

# **An Ontology-based Solution for Knowledge Management and eLearning Integration**

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## 1. Introduction

In this knowledge intensive era, the world's total yearly production of digital information content exceeds the billion gigabytes of storage. Locating information is becoming a challenge, highlighting the problem of "information overload" in our everyday life. This situation is critical in general, but it is also of particular importance within today's organization. In fact, information increasingly plays a crucial role in modern economy. Thus, modern organizations have come to realize that they need a way to manage their *knowledge* and to separate useless information from vital one. This awakening is consolidated by a number of requirements such as the need to deal with employees' high mobility, the need to preserve the intellectual capital across time, and the need to develop internal competences.

Another characteristic of the last decade has been the introduction of eLearning as a competence development tool inside the organization. The set-up of eLearning programs highlighted the urgent need to determine the available knowledge and competences and the required ones in order to achieve corporate goals. It also showed the need to create efficient training sessions enabling a just-in time, just enough learning. In fact, eLearning is too little connected to the real work processes and conditions which results into disparity between the real knowledge need and the delivered training. So it appears clearly that knowledge management and eLearning should be integrated to deal with this problem. We must then provide a framework capable of effectively storing, organizing, retrieving and disseminating knowledge. In this context, an organizational memory coupled with an intelligent tutoring system [12] should be of great interest.

This paper is organized as follows. First, we determine the resources that we must deal with to extract organizational knowledge and offer effective training, and then we give a brief state of the art in the domain of organizational memories and knowledge management. Then we present our ontology-based solution to manage knowledge and disseminate it across the organization and its members.

## **2. Organizational Resources and Training Resources**

As previously said, the ever growing amount of data led to information overload. Besides this phenomenon, a growing demand for pertinence in knowledge retrieval and training and for focused answers appeared within the community of users, especially in a corporate context.

Inside an organization, knowledge can be obtained from numerous sources and formats, ranging from structured sources such as databases to unstructured data in the form of flat file formats. In fact, most of the corporate knowledge is created and stored in the form of documents, with little or no metadata about document content and other useful information such as creation context, utilization context, etc.

This lack of metadata and structure leads to very poor capabilities to query these knowledge sources within an automatic process. Moreover, documents knowledge is invisible when trying to inventory the organization intellectual capital and thus this knowledge stays volatile and disappears across time. The eLearning domain and specially the field of Intelligent Tutoring Systems experience the same situation. Most of the training material is presented in the form of documents to be read by the learner. The emergence of eLearning standards such as SCORM offered a partial solution to the metadata problem by linking metadata documents to learning objects (course aggregation structures, sharable content objects and assets). Our idea is to inspire ourselves from this approach and link metadata files to the organizational documents.

Existing knowledge management systems including document management systems, content management systems and group wares did not provide yet a convincing answer to the problem of unstructured data. So, there is a need, inside a corporate intranet, to set up a framework called an Organizational Memory able to store knowledge “intelligently”, and to provide knowledge retrieval tools capable of reducing information overload and retrieving the appropriate knowledge objects in the form of entire documents or portions of documents, competences, expert profiles, learning objects, and so on. Moreover, this OM could be effectively reused by an *intelligent tutoring system*, thus integrating organizational knowledge with training material.

### **3. Organizational Memories: State-of-the-Art**

Knowledge is the key asset of the modern knowledge intensive organization. According to Conklin, “Organizational memory extends and amplifies this asset by capturing, organizing, disseminating, and reusing the knowledge created by its employees.” [2]. An organizational memory must then provide means to preserve knowledge but also to share it. It must also capture not only formal knowledge, but also tacit one, such as its context, history and rationale. Otherwise, this OM represents only a repository of chunky objects completely disconnected from the organizational activities and from their reason of existence. Such OM construction, which is a

continuous process, allows us to deal with expert departure for example with limited costs for the organization.

Many researches have been done in the domain of OM, among them FRODO [10], KnowMore [1], EXIP [6] and COMMA [5]. All these projects try to model the organizational knowledge. However, no one of them uses eLearning and more specifically ITS as a mean to share knowledge inside the organization. From an eLearning perspective, many projects tried to implement eLearning programs inside the organization but neglected the knowledge management / eLearning integration approach. The project LIP [8] appears as the closest project to ours as it uses an ontology-based approach to find relevant learning objects in a corporate training environment. However, it does not rely on an organizational memory, it does not exploit the organizational resources as the first source of available knowledge for training material, and finally it does not use an intelligent tutoring system.

