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Bridging the Gap between Knowledge Management and E-Learning with Context-Aware Corporate Learning

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Knowledge management and e-learning both address the same fundamental problem: facilitating learning in organizations. But they approach the problem with two different paradigms, resulting in two different types of system. This paper proposes context awareness with respect to the learner's or employee's context as a solution to bridge the gap. The project *Learning in Process* is illustrating a step into that direction.

1. Introduction

Learning in Organizations. That's what both (corporate) e-learning and knowledge management are about. It may appear as simple as that, but in practice there are two different paradigms resulting in two different types of systems. But with the shift to constructivist learning environments and the support of collaborative knowledge building in knowledge management systems, it becomes apparent that this separation does not make much sense and is an obstacle to more effective applications. Still, there are two rather different perspectives. In this paper, these differences and the respective shortcomings are briefly discussed (section 2). These shortcomings can be traced back to the unawareness of certain aspects of the context of the respective user. Therefore, a more thorough consideration of context is proposed as a solution (section 3). As an illustration, the work conducted in the project "Learning in Process" (LIP) is presented in section 4.

2. E-Learning and Knowledge Management — Two Paradigms

2.1 Knowledge Management

Knowledge management is a discipline originating from management studies, but always going hand in hand with information technologies both as a reason for its necessity and as a technical solution for the implementation. Knowledge management

takes an organizational perspective on learning, and the main problem it tries to address is the lack of sharing knowledge among members of the organization. Its solutions try to enable and encourage the individuals' making explicit their knowledge by creating knowledge assets or engaging in discussion forums.

The language of knowledge management is to some degree naïve because it assumes that knowledge is an (almost tangible) good that can be "produced", "captured" or "transferred" and that can be summed up to a corporate memory. Starting from metadata-driven document management, knowledge management has now adopted communication and collaboration solutions in order to address the problem of tacit knowledge. Still, knowledge management does not fully realize that it is mainly about facilitating purpose-oriented *learning* in organizations and that thus understanding how *learning* takes place is extremely important to consider. And learning – in the view of modern constructivist learning theories – is not just transferring knowledge; it is a highly individualized task of construction.

2.2 E-Learning

E-Learning, or better computer supported learning, focuses on the individual's acquisition (or rather construction) of new knowledge and the technological means to support this construction process. One of the main assumptions in e-learning coming from pedagogy is that learning needs or can be improved through *guidance*. The typical form of guidance is the teacher or tutor organizing the learning process. But e-learning has also transferred the concept of lessons to computer-based courses, consisting of several learning resources that are connected with one another in a meaningful way. This comes from the pedagogical insight that it matters for the efficiency of learning in which order learning resources are offered, which can encompass both more traditional courses, modular learning objects, but also more elusive interaction possibilities. This concept of guidance also leads to an asymmetry and a separation of the roles author/tutor and learner. Authors and tutors are pedagogically and didactically trained persons while learners typically are not.

State of the art e-learning approaches provide very sophisticated ideas for improving the learning process. However, its focus on didactically well-founded learning material with rich media content and complex interaction profiles makes it impractical, especially in cost-sensitive corporate settings. While it is true that a clear didactical approach and rich learning programs facilitate the learning of the individual significantly, e-learning approaches have so far not been able to solve the problem of producing these kind of materials. Simulations close to the real world are the perfect answer to constructivist learning theories, demanding situated learning [8] with a high degree of engagement of the learner. But the "real world" in companies looks different. There are some more advanced courses, mostly bought from external training providers. But the majority of learning occurs from less perfect things, authored in a more peer-to-peer manner that still provide significant opportunities to learn. This is especially true for innovative topics, constituted by "less mature" knowledge for which there is no consolidated view, or highly specialized, company-specific subjects.

3. Towards an Integrated View with Context-Awareness

What separates the world of e-learning and the world of knowledge management is their respective limited and isolated consideration of context. If context is perceived on a broader scope, e-learning solutions can "learn" that corporate learning takes place in an organizational context, that learning processes are most often triggered by immediate real-world needs. e-learning can also "learn" that the authoring takes place (and is encouraged to take place) in the same context as the learning itself, thus integrating the peer-to-peer knowledge sharing philosophy.

On the other hand, knowledge management can "learn" that the context of the individual matters, that delivery of information pieces does not help if the individual is ignored, her current state of knowledge into which the new knowledge pieces should be integrated, her most efficient form of learning, which probably includes more than just a document.

On a technical level, what do we have to do?

