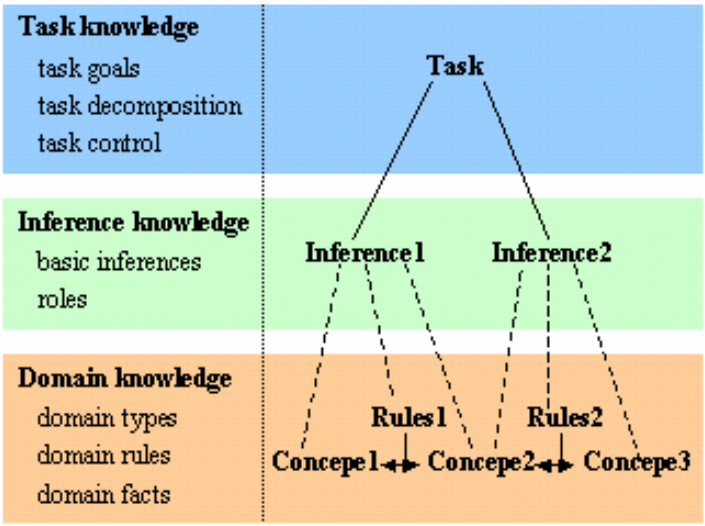

Figure 1 Overview of knowledge categories in the knowledge model.

Figure 1 gives shows an overview of the three knowledge categories, as well as an example at the right side. We can see that task knowledge is an indispensable part of this model. It is "task" that organizes the trivial domain knowledge up to satisfy a goal, that brings them the purpose and competence, and that offers environment for knowledge-to-action transformation.

And on the other hand, "task" is also a key element that constructs a business process. In fact a business process itself can be view as a top-level task that is broken down to subtasks and the corresponding control logic. Each of the tasks in a business process will be assigned with goals, the participating agents (humans or computer software) and the resources. Although the standard business process model, such as workflow, has no knowledge specifications, it offers a good framework for task knowledge construction, and if more knowledge elements are added, for example inferences and domain knowledge objects, workflow itself can be easily mapped to a knowledge model and WFMS as a workflow automation system can be an important knowledge resource.

2.2 Knowledge management and WFMS

Knowledge management is a framework and a tool set for improving the organization's knowledge infrastructure, aimed at getting he right knowledge to the right people in the right form at the right time. And the three key components in knowledge management are agents, business processes and knowledge assets, where an agent can be a human, an information system or any other entity capable of carrying out a task. And the business processes that associate to knowledge management can be divided into two types: an enterprises' daily business process that contains knowledge intensive tasks and the business processes for managing knowledge such as document examination and approval. In this paper we will focus on the first type, the daily business process. And business process mentioned in this paper indicates the enterprise's daily business process by default.

All knowledge-management actions are defined in terms of these tree objects: agents, business

processes and knowledge assets. And their relation can be viewed in figure 2.

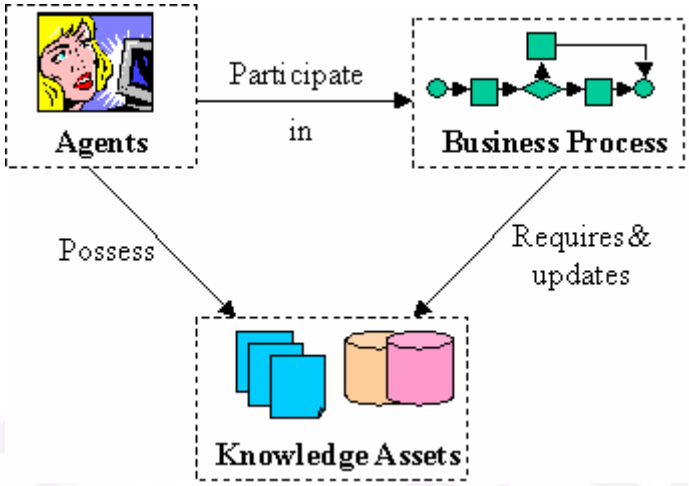

Figure 2 The relation of agents, business process, knowledge Assets

Knowledge assets are possessed by agents, and the agents participate in business processes, in which knowledge is used and updated.