To provide a semantic model able to manage an Organizational Memory, semantic web technologies seem appropriate. In fact, until recently, XML was accepted as the standard for data interchange. It allows users to create their own markup which seems to carry some semantics. However, these semantics are only dedicated to humans who can understand the information described between the tags and these tags are meaningless for software and automatic retrieval tools. To solve the problems and share knowledge with and among computers we should use ontology.

### **3.1 Ontology**

In fact, one of the ontology goals is to provide a common understanding that enables sharing information and knowledge for interoperability reasons, to define the relationships between different resources, to provide understanding of the domain and finally to represent conceptualization using several XML-based languages (RDF, OWL etc.). If it is used across the organization, it means that all the actors will share a common understanding of the resources, problems, activities and so on.

Much ontology has been created to represent an enterprise model such as the TOVE ontology [3] or the Enterprise Ontology [9]. We inspire ourselves from the TOVE model and its organization's ontology component [4]. However, our present goal is not to model all the organizational processes and activities. In fact, we focus on the organizational unstructured resources and their use as material in the eLearning process.

### **3.2 Metadata**

Metadata, which is the second angular stone of our project, can be defined as machine understandable information about resources. In our case, we have to manage both organizational and training resources and we would like to use the same framework for both of them. This will enable us to consider organizational and training resources as belonging to a whole knowledge repository, thus reusing them in various situations (problem solving, training, knowledge retrieval, etc.).

One of the mainly adopted standards in the eLearning field, especially in the industry, is the SCORM standard. This specification relies on the definition of three kinds of resources: content packaging resources, Sharable Content Objects, and Sharable Content Assets. Each one of these resources has a metadata xml document that conforms to two specifications: the "Learning Object Metadata" specification which is a dictionary of tags describing learning content in a variety of ways (such as content description, technical requirements, educational purpose, etc.), and the XML binding of LOM Metadata which defines how to code the tags in XML in order to make them "machine readable". However, the SCORM standard, in its current version, lacks a primordial dimension: in fact, metadata description is made in the form of literals easily understood by human readers but that signify nothing to a program. In fact, such annotations are of limited value unless there is a shared understanding of their precise meaning. In other words, such annotations lack a common semantic model which could be set up through ontology. This is why we propose to describe metadata in the form of RDF-OWL documents and to refer to our organizational semantic resources (with their Uniform Resource Identifiers) in these metadata documents. The adoption of SCORM as the metadata standard allows each document and each

resource of the organization to become a potential learning resource, and to be reused across SCORM-compatible environments.

We introduce our ontological model and our conceptual architecture in the next section.

## 4. An Ontology-based Semantic Model

### 4.1 The Ontology Structure

Our semantic model relies on four types of ontologies created with the Protégé ontology editor [7]. The ontologies can be described as follows:

- First, the *domain ontology* describes the field in which the organization works and its key concepts and relationships.
- Second, the *organization ontology* which is built on top of the TOVE's one [4] intends to describe the organizational structure, in term of divisions, employees, roles, and activities linked to sets of competences;
- Third, the *competence ontology* identifies the available and needed competences inside the organization. Competences are identified in term of learning objectives, which are linked to Knowledge Objects. When needed, an employee is assigned learning objectives.
- Fourth, the *document ontology* refers to the Knowledge Objects and Metadata Objects. It identifies the document key assets and links them to metadata objects.

Fig. 1 shows our general ontology conceptual model.