- We need to **capture the context** of the learner and the situation in which learning occurs. This encompasses both the work context (the individual's position and role in the organization, current process or task) and the personal characteristics with respect to learning (previous knowledge, personal goals, cognitive style etc.). This context should be managed in a way so that several applications can view and update this context in a mutually enriching way.
- We need to **provide context-aware delivery methods** to account for the fact that a learner in a company is not primarily learning, but usually working and interrupting their work for learning. Current methods are only suitable for long-term strategic learning, but not for immediate learning on demand (although there is some research in that direction, e.g.[9]).
- We need to perceive that **resources themselves are created in context and interrelated** with other resources and this context makes a difference in making sense of the individual resources.

In knowledge management research, there have been some approaches to exploit context for improving the solution (e.g. process context in [1] or [2]). An approach to the problem from the e-learning point of view was taken by the project "Learning in Process" the results of which are briefly summarized in the following section.

4. The Case of LIP

4.1 Overview

Learning in Process ([3], [4]) has been a project with a consortium with learning technology experts, knowledge management companies and researchers of context-aware information systems. Its primary goals have been the integration of working

and learning on a process level and learning management, knowledge management, human capital management and collaboration solutions on a technical level. The focus of the project has been on the incorporation of context-awareness into the design of learning solutions[5].

As a first step, the different types of learning processes in a corporate setting were identified according to the primary initiating or controlling instance. Then it was analyzed how the consideration of context can improve those learning processes. LIP considered the following types of learning processes:

- **Course-steered learning.** This type of learning process currently is in the focus of corporate learning strategies. Learning activity is controlled by the pre-defined course structure, where courses typically are relatively large learning units, which can be subscribed to or assigned to. It is important to note that this encompasses both e-learning courses and presence seminars (and, of course, "blended learning" arrangements). Context-awareness in course-steered learning primarily is the adaptivity of course structures based on contextual variables, allowing for alternative (but still pre-defined) learning paths.
- **Self-steered learning.** In this type of learning process, the learner initiates and controls the learning process herself. Typically, she actively searches for learning resources which help to satisfy the current knowledge need. This includes purposefully contacting colleagues for help on a particular problem. Context-awareness can make the selection process more efficient by adding implicit assumptions of the learner (e.g. her current task). This can be used both for exploratory and for descriptive search strategies.
- **Context-steered learning.** The main drawback of course-steered learning is that it only allows for a limited integration of working and learning activities due to the coarse-grained nature. Self-steered learning on the other side allows for interweaving these processes, but it requires non-trivial cognitive abilities (e.g. becoming aware of knowledge gaps and formulating a corresponding query in whatever form). In order to overcome these problems, LIP has elaborated a third type of learning process: context-steered learning. Here the system observes the (potential) learner's work activities, while she interacts with her everyday applications. The system deduces from its domain knowledge and the knowledge of the learner potential knowledge gaps. For these gaps, the system can compile small learning programs from available learning resources and recommend them to the learner, who can decide whether to learn now, to postpone it, or discard the recommendation completely. Here information about the context is used for several purposes: when and how to recommend, what to recommend and how to compile individual learning resources into personalized learning programs.

4.2 Context Model

Essential for any context-aware system is the formalization of what "can used to characterize the situation of an entity" [10], i.e. the definition of a context model or schema for context information. Past research approaches have shown that there is no canonical set of context feature for a certain problem domain. So the system was

designed in a generic way so that appropriate features (together with their acquisition and exploitation strategies) can be added to the schema without affecting the core functionality or the interfaces of the involved services. The core of this generic infrastructure is a data model for context information based on RDFS that is capable of representing imperfection and dynamic phenomena like aging as well as the context history [6] for all context features.

For defining the LIP context schema, a pragmatic approach was chosen that is based on three pillars: (1) the analysis of existing approaches (including both research and standardization activities like IMS Learner Information Profile and PAPI), (2) a scenario-based end users requirements elicitation phase and (3) the identification of potential context sources and usage strategies (e.g. by considering the IEEE Learning Object Metadata (LOM) standard). This ensures that the context schema incorporates both *relevant* and *realistic* context features for the two pilot installations. The result was a context schema that can be divided into three groups, which correspond to the research communities of adaptive e-learning systems [11], business process oriented knowledge management [2] and context-awareness:

- Personal
  - previously acquired knowledge or competencies
  - goals (divided into short-term and long-term)
  - preferred interactivity level (from LOM)
  - preferred semantic density (from LOM)
- Organizational
  - organizational unit
  - role(s)
  - business process (or process step)
  - task (as an activity that cannot be easily mapped to a business process)
- Technical
  - user agent (operating system, browser, plugins etc.)
  - bandwidth
  - available audio

Additional context information, e.g. like the learner typology used in [12], is certainly desirable, but was discarded for the prototypes because there was no appropriate learning material available.

