Project TEAL: Add Adaptive e-Learning to your Workflows

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Abstract: Workflow- or task- embedded e-learning is an actual trend in enterprise and office environments. Having been integrated into enterprise workflow or task management systems, e-learning turns into a powerful tool for enterprise knowledge management: the seamless integration into the working environment allows getting actual information about potential learning goals of the user; using up-to-date e-learning technologies enables just-in-time delivery of goal-oriented, user-tailored learning curricula, helping employees to solve problems autonomously and competently. This paper reports about the results of the project TEAL (Task-embedded adaptive e-Learning) taking place at German Research Center for Artificial Intelligence (DFKI). The aim of the project was to prove the concepts and feasibility of task-embedded e-learning by designing a reference architecture and realizing prototypical implementation based on the existing components built at DFKI: WFMS Taskman, LCMS DaMiT and ActiveMath.

Key Words: task embedded learning, workflow learning, ontology, business process oriented knowledge management, business process management
Category: H.3.7, H.5.4

1 Introduction

Modern enterprises face hard restrictions and requirements than it was a decade ago due to the progress of globalization and world economy developments [UNDP 03]. Ubiquitous computing and emerging internet technologies lead to more and more complex computational environments that increase the danger of the information overload in the enterprise that present a challenge for enterprise employees. In order to achieve and keep the competitive edge, todays enterprises have on one hand to carefully adjust their business processes to the permanently changing enterprise business goals [Sheer 05]. On the other hand the enterprise has to care about the effectiveness of each employee that depends heavily on the employees‘ skills, competency level and employees‘ ability to effectively learn in the situation of information overload.

While the problem of business process optimization in the enterprise can be solved by introducing workflow management systems (WFMS) and business process management (BPM) software [Ultimus 05], the problem of information overload and employee skill/competency support can be solved by introducing knowledge management and e-learning solutions [Prusak 01]. The integration of the above approaches (i.e., workflow management, knowledge management and e-learning), named "Workflow learning"™, is a unique combination that allows to increase the effect of both. Having been integrated into enterprise workflow or task management systems, e-learning turns into a powerful tool for enterprise knowledge management: firstly, the seamless integration of e-learning into the working environment (working context) allows to get actual information about potential learning goals of the user and adjust the learning process to the current user needs; secondly, the integration of learning into the workplace increases the acceptance of learning because the learning process in not seen as extra burden and is a part of daily work. In [Atkins 03], Sam Atkins gives the definition of "Workflow Learning"™that assumes integration of enterprise software and e-learning into one workflow using service oriented architecture (SOA), generating learning tasks as part of the enterprise workflow and permanent control on the learning task execution. Although we agree that it is a possible approach for solving the problem, we advocate the approach of the lightweight proactive information delivery and business process-oriented knowledge management described in [Holz et al 05]. In the TEAL project, we extend the idea of context-specific, proactive information delivery by using up-to-date e-learning technologies enabling just-in-time delivery of goal-oriented, user-tailored learning curricula, helping employee to solve problems autonomously and competently [Rostanin and Holz 05]. This paper reports about the results of the project TEAL taking place at German Research Center for Artificial Intelligence (DFKI). The aim of the project was to prove the concept and feasibility of task-oriented proactive delivery of e-learning courses by designing a reference architecture and realizing a prototypical implementation based on the components built at DFKI: WFMS Taskman [Taskman], LCMS DaMiT [DaMiT], LCMS ActiveMath [LeActiveMath].

2 Task-embedded e-learning

As it was said above, the enterprise business processes set hard requirements to the task-embedded e-learning. The information delivered to workflow participants has to satisfy the current users' information needs (be just-in-time) but not to overwhelm them (be just-enough). Considering this facts, we argue that task-embedded learning has to be highly adaptive and goal-oriented (see 2.1).

2.1 Goal-Oriented Learning

Fundamental research on goal-oriented learning in general, and, in particular, with respect to AI and machine learning has been conducted by [Ram and Leake 85]. Goal-oriented or targeted learning is something that one meets in everyday life. Using AI terminology, let us call the person who deals with any kind of tasks an agent. Such agents often have to cope with previously unknown kinds of task. Facing a new task, an agent first makes mental inferences and checks whether he has enough knowledge to perform the task. If the inference fails (i.e., necessary knowledge is not present), a knowledge gap is identified. After the knowledge gap is identified, the learning goal "cover the knowledge gap in the context of the given task" arises. Learning goals that arose earlier and had not been satisfied or have been satisfied only partially will influence the learning process even if the agent currently has a new learning goal. Moreover, learning goals tend to evolve during the learning process: they can be generalized, specialized, and - if they become obsolete - eliminated.