Workflow management system (WFMS) is the place where daily business processes are defined and executed, it not only stores the workflow models but also instantiates these models and records the actions that are taken and the events that are happening. We can find that WFMS will play two different roles here: on is a knowledge consumer, who require some knowledge assets in order to fulfill the knowledge intensive task (KIT); the other is a knowledge provider, who by recording the execution trail of business processes, provide a good framework for knowledge collection. So WFMS should be an important part in the process of managing knowledge, especially knowledge capture and knowledge dissemination. And the relation between WFMS and knowledge management can be view in the following figure.

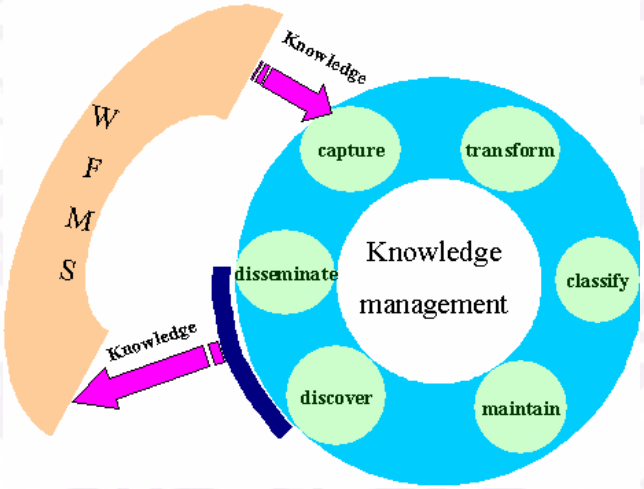

Figure 3 WFMS and knowledge management

The knowledge that is required and used in WFMS maybe knowledge of any type: domain knowledge, inference knowledge or task knowledge. And this knowledge can be stored in databases, data warehouses, documents, multimedia files etc. The ontology of knowledge and intelligent knowledge retrieval are the hot topics in knowledge management.

And the knowledge that can be offered by WFMS comes down to five classes: 1) Workflow reference model, as a kind of domain knowledge; 2) Task knowledge, which describes what knowledge

is used to meet the goals of a task and how is it used. Task knowledge is formed dynamically when the task is carried out; 3) newly created domain or inference knowledge, such as a new design document, a new competence description of an agent, together with its creation context; 4) Real-time quality evaluation of knowledge assets; 5) Some other audit information.

3. A new integration architecture

"Knowledge comes from practice and should return to practice." WFMS as a system for tasks routing and allocation, is the first place where knowledge is created, shared and used is closely related to knowledge. From a knowledge consumer's part, it will be very helpful that the system will actively offer some relevant knowledge, such as the materials of some similar projects, the relating reports, papers, or some persons that may be helpful for this task, when executing a knowledge intensive task. But now most WFMS has very few knowledge considerations. On the other hand, although WFMS can offer a lot of valuable knowledge (of five types as is mentioned), this ability is omitted. In order to resolve the problem, we will propose a new integration architecture that can support the following functions.

1) WFMS will actively (i.e. without an explicit, detailed request by the employee) and intelligently recommend relevant knowledge considering the context of the tasks. And the user is free to accept or dismiss the recommendations, or to select different material according to his personal knowledge. Whatever the choice, the system will keep track of the solutions and record the results and the context automatically for refining knowledge recommendation at the later time.

2) When executing a business process, WFMS will not only offer supports to record what knowledge is used in a task, but also encourage users to figure how the knowledge is used and its quality evaluation, which can be done in coarse or fine granularity. In the coarse granular mode, a task can be viewed as a black box with goals and input/output knowledge. And each item of the knowledge has a property card that will describe its basic natures, such as its location, form, role in the task, the importance weight, quality evaluation etc. And in the fine granular mode, the users can define the corresponding task knowledge. That is to break the task down to sub-tasks, inference till the domain knowledge resources, as is shown in figure 1. And also each knowledge item will have a property card.