This holistic view of the context in which learning takes place brings together the aspects that are typically the domain of knowledge management (the organizational aspect) and learning management (the personal perspective). Semantic linkage of these two aspects is achieved through a competency catalog, which forms also the semantic basis for current approaches to holistic human resources development (e.g. [13]). Apart from a hierarchical structure, this competency catalog also allows for (currently) five different competency levels. Competencies are linked directly to the individual context as existing competencies and future goals and indirectly by associating the organizational context entities with competency requirements (see Fig. 1). On the other side, learning objects are described by their objectives (expressed as competencies that are acquired after successful completion) and their prerequisites

(expressed as competencies that are required to understand the presented resources). This enables the context-aware matching procedure, which is described in the following section.

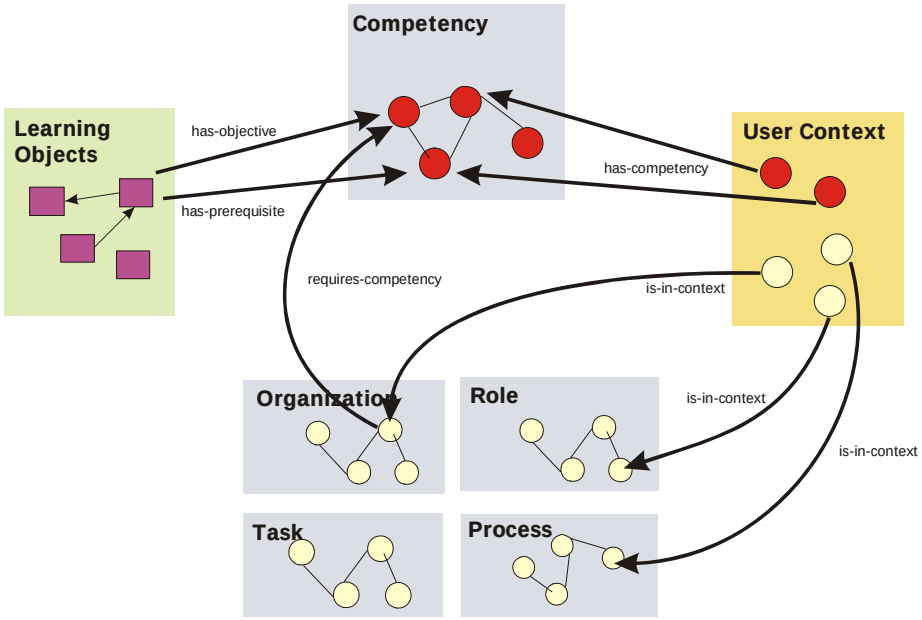

Fig. 1. Competencies as the semantic glue between the context and learning resources

4.2 Matching Procedure for Context-Steered Learning

The overall aim of LIP was the context-aware *delivery* (encompassing both the time of delivery and the delivered items) of available e-learning resources, which can be traditional courses, learning objects, but also other resources like colleagues/experts or discussion forums. Learning objects themselves are expected to be modular and self-contained; they are described by their objectives and prerequisites in terms of competencies. It was realized that it is of crucial importance that they can have dependencies on other learning objects, which have to be taken into account by the system. This is an important distinction to pure (just-in-time) information retrieval applications and typical document-oriented knowledge management applications. This consideration of semantic dependencies represent a form of pedagogical guidance, which avoids overstraining the individual with the unknown and thus helps to reduce (or at least not increase) the feeling of uncertainty typically associated with an information or knowledge need [14].

The technical nucleus of LIP is a matching procedure (see Fig. 2) that allows for compiling on demand personalized learning programs based on the current competency gap. This matching procedure can be divided into the following three parts:

- In the **knowledge gap analysis**, the system checks the user's current context or situation. The current knowledge gap is the set of current competency requirements minus the set of current competencies of the user. For this knowledge gap, the system can retrieve appropriate learning objects. In order to fill the knowledge gap, we retrieve all learning objects that deliver one of the competencies in the knowledge gap.
- **Learning Program Compilation.** Usually a single learning object will not be enough to bridge the gap, because the gap is too big, and because learning objects themselves can have prerequisites that the user does not meet yet. Therefore we need to provide the user with a complete learning program. This is accomplished by recursively adding learning objects for unsatisfied prerequisites and pruning based on features in the user's context (for details see [3]).
- **Preference-based Ranking.** After compiling several possible Learning Programs, the system ranks the alternatives according to the user or organizational preferences. This includes the following properties, which correspond directly to IEEE LOM metadata elements: interactivity level, semantic density, but also overall estimated learning time. As a result of this process, the user can be presented with the ranked list, from which he can select the desired learning program.

