An Ontology Based Tool for Competency Management and Learning Paths

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Abstract: Ontologies have already been created in different scientific areas, including knowledge and competency management, however few ontological applications are available at the moment. In this paper we present an ontology based application that we have developed for competency management and learning paths. Specifically, we provide an overview of competency management and related work in this area, a description of the competency ontology and a functional and architectural analysis. This system is being currently deployed for research purposes in a national subsidiary of Microsoft, the IT services multinational firm, with a Microsoft .NET implementation communicating with the competency ontology.

Keywords: Competency management, ontology, human resource management, learning paths

1 Introduction

Competency based management has become a very crucial element in the effective operation of an enterprise or an organization, due to the increased need of the latter to be agile enough to adapt to quick market changes and re-orientation of their business plans. In this situation, competency management systems (CMS) become the core human resource tool, which enables the enterprise to manage and develop the skills of their employees, recruit the most appropriate candidates, make effective succession planning and employee development plans.

Apart from enterprise competency management systems, research is being conducted on the development of ontology based CMS which can provide possibilities such as the easy integration and mapping of different competency ontologies. Moreover, research efforts have been realized in the development of ontological e-learning systems. However, very few – if any – systems exist which integrate e-learning functionality with an ontological CMS. The mapping of employee or departmental/organizational skill gap analysis with the appropriate learning objects is crucial in order to develop the correct learning paths and consequently the appropriate competencies of employees or organizations.

This paper focuses on the description of an ontology based competency management system, which also integrates e-learning functionality in order to address this issue.

The interested reader can find an essential introductive overview of the key concepts in competency based management, as well as a description of the competency ontology, the functional and technical architecture of the system. The practical experience of the authors derives from the deployment of a Microsoft .NET version of the described system, in Microsoft Hellas, the Greek subsidiary of the leading IT enterprise Microsoft Corporation.

In the next section, we provide a brief history of competency management, a definition of the term and a description of its core elements and we describe the research efforts conducted in ontological CMS and ontological e-learning systems. In section 3, we describe the competency ontology, while in the next two sections we analyse the functional and technical architecture of the system. Finally, conclusions and possible topics for further research are being presented.

2 Competency based management

Throughout the years competency based approaches have proved to be a critical tool in many organizational functions, such as workforce and succession planning, performance appraisal etc. The main reasons for selecting these approaches are the following:

- They can provide identification of the skills, knowledge, behaviours and capabilities needed to meet current and future personnel selection needs, in alignment with the differentiations in strategies and organizational priorities.
- They can focus the individual and group development plans to eliminate the gap between the competencies requested by a project, job role, or enterprise strategy and those available.

According to the HR-XML Consortium Competencies Schema (http://ns.hr-xml.org/2_0/HR-XML-2_0/CPO/Competencies.pdf), a competency can be defined as ***"A specific, identifiable, definable, and measurable knowledge, skill, ability and/or other deployment-related characteristic (e.g. attitude, behaviour, physical ability) which a human resource may possess and which is necessary for, or material to, the performance of an activity within a specific business context."***

The use of ontologies in a competency-driven e-learning system is a research area that is being explored during the last years. Some ontology based competency based tools or prototypes have been introduced, such as "CommOn" [Trichet and Leclere, 2003], a framework for building competency based systems. CommOn is based on two models (implemented with specific tools) which guide firstly the building of competency reference systems related to particular domains such as Healthcare or Information and Telecommunication, secondly the identification and the formal representation of competency profiles and thirdly the matching of competency profiles. The CommOn framework allows one to build shareable ontologies and knowledge bases represented with Semantic Web Languages and to develop Competency-Based Web Services dedicated to Human Resource Management. Also, other systems include "SMS – Skills Matching System" [Colucci, Di Noia, Di Sciascio, Mongiello, Donini, Mottola, 2003] which is a prototype that is not linked with e-learning systems, "GMS" [Vasconcelos, Kimble, Rocha, 2003] which is an

ontology based competency management system for managing group competencies and which is not integrated with e-learning functionality or system. Moreover, an architectural proposal of a prototype system for ontology based competency management is presented by Reich, "Ontology based competency management in Swiss Life" [Reich, Brockhausen, Lau, Reimer, 2002], as a further step to XML-based competency management systems, such as "MaSel" [Garro, Palopoli, 2003]. However, these prototypes do not integrate e-learning functions or links with learning objects and resources.