3) All the five types of knowledge that WFMS offers (workflow model, newly formed task knowledge, new created domain knowledge, knowledge evaluation etc.) will be exported. And after a series of processes, for example knowledge examination, approval and classification process, they will be included in the knowledge repository and be reused. In this way, the knowledge will be automatic linked to its creation and usage context and can be retrieved accordingly, should the need arise.

The new architecture is shown in figure 4.

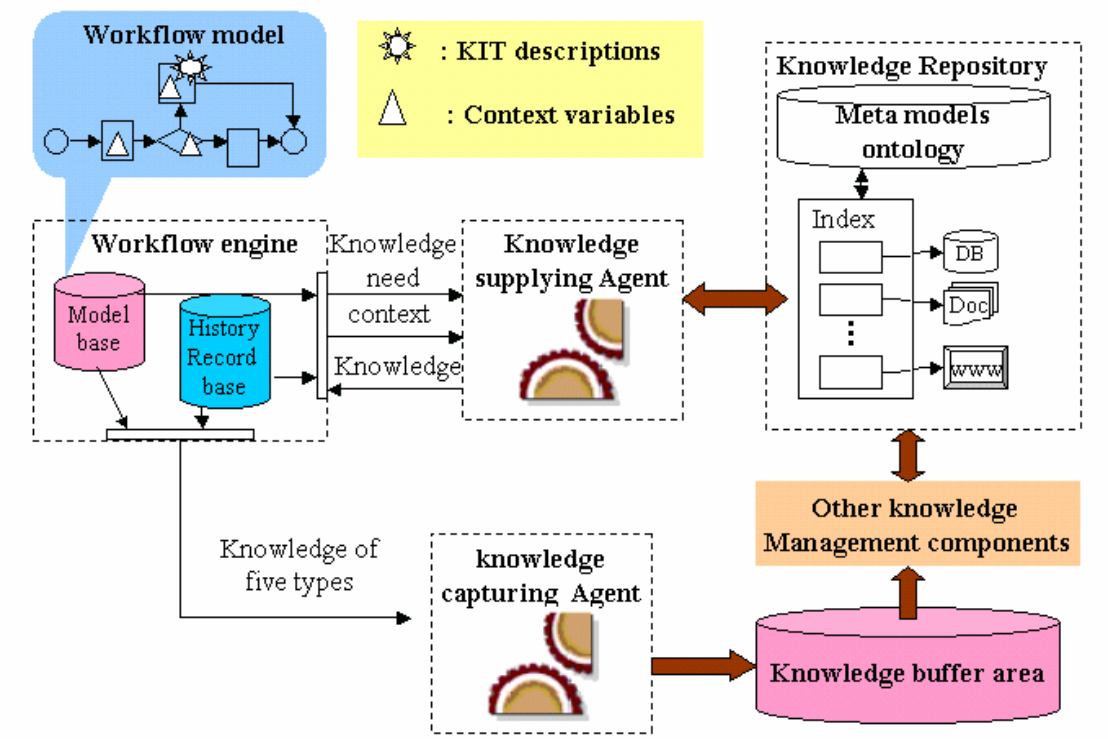

Figure 4 A new architecture for Workflow and knowledge management integration

We will describe this architecture in two phases: process definition time and process enactment time. Although the boundary of these two phases is not very clearly (some elements that is defined in the first phase will be fulfilled or update in the second phase), the two phases have different focuses.

- **Process definition time**

The main action in this phase is to model the overall business process with a workflow tool. In order to enable the intended active knowledge function, the workflow model is extended with some knowledge specifications: KIT (Knowledge Intensive Task) descriptions and the corresponding context variables, as is shown in figure 4. KIT descriptions include the respective knowledge need and knowledge track. The knowledge need is described as generic queries or query schemata, together with the agent responsible for their processing. Because the knowledge need is context-aware, some context variables, such as the task's name, the process's name, the applicant of the process (may be a business partner) etc, are added. At the runtime, the agent processes the instantiated queries thus delivers relevant knowledge that helps to execute the activity in question. And the knowledge track mainly describes what knowledge is used to execute this task, how it is used and how is its quality.