2.2 The TEAL Architecture

One of the main tasks in the TEAL project was to develop a flexible architecture that allows for just-in-time learning in workflow environment (see fig. 1). The components comprising the architecture are presented below:

WFMS A WFMS is "a system that defines, creates, and manages the execution of workflows through the use of software, running one or more workflow engines, which are able to interpret the process definition, interact with workflow participants and, where required, invoke the use of IT tools and applications" [Allen 05]. WFMS contain two basic components: the first component is the process modeling (PM) component, which enables administrations and analysts to define processes and activities, to analyze and simulate them, and to assign them to people. The second component is the process execution (PE) component, sometimes called the run-time system. Normally, workflow participants deal only with the PE component using a web-based or desktop-based WFMS client. In the TEAL project we used the Taskman system [Taskman] as the WFMS for the task-embedded learning.

LCMS LCMS is a multi-user software system designed to enable learning developers to create, store, reuse, manage, and deliver digital learning content from a central learning object repository (LO Repository). The LCMS DaMiT used in TEAL is extended by incorporating an on-the-fly goal-oriented course generator developed in the LeActiveMath project (see 2.4).

LO Repository Is a part of the LCMS that manages storing and retrieval of learning objects (LO) as well as maintenance of the learning concept ontology. The LO repository provides access to LOs through both a web service interface (**TEAL DB Service**) and direct SQL queries to the database.

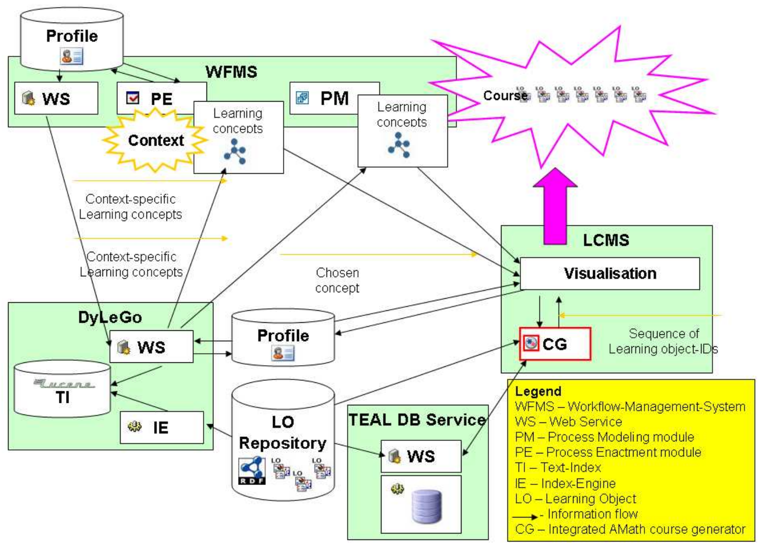

Figure 1: Architecture of task-embedded e-learning

DyLeGo - Dynamic Learning Goal A SOA-based middleware system enabling task-embedded e-learning by implementing the following functionalities accessible through a web service interface:

1. Building a text index of the learning concept ontology from the LO repository for a high-performance search of learning concepts.
2. Retrieving learning concepts from the ontology based on the full text search in the index;
3. Delivering filtered list of potential learning goals to the user based on the current task context.

The working scenario of the presented system is depicted on fig. 2:

1. **DyLeGo call:** The software developer Bob is a participant of software development workflow in the company C. At the moment when Bob creates a task in the WFMS, the WFMS automatically launches a learning goal query to DyLeGo. DyLeGo receives the context information from the WFMS and starts with learning concept retrieval.
2. **Learning concept retrieval and filtering**: DyLeGo starts the learning concept retrieval in the LO repository of the LCMS. If learning concepts that are relevant to the task are found, they should be filtered using the information from the workflow context. For example, if Bob is an expert in SQL, learning content about basic concepts of SQL is out of interest for him.

3. **Learning strategy identification:** After retrieving and filtering of the learning concept, learning strategy should be determined. Which learning strategy in learning process should be chosen depends on the learning goal itself, the role of the user and the learning history of the user. In the TEAL project we defined 4 following types of learning strategies:

   overview Very short description giving the general impression about the subject to be learned. One can compare this with glossary description. On the basis of the overview Bob should be able to judge whether he needs to learn this subject deeper or not.

   cursorily If the learner decided to learn the subject but he/she does not need to get expert-level knowledge on it, the cursorily strategy should be chosen. For instance, it would be the case if Bob's manager would like to get acquainted with possibilities of the SQL language.

   detailed Provides expert-level knowledge on the subject. If Bob would like to optimize a complex Oracle query and has no idea about optimization, a detailed course on Oracle SQL tuning should be delivered for him.

   repeat Serves as reference material on the subject. If Bob finished the course on Oracle SQL tuning he might still need a succinct reminder course on Oracle optimizer hints.

   At the end, DyLeGo returns learning concepts and recommended learning strategy as potential learning goals to the WFMS.

4. **Potential learning goal visualization:** Bob receives potential learning goals delivered by DyLeGo and selects one or more of them. The LCMS generates learning course dependent on the selected potential learning goals (see 2.4) and delivers it to Bob, so that Bob can start learning.