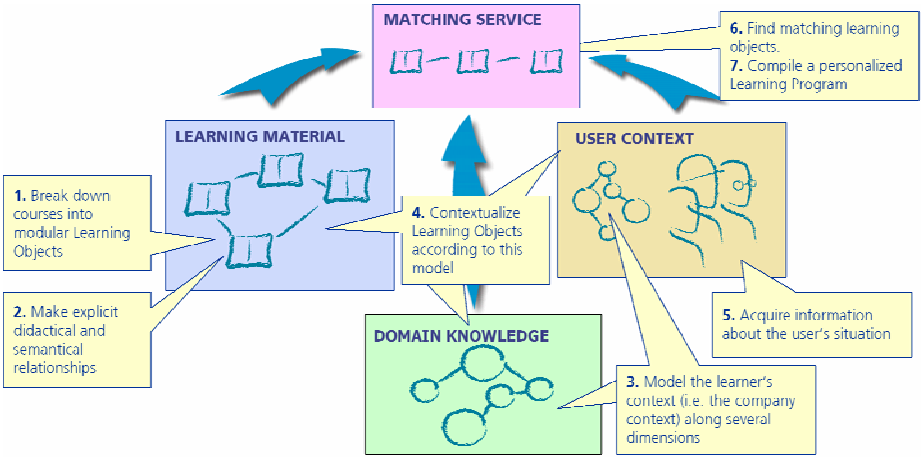

Fig. 2. LIP Matching Procedure for learning material

Although LIP has concentrated on the delivery, it has also enabled context-aware execution of learning objects. Current learning objects are typically unaware of the context in which they are actually executed, apart from some limited awareness of learner preferences. Especially, these learning objects do not take into account the organizational or business context. Apart from pedagogical difficulties, this can be traced back to the technical problem of not being able to access any context-related information from within a standardized execution environment like SCORM.

Therefore, LIP has extended the standardized SCORM API available to learning objects at execution time with direct access to context information. This is achieved through mapping the context features to the CMI data model of SCORM. This technically enables the creation of truly adaptive learning objects.

4.3 System Architecture

The integration of context-aware functionality into a learning system architecture was guided by the principle of loose technical coupling while retaining a high level of semantic coherences between the different parts of the system. Complex corporate environments typically do not allow for a complete new, all-in-one system. Rather, there are specialized systems already in place. To account for that, LIP was taking a a service-oriented approach that defines a set of services with well-defined interface and interaction patterns so that existing systems can continue to exist autonomously while being able to take a role in the LIP architecture. The following services (which are further decomposed into subservices on the level of implementation):

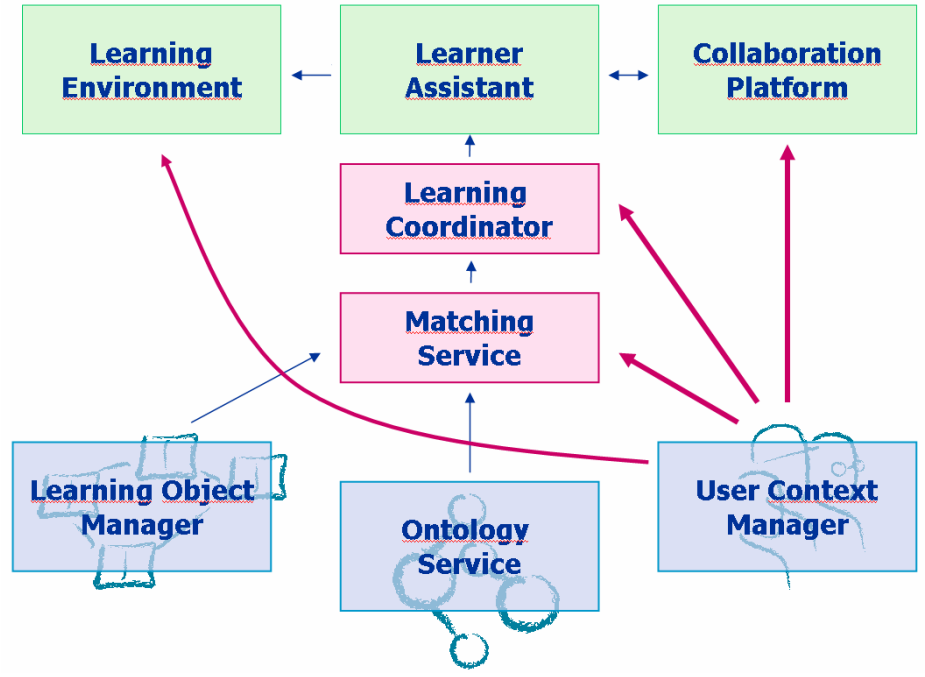

Fig. 3. Loosely coupled architecture of LIP

- The **Learning Object Manager** represents the functionality that is typically offered by a Learning Content Management System (LCMS). It stores learning resources and their metadata and allows for metadata-based retrieval.