Research work is also conducted in the usage of ontologies in learning objects, in order to facilitate the discovery and reuse of learning objects stored in local and global repositories (e.g. Sicilia 2002, Urban 2003). A learning object is defined as "any entity, digital or non-digital, that may be used for learning, education or training" (IEEE Learning Technology Standards Committee 2001). Initiatives such as the IEEE Learning Object Metadata (LOM), Dublin Core and IMS Global Consortium, are developing standards, specifications and reference models for learning objects in order to facilitate the on-line retrieval and reusability of the latter. In the future developments of the discussed system, lies the automatic discovery of learning objects from global repositories and their mapping with competency gap reports, in order to facilitate the user to access both local and global repositories of learning objects.

In Europe, there are three main projects that focus on ontology based competency development, namely "TenCompetence" - which integrates models and tools in the creation, storage and exchange of knowledge resources, learning activities, competence development programmes and network data for lifelong competence development; "Knowledge on Demand", (Sampson D., Karagiannidis C. and Cardinali F., 2002), which aimed to design, develop and test a learning environment, as a dynamic and adaptable on-line environment which allows the individual learner to acquire knowledge according to his/her personal learning needs, without however taking into account the organisational aspect of competency development; and "Learning in Process" which addresses both the organisational and personal aspects and enables user context aware delivery of e-learning material [Schmidt, A., Winterhalter, C. (2004)].

Moreover, the use of ontologies in e-learning applications has been theoretically researched, e.g. with the architectural proposal of a prototype system for e-learning using ontologies (Stojanovic, Steffen, Studer, 2001) and (Schmidt and Winterhalter, 2004**).** Some research efforts in integrating competency ontologies with e-learning have taken place in theoretical background (Woelk 2002) and have been partially implemented (Hirata, Ikeda, Mizoguchi, 2001).

Additionally, many learning management systems integrate competency management features, without ontological support. For a detailed analysis of the main competency management features included in some popular Learning Management Systems (LMS), one can refer at the paper (Draganidis and Mentzas, 2006).

Evidently, there is a gap in the integration of ontology based competency-driven e-learning systems, apart from "Learning in Process" project, with which we have a parallel architecture with the inclusion of the human resources aspect – e.g.

succession planning, training needs analysis, expert finding etc. Our system's target is to develop and deploy an ontology based competency management system, which will provide the possibility for further enhancements, such as succession planning and training analysis, always using the developed ontology as a reference. Moreover, through the use of web services the system can be integrated with other human resource management or e-learning systems.

3 Competency Ontology

The correct design of competency ontology is a crucial step in the development of an effective competency management system, which possibly has to collaborate with other similar systems or e-learning and human resources applications. Effort has been made in analyzing the competencies, their definitions and the corresponding proficiency levels through available dictionaries or after careful consideration. Moreover, ontology design included the correlations between all the entities of the ontology, namely competencies, employees, jobs, learning objects etc.