2.3 Identification of Learning Goals in the Task Context

Task context includes a variety of information about the task environment that allows identifying potential learning goals:

- **Task information**
  - **Task name, description, task-relevant concepts and documents** provide the key information about what the user is currently doing. Using task name we can identify potential learning goals of the user.
  - **Reference to the instantiated task model** if the current task is instance of the certain activity model it can give more precise information on what the user is currently doing than just using a task name.

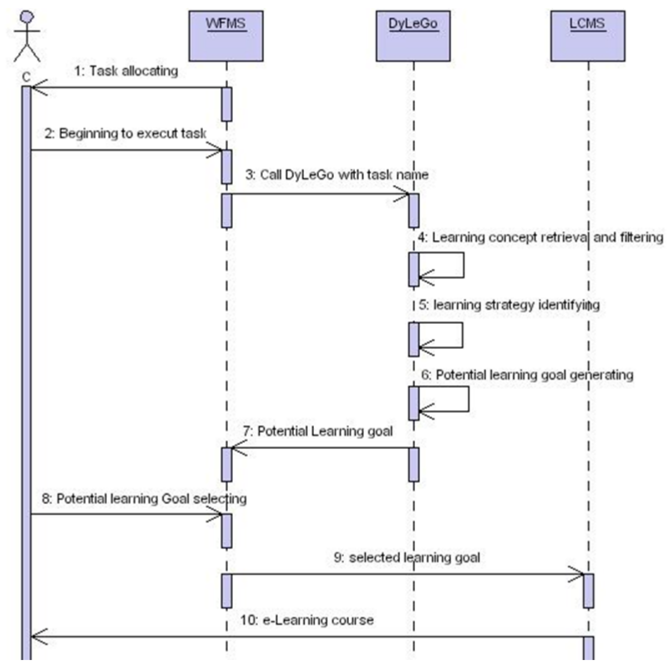

Figure 2: Task-embedded e-learning with DyLeGo: sequence diagram

- **Project information, connection to other tasks** The information about the project and other tasks (predecessor, successor etc.) of the user can help to interpret current user actions.

– **User information**

- **User role** is the base for determining learning strategy of the user.
- **User skills, interests, working and learning profile** allow us to exclude concepts that user already knows or include concepts that are unknown for the user.

The basis for the retrieval of potential learning goals is the ontology of learning concepts contained in the LO repository of the integrated LCMS. The learning concept ontology depicts the outline of the learning content in the LO repository. The goal of the learning concept ontology is to model the domain of knowledge related to the given workflow. LO contained in the LO repository are bound to the corresponding concepts using special metadata. The more concepts are preserved in the ontology, the finer knowledge gap identification can be achieved. In order to enable potential learning goals search, the DyLeGo system creates full text search index of the learning concept ontology (concept name, description). After the request from the WFMS system arrives, the search of learning concepts in the text index using task context information is performed. The result of the search are filtered using learning history and competence profile (delivered from the WFMS). The concepts left after filtering are returned to the WFMS together with their short descriptions and proposed learning strategy.

2.4 Generating an Adaptive Goal-Oriented Course

In the LeActiveMath project, an advanced course generator [Ullrich 05a] was developed that implements competency-oriented learning strategies based on modern pedagogical research. The pedagogical knowledge is generic, that is, independent of the content. While the developed learning strategies were originally target at learning mathematics, they can be applied on different content, for instance the one of the TEAL project. This general applicability is achieved in the following way: the pedagogical knowledge uses an vocabulary targeted at describing learning resources from a pedagogical perspective that captures the information necessary to reason about resources from a pedagogical point of view. This vocabulary is specified in an ontology of instructional objects [Ullrich 05b]. In order to connect a LO repository to the course generator, one has to specify a mapping from the ontology to the metadata representation used in the repository and a wrapper that answers queries about the learning resources coming from the course generator. In information processing, such an approach is called a mediator architecture (for a recent overview, see [Doan et al 04]). The result of the course generation is a structured sequence of learning resource identifiers similar to an IMS Content Package [IMS 03], which can be further processed by the system that called the course generator.

The integration into TEAL followed this approach: a mapping between the ontology of instructional objects was specified and a wrapper connected the mediator to the LO repository of the LCMS DaMiT. Each time the WFMS Taskman needs to provide the employee with a sequence of learning objects, it starts the course generator with the identifiers of the target learning concepts and chosen strategy. As a result, the WFMS Taskman receives a sequence of LO identifiers that are presented to the learner by the LCMS DaMiT.

3 Conclusions

In the current paper we reported about the results of the TEAL project:

1. We introduced a reference architecture for integrating e-learning into enterprise workflows.

2. We introduced the DyLeGo system serving for dynamic identification of employee's learning goals.

3. We reported about integrating a dynamic course generator into the LCMS DaMiT that enables just-in-time delivery of the adaptive learning courses in the workflow context.

In the future we would like to check the DyLeGo concept on WFMS others than Taskman. The second step would be to evaluate the system in industrial and academic scenarios.

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