Scruffy Technologies to Enable (Work-integrated) Learning

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Abstract. The goal of the APOSDLE (Advanced Process-Oriented Self-Directed Learning environment) project is to support work-integrated learning of knowledge workers. We argue that work-integrated learning requires extreme flexibility on a variety of aspects from supportive learning systems. This flexibility can not be achieved by typical (neat) eLearning systems. In this contribution we present how a battery of scruffy technologies (e.g. combining semantics, associative networks and collective intelligence approaches) can be utilized to achieve this flexibility for user profile maintenance and context-based retrieval.

1 Neat versus Scruffy

Typically eLearning systems are a wonder of carefully designed content, fine-granular models, interdependencies and hand crafted metadata: The learning domain is broken down into meaningful learning units or modules which encompass concepts, facts and processes. They entail fine granular learning information, exercises, tests, etc. Each of these units is carefully designed using a multitude of different media appropriate for the learning type and purpose the unit is playing. A dependency structure identifies prerequisites and post-conditions. Based on the units learning paths (courses) can created by instructional designers taking into account the target group as well as preferred didactical aspects. In order to allow for improved personalization a multitude of metadata is attached to the units. In addition, eLearning systems provide detailed user models which allow for the representation of different learning levels in the different areas, learning preferences, etc. Tutors and teachers are represented in order to allow students access to expert help. Not to speak of class and lecture management, simulation and games, etc.

In short, one is faced with a thoroughly designed network of interrelated pieces which need to be artfully concerted to deliver a meaningful learning experience to the user. Reflecting on these properties one can easily understand why eLearning content is expensive to create, requires lots of (metadata) standardization, and also requires a lot of organizational structure.

On the other hand new learning approaches such as work-integrated learning (see (Lindstaedt 2006) for possible scenarios) and organizational learning put one requirement in the center of attention: *Flexibility*. Being closer to the application of knowledge (rather than on the internalization of knowledge) such approaches critically rely on providing always the newest available content in ever changing learning situations. While in traditional course-oriented eLearning one could still manage the large amount of design work (also because the learning domains stayed rather stable) this is not the case any more in these new settings. Here we have to satisfice for the best possible available learning information instead of striving for the best designed eLearning content.

Thus, in such situations it is simply impossible to create and maintain such a carefully crafted network of interdependent learning pieces and structures. Instead, we have to move towards embracing approaches which enable us to best deal with change – while at the same time accepting their side effects such as a lower level of accuracy, likelihood of errors and not always optimal instructional design.

Within this paper we present possibilities of moving away from the purely neat approaches of instructional design (based on hand crafted verified formal models) to the application of scruffy technologies (hybrid approaches which also take empirics into account) to enable work-integrated learning. The "intelligence" within such systems may be "seen as a form of search, and as such not perfectly solvable in a reasonable amount of time" (Gigerenzer & Todd, 1999).

We present the APOSDLE approach of applying a battery of advanced scruffy technologies to bridge the gap between coarse grained models and fine grained learning needs. The ultimate goal of this research is to minimize or at best fully eliminate the need for formal models. This will also significantly reduce the amount of human effort needed to create eLearning systems. Our approach follows the motto: Better about right, than exactly wrong.

APOSDLE Scruffy Approach

APOSDLE offers individual learning support to people working with information and contributing new content to an organisation's knowledge pool. These "knowledge workers" may include e.g. engineers, researchers, software developers, consultants, or designers. It follows a "learn @ work" approach meaning that learning takes place in the user's immediate work environment and context. It offers integrated support for all three roles a knowledge worker interchangeably fills at the workplace: the role of the worker, the role of the learner, and the role of the expert (for more details please refer to www.aposdle.org). APOSDLE is funded within the European Commission's 6th Framework Program under the IST work program. It is an Integrated Project jointly coordinated by the Know-Center, Austria's Competence Centre for Knowledge Management, and Joanneum Research. APOSDLE brings together 12 partners from 7 European Countries.