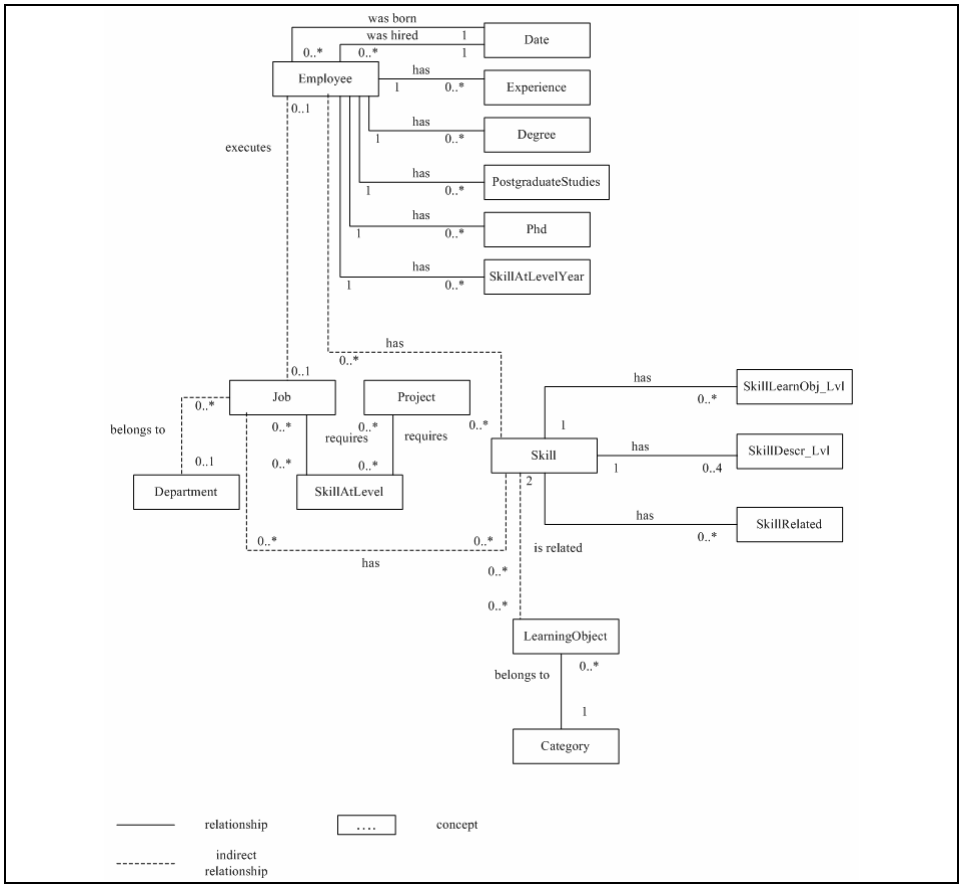

Figure 1: The Competency Ontology

Figure 1 presents the developed competency ontology which consists of seventeen classes in total, six of which are main classes and are used to describe employees, projects, jobs, competencies and organizational departments, while the other eleven classes are auxiliary classes used to describe the main ones and the relationships amongst the latter. By using the class *SkillLearnObj_Lvl* we define an association between a learning object and a skill. This association refers to a specific proficiency level. Moreover the class *SkillRelated* is used to determine the proximity amongst different skills and considering that the system has calculated the gap, the learning path can be established. In case there is no learning object found for a competency the system searches for learning objects that are connected to related competencies.

4 Functional Architecture

Our research efforts focus in developing a prototype ontology-based system which will integrate competency management with e-learning and other human resource functions, such as succession and career planning, training needs analysis and organizational planning; The functions that the systems offers can be divided into to main categories: Core System Functions and Reporting Functions, as depicted in Figure 2. Human-Computer interaction analysis was also conducted to design a User Interface that can effectively meet the need of the two users category, namely human resource staff and employees, for simple and quick access to all system's functions.

Core system functions include functions that are responsible for inserting, updating and deleting ontology's data. Apart from functions such as Insert Learning Object, Create Job Profile, Update Project, Delete Learning Object's Category etc. it also utilizes functions for creating, updating and deleting a relationship between two competencies, a job assignment and an association between a learning object and a competency. Reporting functions provide the system user with a number of view functions, such as "View Competency Model" and also some more complex views, such as "View Employee's Competencies" and "View Jobs' Infos", which produces a table with all organization's jobs, the corresponding department and the corresponding employee. Additionally, various reports on skill gap analysis, succession planning, experts and projects are provided.