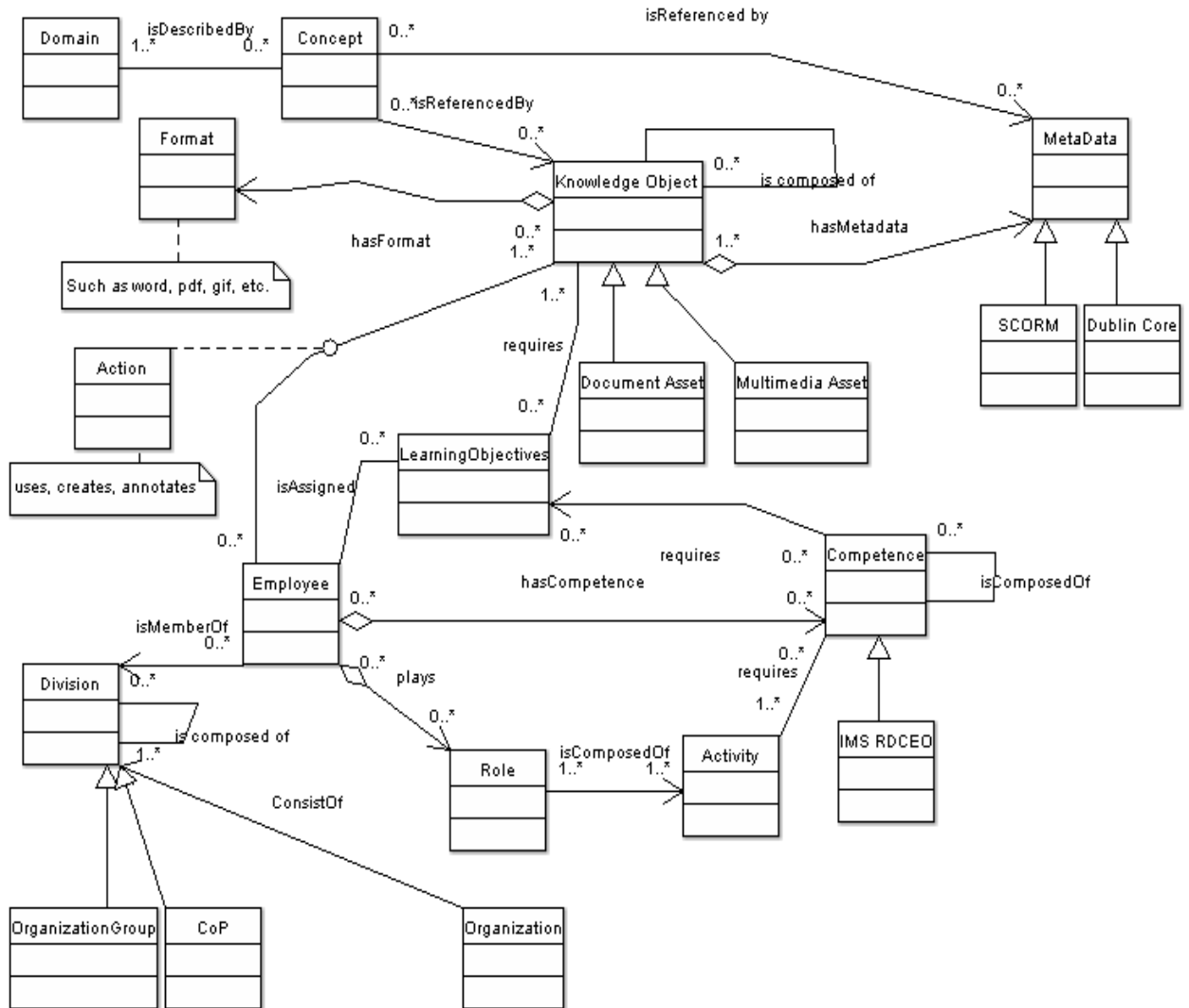


Fig 1. Ontology Conceptual Model

## 4.2 Conceptual Architecture

The Knowledge acquisition problem is the first point to reflect on when building an Intelligent Tutoring System, but also when building an Organizational Memory. Our approach to knowledge acquisition is articulated around ontology and is a document based approach, as documents are the most common resource inside an organization.



Our conceptual architecture (Fig. 2) is composed of 4 layers and can be divided in two categories of tools: Knowledge Editing Tools and Knowledge Exploitation Tools, organized around the OM.