The foundation for the APOSDLE approach is to not rely on specifically created (e)Learning content but to reuse existing (organizational) content which was not necessarily created with teaching in mind. We tap into all the resources of an organizational memory which might encompass project reports, studies, notes, intermediate results, plans, graphics, etc. as well as dedicated learning resources (if available) such as course descriptions, handouts and (e)Learning modules. The challenge we are addressing is: How can we make this confusing mix of information accessible to the knowledge worker in a way that she can advance her competencies with it?

A frequently traveled path (also within eLearning systems) is the creation of fine-grained semantic models which allow for the categorization and retrieval of such resources. But as we discussed above, the creation of such models, their maintenance and the annotation of resources with their concepts prove prohibitive in a dynamic environment. Thus, *the APOSDLE approach is a hybrid one: complementing coarse grained semantic models (maintained as much as possible automatically, see below) with the power of diverse associative methodologies, improved over time through usage data and user feedback (collective intelligence).*

Here the models play two roles: serving as initial retrieval triggers and providing the basis for simple inferences and heuristics to interpret user interactions. A disadvantage of this approach is that “statements” made by the system such as “this resource helps you to understand the concept of use case modeling” or “this person has expertise in use case writing” rely on empirical observations with no claim to accuracy. However, users have become increasingly accustomed to this concept through their usage of (internet) search engines. Also, obsolete models do not provide any added value and additionally are in danger of providing a false sense of security.

Within our research we have identified two main areas in which this hybrid approach can be applied: context-based retrieval and user profiles maintenance. And since for the time being, we were not able to make this happen without semantic models we propose how the creation and maintenance of such models can be supported with scruffy technologies as well. In the following we shortly sketch out our solution ideas and present the core of the first prototype of the APOSDLE Platform.

Semantic Modeling Support

In order to support work-integrated learning a system needs to have knowledge about the learning domain, the work processes in which knowledge from the learning domain needs to be applied, the relationship between work tasks and required competencies, and the relationships between these. The creation of these models for any real world application is far from trivial (a fact we also experienced painfully while working on our first APOSDLE prototype). Thus, the approach taken here is to settle for coarse grained models, to discover parts of these models automatically based on the analysis of the knowledge base and the user interactions, to propose meaningful mappings between these partial models and finally to provide them to the knowledge engineer together with tools which help her in their analysis, modification and maintenance based on usage data. Such tools could:

- propose domain concepts based of automatic extraction of keywords from the knowledge base

- propose initial domain and process structures (and their mappings) based on automatic extraction of partial semantic structures from the underlying systems (e.g. folder hierarchies, workflow systems)
- propose domain model based metadata for annotating resources based on automatic clustering algorithms
- check the coverage of a domain model with resources from a knowledge base based on automatic clustering algorithms
- propose relationships between model concepts based on automatic mappings
- analyze models based on usage data
- channel user feedback concerning model evolution and tagging of resources directly to the knowledge engineer

Within the first APOSDLE prototype we have created a number of plug-ins for the ontology editor Protégé which support the knowledge engineer in many of the ways described above (Pammer et al. 2006, 2007).

Context-based Retrieval

The semantic models together with the resource annotations allow for an initial, coarse retrieval. However, these retrieval results will most likely be to general for a specific user context. Thus, the semantic models need to be complemented with a variety of similarity measures both on the semantic and the resource level. An associative network can be utilized to integrate semantic as well as text and multi-media based retrieval by building up connections based on:

- automatic identification of similarities between domain model concepts based on graph analysis algorithms (e.g. nearest neighbour)
- automatic identification of similarities between resources based on text or multi-media analysis algorithms
- automatic maintenance of these similarity measures based on usage data and user feedback

The *Associative Network* (see Figure 1) is used for context-based retrieval of resources. It is queried by the User Profile Service (see below) for resources corresponding to the current context of the user.