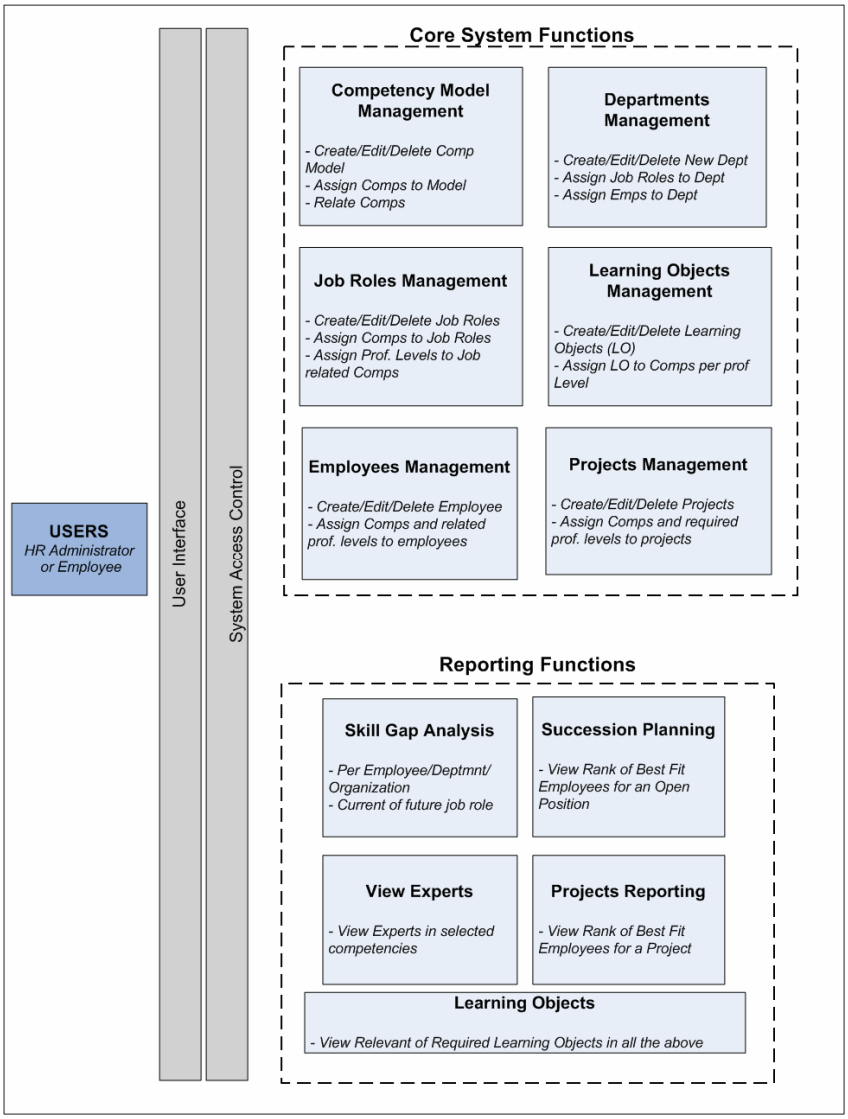

Figure 2: Functional Architecture of the System

5 Technical Architecture

In this section we provide an overview of the technical architecture of the system, as depicted in Figure 3. The front-end has been designed as jsp pages and through them the users can access the various functions of the system, while some of the jsp pages include JavaScript functions. The Apache Tomcat has been used as Servlet Container. The back-end is implemented in Java and access to the ontology is

provided through the Jena API and RDQL. Jena[1] is an open source Java API for RDF and RDQL is a query language for RDF in Jena models. The idea is to provide a data-oriented query model so that there is a more declarative approach to complement the fine-grained, procedural Jena API.

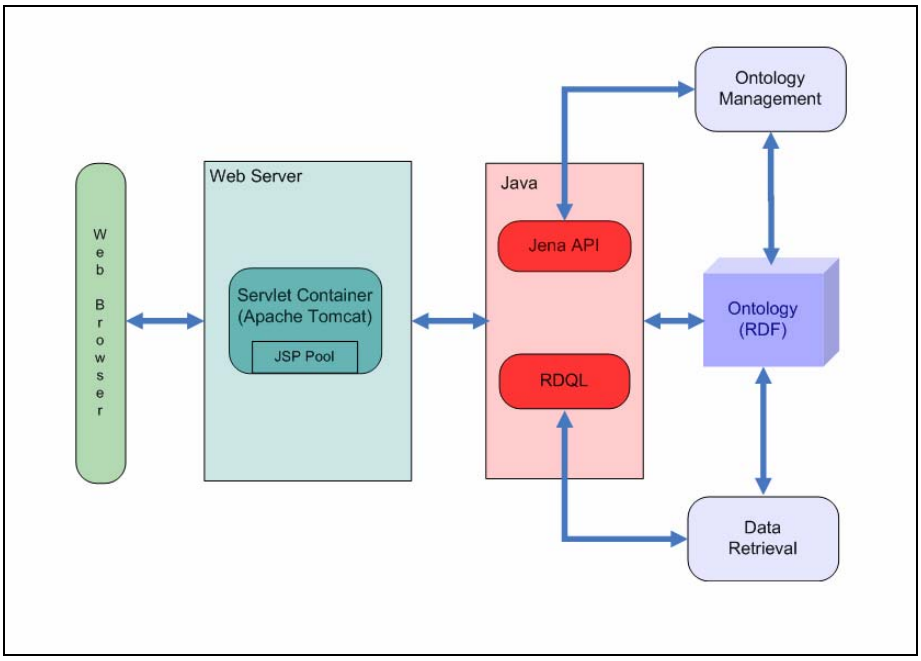

Figure 3: Technical Architecture of the System

It is "data-oriented" in the sense that it only queries the information held in the models; there is no inference being done at this stage but the Jena model can provide some smart functionality such as creating on-demand certain triples. The RDQL system accepts as input a description of the application's requirements, formed as a query and returns that information in the form of a set of bindings. The back-end consists of a number of java classes and there are six main classes: SkillManager, DepartmentManager, EmployeeManager, JobManager, LearnObjManager and ProjectManager and each one of them is responsible for the management of the corresponding ontology's class. Finally, all the data are stored in a RDF ontology.