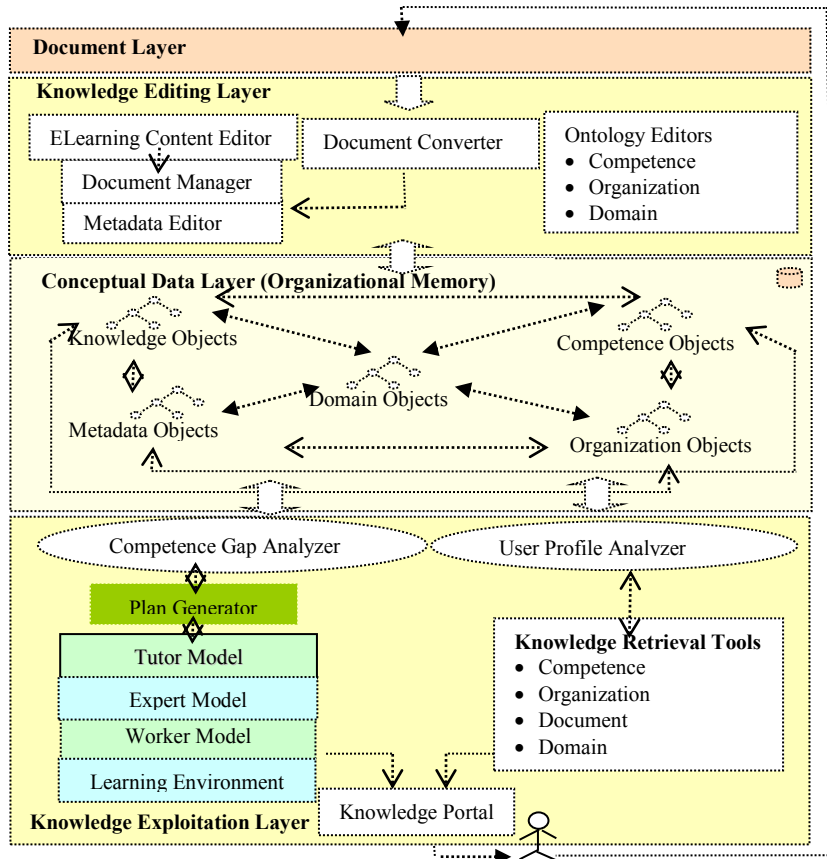
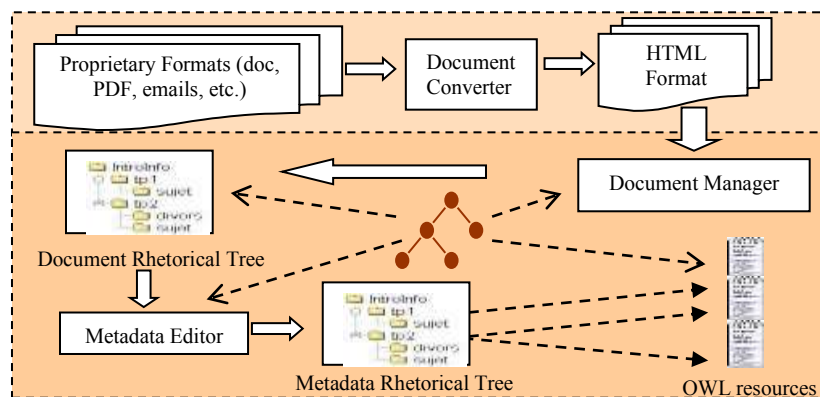


Fig 2. Conceptual Architecture

In fact, we envision our platform as a **Knowledge Portal**, where user can log in, and which triggers events according to the user actions inside the portal. The portal is mainly an interface that gives access to the organizational resources and applications and tracks the user actions. In fact, we can imagine a workflow management system or a human resource management system feeding our semantic model and triggering events according to user context, role, and tasks.

The Document Management Cycle (as illustrated in Fig. 3) takes as an input the ontologies and the raw documents (converted beforehand in SCORM compatible HTML format), and produces a set of semantic structures: the document rhetorical tree, the metadata rhetorical tree and the associated OWL resources. The document rhetorical tree is created by dividing the raw document into knowledgeable parts, similar to Sharable Content Assets in the SCORM specification. Thus we create a tree of assets. If applicable, these assets are then linked to ontologies, showing for example, that competence A can be achieved by reading asset 1 and asset 5. This structure can then help modularize eLearning courses which could be targeted to specific needs. Then a Metadata Rhetorical Tree is created, each node corresponding to its counterpart in the Document Rhetorical Tree. A SCORM-conformant OWL resource is finally created for each node of the metadata tree.



**Fig 3.** Document Management Cycle

We present the tools that are necessary to support the architecture in the following section. They are conceived so that they are accessible through login into the Knowledge Portal. They can be divided into two categories: Knowledge Editing Tools which enable us to create and store knowledge inside the organizational memory, and Knowledge Exploitation Tools which enable the reuse of knowledge in various manners (competence development, training, etc.).

#### **4.2.1 Knowledge Editing Tools**

A number of tools can be used at the editing level. First, a set of ontology editors are provided to enter ontology instance data. We provide three types of editors: a competence editor, an organization editor, and a domain editor. Document Ontology data is created through the document management cycle previously described. A user can decide that any textual resource could be of interest including forum messages or more formal documents and he can create document semantic structures.