And the model of knowledge repository is also very important part. Knowledge repository contains a variety of knowledge sources to be searched and retrieved for active task support. These sources are made of different nature, resulting in different structure, access methods, and contents. To enable precise-content retrieval form heterogeneous sources, a representation scheme for uniform knowledge descriptions is needed. To this end, structure and metadata, information content and information context are modeled on the basis of formal ontology [6]. The Index in Figure 8 is thus realized as a set of descriptions modeling the information sources and facilitating an ontology-based access and retrieval. The ontology-based knowledge management is now a hot topic in this field.

- **Process enactment time**

In the process enactment time, the workflow models already defined will be imported in the

workflow execution engine, and whenever it comes to a knowledge-intensive task, the special properties attached to KIT is deciphered and executed, which means that the engine will not only activate this task and allocate it to the appointed persons, as a standard workflow engine does, but also call an appropriate "knowledge supplying agent" (which is specified in the KIT description). And the agent performs the actual retrieval of relevant information from the information source. It relies on knowledge schema to realize an ontology-based knowledge retrieval and utilize the context information from the ongoing workflow – found in the instantiated KIT variables – in order to determine relevant information. Traversing the formal ontology according to specified search heuristics, the information is able to extend and refine the given queries and to reason about the relevance of available items. Of course the users can decide whether to use or dismiss the proposal knowledge, and what's more they can query knowledge repository manually or search for knowledge out of the repository according to their personal experience. And then WFMS will support them to fulfill the knowledge report about what knowledge is used, how it is used and how about this knowledge in coarse or fine granularity. All this knowledge will be stored in WFMS's two databases: workflow model base and workflow instance base. And the "knowledge capturing agent" will routinely retrieve the knowledge from these two databases and organize them in a new form and store them in knowledge buffer area. And after some knowledge processes such as examination, approval, classification it will be imported to knowledge repository for reuse.

Considering the implement of this architecture, there are four key points:

1) the extended workflow models have such knowledge specifications as KIT description and the corresponding context variables;
2) the ontology of knowledge repository;
3) the knowledge retrieval algorithm of "knowledge supplying agent";
4) and the knowledge transform rules of "knowledge capturing agent";

In this paper, we will discuss the first key point: the extend workflow model.

4. Extended Workflow model

As is said, a standard business process model, like workflow model, has no knowledge considerations. To support the architecture in figure 4, we have to extend the standard workflow model by adding a special task type: knowledge intensive task (KIT). KIT is inherited from a common task, so beside the conventional property items such as goals, executing agents etc, some knowledge specifications will be added to KIT: KIT description and context variables. And the KIT description has two parts: one is knowledge need, and the other is knowledge track. Conceptually, this means to extend business process to cover not only what is to be done but also what is needed to do it and how to do it.

- **Knowledge need**

A knowledge need represents a demand for necessary knowledge for the support and accomplishment of a knowledge intensive task. And from the representational point of view it is important to note that the knowledge need can be represented as some kind of query – possibly a dynamic and sophisticated one. It has to be stated:

1) What knowledge is needed, i.e. which variables have to be filled?
2) How to obtain the knowledge, i.e. which sources to consider and which search heuristics to

use?

3) How the concrete information need at runtime depends on the context of the actual application and the state of the business process?

According to these considerations, a knowledge need template is proposed in table 1:

Basic knowledge need properties				
Name	**Content**		**Fulfilled way**	**Edited in execution time?**
Process instance's ID	(Context variable)		Automatically	No
Task name	(Context variable)		Automatically	No
Contact person	(Context variable)		Automatically	No
Personal interests	(Context variable)		Automatically	No
$Topic_1$	context variable or not		Automatically or Manually	Yes
$Topic_2$	context variable or not		Automatically or Manually	Yes
…	…		…	…
$Topic_n$	context variable or not		Automatically or Manually	Yes
Supplying agent			Manually	No
Category			Manually	Yes
Advanced knowledge need properties				
$Topic_1$'s weight			Manually (mean value by default)	Yes
$Topic_2$'s weight			Manually (mean value by default)	Yes
…	…		…	…
$Topic_n$'s weight			Manually (mean value by default)	Yes
Time	context variable or not		Automatically or Manually (with default value)	Yes

Table 1 Knowledge need template

Table 1 indicates that some property items can be fulfilled by context variable and the knowledge need can be dynamically formed considering different business process instances.