6 User Scenarios

We will know consider a user scenario, *"Skill Gap Report for an Employee"*, in which we will provide the reader with a description of the functional performance of the system – relevant screenshots are available upon request.

In this user scenario the user wants to produce the Skill Gap Report for an employee. After selecting the employee a report is produced, where the system compares the

[1] http://jena.sourceforge.net/

possessed versus the required competencies and in case of a negative skill gap result, it provides the employee with a personalized learning path, with all the learning objects and experts needed, in order to help the employee improve his/her proficiency level.

Figure 4 provides a description of the way that the system performs this function. As shown in Figure 4, once the user has selected the employee, the system finds his/her competencies and compares them to the required competencies. If there is a gap (i.e. employee possesses a proficiency level lower than the required) the systems searches for corresponding learning objects and experts. In case that there isn't a learning object or expert the search does not end. The system searches for related competencies and then for the corresponding experts and learning objects.

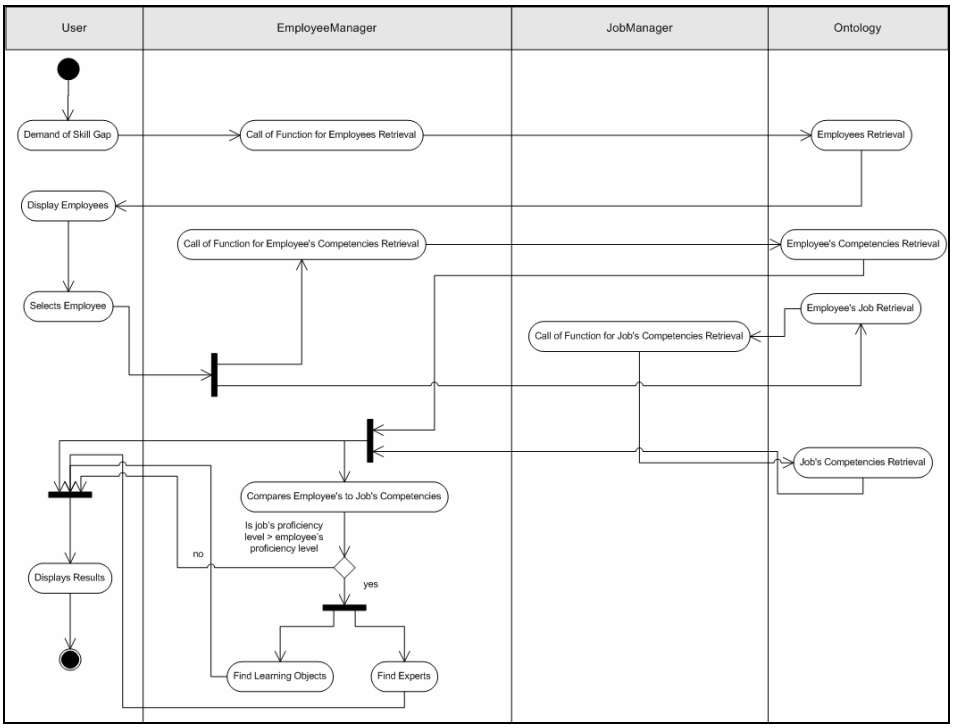

Figure 4: Functional Performance for Employee Skill Gap Report

7 Conclusions and Further Research

In this paper we have provided an introduction to the competency management area and a practical approach to the integration of competency management, e-learning and ontologies, presenting a prototype ontology based system. The competency ontology, the functional and technical architecture of the system have been analyzed together with some user scenarios and issues that need further research in ontological systems, such as RDF cascading.

Our next steps include the deployment of an ontological .NET system in Microsoft Hellas and the extension of the system with semantic search capability and inference engine, as well as the evaluation of the effectiveness of ontological systems in real-life environments. Moreover, further research lies in the area of expanding the system with semantic attributes, such as adding semantic annotation to the web services exported, in order to enable it with broader integration capabilities with other ontology based human resources systems. Moreover, by adding semantic web services capabilities to the system, we will enable semantic web matchmakers to accept the descriptions of our available services and match them against requirements from different requestors, in an automatic way. This process can currently be deployed manually, through registering the produced web services to Universal Description, Discovery and Integration directory (UDDI).

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