An eLearning Content Editor is also provided to create SCORM-based training material which enters also the document management cycle. In fact, we can use either a top-down approach by decomposing source document into assets, or a bottom-up approach, by creating assets and then gathering them into a document tree structure.

The ontologies along with eLearning objects and document semantic structures are stored into the OM (Data Layer).

The user can then benefit from the knowledge management by a number of knowledge exploitation tools described in the following section.

#### **4.2.2 Knowledge Exploitation Tools**

We provide the user with two main functionalities: knowledge retrieval, knowledge sharing and with an interface showing knowledge of interest to the user:

- Current user' tasks (within a project) are displayed and related learning objects highlighted as learning must be part of the employees' daily tasks;
- Lists of created documents, with their semantic structures if available;
- Lists of documents that could be of interest to the user. This list can be built manually and/or automatically by using user ontological profile and analyzing his current tasks;
- Communities of practice that could be of interest to the user;
- The user profile in term of ontological concepts;
- The user profile in term of training sessions and mastered learning objects;
- List of user's competences.

In all the cases, the user can accept or reject the system's suggestions, and indicate manually subjects of interest.

- ***Knowledge Retrieval***

The Knowledge Retrieval Tools enable searching the OM and accessing various kinds of knowledge objects, including people (expertise location), learning objects, domain objects, and competence objects. Generally, current search engines operate by maintaining an index of terms gathered from source pages and the user can submit his query by using totally different terms or ambiguous terms which limits the effectiveness of the search. Our search engines benefit from the document semantic structures by providing more fine-grained results and highlighting only the pertinent areas inside the source documents. Moreover, the resulting list can be narrowed by using the ontological structure hence contributing to solve the information overload problem. It can also be enhanced by analysing the user profile and his ontological concepts of interest, thus leading to more personalized results and contributing to solve the ambiguity problem and the vocabulary mismatch problem.

Finally, the knowledge search is not always initiated by the user. In fact, in some situations, such as the inclusion of a new member inside a project team for example, the system can detect automatically, by analysing his profile, if there are knowledge objects of interest to this user. The system can suggest a training session through notification on the Portal or suggest readings, etc.

- ***Knowledge Sharing: Training and Communities of practice***

Our training tool is an intelligent tutoring system, which possesses an expert model, a learner model and a tutor model. The expert model is fed by our ontology structure and document semantic structure. In fact, our competence ontology identifies the expertise to master inside the organization. The learner model is an overlay model of the domain knowledge. Finally, our knowledge objects embed their own pedagogical strategy, developed by the knowledge object designer.

A competence gap analyzer determines a competence gap analysis based on target competences, the user profile and the ontological structure. In fact, it measures the difference between the target competences (related to tasks, constraints, functions,

roles, etc.) and the actual learner model which contains his past training sessions, his tasks, his competences, etc... A plan generator then gathers the required knowledge objects inside the OM, using the ontology and metadata structures. The resulting high level plan is constituted of various knowledge objects such as documents, emails, learning activities, etc. It can then be deployed by the intelligent tutoring system learning environment with some flexibility according to the learner, to a pedagogical strategy, etc.

Besides our ITS, we offer the user with the possibility to participate in communities of practice. Communities of practice [11] are the second way to disseminate tacit and explicit knowledge and are implemented by ontology-based forums the user can access from the Knowledge Portal. Forum messages are treated as any other non structured resource, and can thus constitute a knowledge source.

#### **4.2.3 Examples of Scenarios**

We now present two scenarios to illustrate how our tools can be used. Let's suppose that we built domain ontology about the Semantic Web.

- **Scenario 1:**

In the first scenario, an employee A decides that his report about Semantic Web Languages (let's name it ITS\_document\_1) could be of interest for the organization's members. He decides to link it to the organizational memory by creating document semantic structures. Fig. 4 shows an excerpt of an owl ontology and instance, linking the document to an author and to a number of concepts. For instance, ITS\_document\_1 is a document whose author is AmalZ and whose related concept is OWL. Moreover, the resource "Semantic Web Languages" refers to two other resources which are "OWL" and "RDF".

Another employee B has to produce a report about the use of the Semantic Web to manage the organizational resources. He could first check the available documents inside the organization about this subject, and could use the Knowledge Retrieval Tools to that purpose. Thanks to the linkage between metadata documents and ontologies, the results of his search would be probably more accurate and would return the report ITS\_document\_1 as a resource of interest. Moreover, thanks to the

domain ontology that indicate that semantic web languages are a subclass of the semantic web, the user B's query could be refined by the system, asking the user if he is interested in semantic web philosophy or semantic web languages for example.