- The **Ontology Service** allows for persistence storage and querying of the ontologies involved, i.e. the organizational structure, the competency catalog and the context schema.
- For managing the context, a generic **User Context Manager** [6] was developed that can collect this information from various sources and support different services with a specific views.
- As sketched above, a **Matching Service** can compile personalized learning programs from the available learning material (*Learning Object Manager*), the user's current context (User Context Manager) and the context's knowledge requirements (provided by the *Ontology Service*).
- A **Learning Coordinator** decides based on context changes when to display suggestions about available personalized learning programs and communication or collaboration spaces. There can be several strategies to implement this behavior.
- The **Learning Assistant** represents the component that displays recommendations to the user and captures context changes from the user's interactions with her applications. This component typically resided on the user's machine, although some server-side processing is involved.
- Learning can be organized by the learner in the **Learning Environment**, which allows for finding, scheduling and executing learning programs. Additionally, it makes available through the SCORM API the user's current context in order to enable adaptive learning content.
- A **Collaboration Platform** was "contextualized" with the help of this service by providing contextualized expert finder functionality, group formation and interaction spaces, where learners can themselves create "knowledge assets" which can be made available (e.g. by recommendation or in self-steered learning processes) to other learners based on the context in which they were created.

With the matching service in the center of the architecture, this architecture can be characterized as applying the "Context Matcher" pattern as described in [15].

5. Related Work

There is a long tradition of research in the area of *adaptive systems* (especially in domain of learning) where context information about a user is typically called "user model" [11]. The major limitation of those approaches was (1) that they were always geared towards a single application, whereas corporate environment typically require a wide range of applications that can exploit information about the user's context, and (2) that they are usually biased towards the personal characteristics part of the user context. As shown in the previous section, the consideration of both context aspects can help to overcome the separation of the disciplines of knowledge management and e-learning and provide more holistic context-aware functionality.

On the *knowledge management* side, there has also been some research on linking KM systems to their organizational context, in particular to their business process context [2]. These approaches were a major step into the direction of facilitating

workplace learning with a broader scope, but they have not acknowledged the importance of pedagogical guidance. Context-aware delivery of e-learning material is not just the same problem as just-in-time information retrieval.

The idea of supporting *learning on demand* and the interweaving of learning and working processes has also been the foundation for the "Knowledge on Demand" (KOD) project[17], which has concentrated on resource metadata rather than "user metadata", and the AD-HOC platform [9], which demonstrates the potential of knowledge management systems for learning. However, these approach do not fully realize neither the full potential of a thorough consideration of context, nor the non-trivial problem of dealing with imperfect and dynamic user context information. This becomes most apparent with their lack of a generic user context management functionality.

6. Conclusions and Outlook

The LIP approach has shown how e-learning systems can be made more aware of the context in which learning takes place. This allows for a natural integration with knowledge management functionality which has a more peer-to-peer philosophy *and* for the creation of higher quality e-learning objects which are adaptable to the context in which they are executed. Evaluation studies have shown that the user acceptance of such systems is fairly high and suggest that this blending of e-learning and knowledge management functionality can help to improve workplace learning.

It has been recognized as essential that semantically deep integration of different corporate systems via their common (or at least related) usage context needs generic user context management functionality which also acknowledges the complexity of this acquisition and management task. Especially change (including the phenomenon of aging) and the imperfection of acquisition and reasoning techniques pose severe challenges to deep contextualization of systems.

Apart from researching the fundamental problem of user context management, we plan to explore the possibilities of automatically contextualizing resources to provide contextually enhanced navigation support [7] as a next step. This will allows for an exploratory learning environment in which both didactically prepared learning resources and knowledge assets created by users can be presented in a uniform way. These navigational support elements will not only be based on the user's context, but also on the context of the resource. This will include research on how the resource context relates to the user's context and how the context of creators and users of resources can be exploited for improving content creation and learning processes [16].

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