For processing the information present in the Associative Network a technique called spreading activation is employed. Spreading activation originates from cognitive psychology (cf. (Anderson 1983)) where it servers as mechanism for explaining how knowledge is represented and processed in the human brain. The human mind is modeled as network of nodes, which represent concepts and are connected by edges. Starting from a set of initially activated nodes in the net, the activation spreads over the network (Sharifian & Samani 1997). During search, energy flows from a set of initially activated information items over the edges to their neighbours. The information items with the highest level of energy are seen to be the most similar to the set of nodes activated initially. A detailed introduction to spreading activation in information retrieval can be found in (Crestani 1997). A description of our studies on the topic can be found in (Scheir & Lindstaedt 2006).

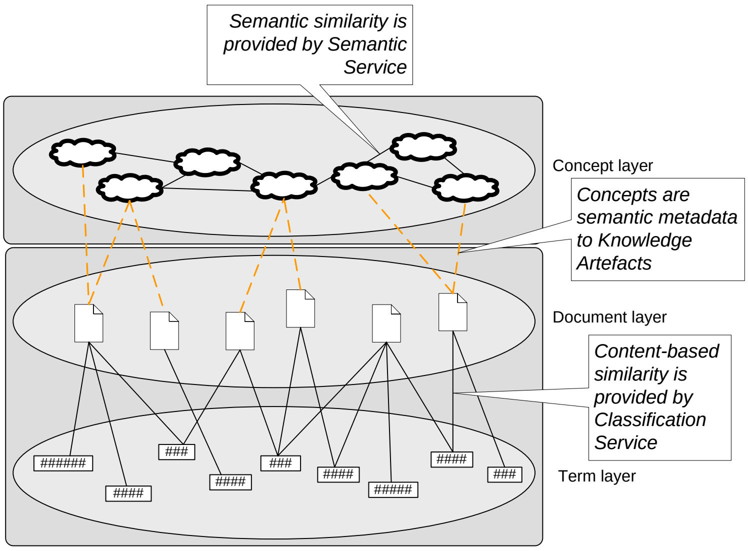

Figure 1: The associative network exploits two different forms of similarity, i.e. semantic similarity and content based similarity. Semantic annotations function as a 'glue' between these two forms of similarity.

User Profiles

Especially within work-integrated learning it is essential that the context of the user can be discovered from her actions and that her competencies can be inferred from the task executions. Utilizing the established mapping between tasks and competencies (Ley 2007) it should be possible to:

- automatically discover a user's work task based on user interactions (e.g. keystrokes, application usage) in relationship to the process model
- automatically infer a user competencies based on task execution heuristics
- improve user profiles based on usage data and user feedback

The *User Profile Service* serves as a repository for user-related information and as an engine enabling the APOSDLE system to infer information about the user. Information about the user is referred to as user context. The user context has been defined during the development process to be 'the substrate in which events occur and (which) allows a meaningful interpretation of data. Furthermore, the context is characterized by a relevant subset of all surrounding potentially dynamic (e.g. temporal, environmental) information and (external and internal) conditions' (Ulbrich et al. 2006). Information and conditions are subsumed under a meta-model, which consists of three separate models for the first prototype (task model, competency model and domain model). For two pairs of models mappings are defined. Mappings related elements from one model to the elements from another model. The User Profile Service utilizes a history-based user profile representation where activities of users are stored in a database together with a timestamp and the element from the meta-model, which had been involved in the interaction (Montaner 2003).

The services, which the User Profile Service provides are aligned with Kobsa's conception (Kobsa 2001) of tasks to be executed during a personalization process: acquisition, representation or secondary inference and production of content. Here the main focus is on the inference task. Examples for the services provided by the User Profile Service are the maintenance of a user's personal profile (i.e. her user data like name, address, organisation etc.), storage and provision of – among others -- a user's task and competency history, inference of a user's competencies from the tasks she has executed, and inference of a user's level of expertise with respect to a given competency in relation to other users.

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