<pre> &lt;rdf:RDF xml:base="http://www.owl- ontologies.com/ITS.owl"&gt; &lt;owl:Ontology rdf:about=""/&gt; &lt;owl:Class rdf:ID="Document"/&gt; &lt;owl:Class rdf:ID="Person"/&gt; &lt;owl:Class rdf:ID="Concept"/&gt; &lt;owl:ObjectProperty rdf:ID="refersTo"&gt; &lt;owl:ObjectProperty rdf:ID="hasAuthor"&gt; &lt;rdfs:domain rdf:resource="#Document"/&gt; &lt;rdfs:range rdf:resource="#Person"/&gt; &lt;/owl:ObjectProperty&gt; &lt;owl:ObjectProperty rdf:about="#isReferredBy"&gt; &lt;rdfs:domain rdf:resource="#Concept"/&gt; &lt;owl:inverseOf rdf:resource="#refersTo"/&gt; &lt;rdfs:range&gt; &lt;owl:Class&gt; &lt;/rdfs:range&gt; &lt;/owl:ObjectProperty&gt; &lt;/rdf:RDF&gt; ..... </pre>	<pre> &lt;ITS:Concept rdf:ID="OWL"&gt; &lt;ITS:isReferredBy&gt; &lt;ITS:Document rdf:ID="ITS_document_1"&gt; &lt;ITS:hasAuthor&gt; &lt;ITS:Person rdf:ID="AmalZ"&gt; &lt;ITS:isAuthorOf rdf:resource="#ITS_document_1"/&gt; &lt;/ITS:Person&gt; &lt;/ITS:hasAuthor&gt; &lt;ITS:refersTo rdf:resource="#OWL"/&gt; &lt;/ITS:Document&gt; &lt;/ITS:isReferredBy&gt; &lt;ITS:isReferredBy&gt; &lt;ITS:Concept rdf:ID="semantic_web_languages"&gt; &lt;ITS:refersTo rdf:resource="#OWL"/&gt; &lt;ITS:refersTo&gt; &lt;ITS:Concept rdf:ID="RDF"&gt; &lt;ITS:isReferredBy rdf:resource="#semantic_web_languages"/&gt; &lt;/ITS:Concept&gt; &lt;/ITS:refersTo&gt; &lt;ITS:refersTo&gt; &lt;ITS:Concept rdf:ID="RDFS"&gt; &lt;ITS:isReferredBy rdf:resource="#semantic_web_languages"/&gt; &lt;/ITS:Concept&gt; &lt;/ITS:refersTo&gt; &lt;/ITS:Concept&gt; &lt;/ITS:isReferredBy&gt; &lt;/ITS:Concept&gt; </pre>
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**Fig 4.** Excerpt from an OWL Ontology and OWL data

- **Scenario 2:**

Let's suppose that a member B is assigned to a new project, and let's assume that this project was linked to a set of competences. By analyzing member B's profile according to his past projects and competences and according to his corporate meta-tagged documents, the Intelligent Tutoring System is able to detect his competence gaps and to suggest the most appropriate learning objects to fulfill this need. The generated plan include real training objects (using exercises and driven according to a pedagogical strategy) as well as corporate documents as suggested readings.

## **5. Conclusion and Future Work**

In this paper, we presented a solution to the knowledge acquisition problem in intelligent tutoring systems through the use of the organization available knowledge in training sessions and the set-up of an ontology-based organizational memory (OM). The use of ontology enables the creation of a semantic model of the organizational resources and can be expanded to cover all the organizational activities such as tasks, projects, workflow management, etc. At present, we elaborated and we built tools to create, organize, retrieve and effectively exploit the knowledge residing in the OM to achieve corporate competence development and training. Our platform is developed in java and the OWL ontologies are developed with the Protégé Ontology editor.

The interest of our integrated approach to knowledge management and eLearning is self-evident. It remains to demonstrate its applicability in real work settings. We are currently working on domain ontology development inside a real corporate environment and experiments have begun.

Future work may explore the interest of a more fine-grained approach to document semantic along with an automatic process for metadata generation. Moreover, we aim to enlarge our organizational modeling and to enhance the business processes and the workflow management with contextual help and eLearning sessions, hence creating a decision-support system.

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