- **Knowledge track**

As is said, knowledge tracks can be coarse or fine granular. In the coarse mode, the task acts like a black box with information inputs and outputs.

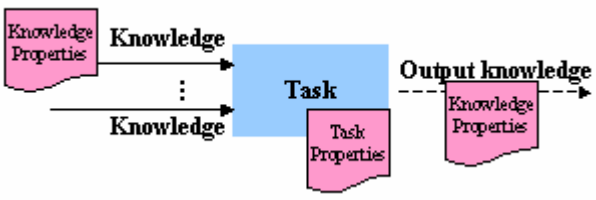

Figure 5 Knowledge specifications in coarse granularity

Each knowledge item will have a property card that describes how is this knowledge and how this knowledge is used. And the property card's template is shown in Table 2.

Name	Content		Fulfilled way
Knowledge	Name		Automatically or annually
Possessed by	Agent		Automatically or manually
Used In	Task (Context variable)		Automatically
Role	Input or output?		Manually
Form	Mind? Paper? Electronic? Action skill? Other?		Automatically or manually
Usage	As a document template? Useful in Content? Or other comments.		Manually
Quality evaluation			Manually
Importance weight	If input knowledge.		Manually

Table2 the knowledge property template

And in the fine granularity mode, the process of the knowledge flow inside the task is described, which means to break the task down to subtasks, and the subtasks to inferences until the domain knowledge that is the raw knowledge resource. No matter what, each knowledge input/output, excluding the template knowledge items, will have a property card similar to that in table2. The process of the knowledge flow inside a task is actually task knowledge and can be viewed in figure 1, especially the example in the right side.

5. Related work

The idea of extending workflow management system to knowledge is becoming more accepted in the last few years. Ref. [2] discusses the knowledge that is related to workflow, but the architecture or system for knowledge capture and dissemination is not yet addressed. Ref. [3] and Ref. [4] presents an architecture for information management assistants, which will assess the user's work context for starting active information delivery, this idea is quite similar to our approach, but it doesn't address the possibility of retrieving knowledge from WFMS either. And Ref. [1] proposes commKADS, a knowledge managing methodology, which discuss the definition and modeling of knowledge. Their main idea is that knowledge should be closely related to tasks, this idea does give us some inspiration, but their work is restricted in knowledge management, and does not care about the WFMS's knowledge need and its ability to actively capture knowledge in daily business processed. And there is other related work, such as ontology-based knowledge management, XML-based document representations, which are discussed in Ref. [6], [10], [11], [12], [13] etc.

6. Conclusion

Knowledge is information made actionable. So knowledge is closely related to business processes,

especially an enterprise's daily business process. And WFMS, as a business process execution system, plays an important role in knowledge management. WFMS not only is a big knowledge consumer but also can be an important knowledge provider. But unfortunately, the standard workflow technology has very few knowledge considerations. In this part, we propose a new architecture for the deep integration of WFMS and knowledge management, which extends conventional workflow model by such knowledge specifications as KIT description and the corresponding context variables, and puts forward two agents that take charge of active knowledge supply and routinely knowledge capture. With this architecture, WFMS can intelligently supply relevant knowledge according to the context of a task, and actively record the knowledge usage and creation trail that will be imported to knowledge repository for knowledge assessment and reused. Considering the implementation of this architecture, there are four key points: the extended workflow model, the knowledge ontology schema, the knowledge supplying agent's query algorithm and the knowledge capturing agent's transform rules. In this paper one of the key points, the extended workflow model is studied, and the others will be our future research topics.

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