Ontologies used for Competence Management[1]

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Abstract: Developing multi-agent systems requires an adequate modeling of knowledge in order that the agents and the human person are able to understand and accept the concepts of domain area in the same way. Ontologies allow developing an coherent framework for a specified domain. Based on the concepts used ant the relations between them, the agents are able to understand, reason and act in the domain in order to accomplish their goals and finally the system functions. Based on appropriate ontologies defined for a particular domain, a multi-agent system that allows managing, searching and matching the user competences with the existent competences is presented.

Keywords: ontology, compentence modeling, multi-agent systems

1 Introduction

Complex systems from the real world are a challenge for designers due their complexity and their requirements. Designing such complex systems should include also some intelligent behavior due to their complexity. Knowledge management is one of the most important aspects that offer to the designers a real base for developing intelligent features of the system. Multi-agent systems had an expansively evolution in the last decades. For every domain the knowledge must be appropriately represented and understood by all the participants being humans or intelligent agents.

From [13] ontology is a formal theory within which not only definitions but also a supporting framework of axioms is included (perhaps the axioms themselves provide implicit definitions of the terms involved). Regarding the multi-agent systems, we can state that ontology is a description (like a formal specification of a program) of the concepts and relationships that can exist for an agent or a community of agents.

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For reducing the complexity we intend to define the ontology related necessary terms for:

- multi-agent communication;
- requirements from the user concerning the agents and requirements between agents;
- competence description, competence comparison and competence evaluation and related information that are given to the agents in order that they are able to accomplish the requirements.

Based on [14] the:

- entities will refer to the communication, requirements concerning the agents and competences;
- representations (their composite representation and representational units) concerning the competences will be given in the form of competence description or association of activities (sub competences).

The inclusion of a competence in the other one it is not similarly with the inheritance.

The paper is organized as follows. In the next section the ontology concepts are reviewed. The third section gives specific problems concerning the competences The fourth section introduces an example of multi-agent system for constructing and finding competences. The fifth section details schemas and gives some particular examples of necessary ontologies based on XML files. The last section suggests the contents of future works.

2 Ontology Concepts

For facilitating the sharing and the use the ontologies were developed in AI many domain models. From [13] ontology is a formal theory within which not only definitions but also a supporting framework of axioms is included (perhaps the axioms themselves provide implicit definitions of the terms involved). Concerning the multi-agent systems, we can state that ontology is a description (like a formal specification of a program) of the concepts and relationships that can exist for an agent or a community of agents [15]. But between the multitude of ontology definition the following is one of the most appropriated to our purposes: *An ontology is a formal, explicit specification of a shared conceptualization* (the terms are detailed in [7]). *Conceptualization* refers to an abstract model of some phenomenon in the world which identifies the relevant concepts of that phenomenon. *Explicit* means that the type of concepts used and the constraints on their use are explicitly defined. *Formal* reflects to the fact that the ontology should be machine readable. *Shared* reflects the notion that an ontology captures consensual knowledge that is accepted by a group.

The role of ontologies in AI is to facilitate the construction of a domain model. An ontology provides a vocabulary of terms and the relations between them in order to being able for modeling the domain. Due to the fact that ontologies aim at consensual domain knowledge their development is often a cooperative process involving different people or organizations. Concerning the people is said that they commit themselves to that ontology if they agree to accept that ontology.

Ontologies are introduced to facilitate the knowledge sharing and reuse between various agents, regardless of whether they are human or artificial in nature. They are supposed to offer this service by providing a consensual and formal conceptualization of a certain area. As a conclusion, ontologies are formal and consensual specifications of conceptualization that provide a shared understanding of a domain, an understanding that can be communicated across people and specification systems. From the fact that the ontologies define:

- formal semantics for information, allowing that it is processed by a computer and
- real-world semantics, that makes it possible to link machine-processable content with meaning for humans based on consensual terminologies;

these considerations allow to argue how can ontologies be used to communicate real-world semantics between human and artificial agents and also these implies that the ontologies have as important features their dynamicity and a network architecture.

Due to the fact that the ontologies are conceived in order to cover many domains from the simplest ones to the most complexes ones the designers must make a choice form the from the following [7]:

- Domain ontologies- capture the knowledge valid for a particular type of domain (e.g. teaching, IT);
- Meta data ontologies that provide a vocabulary for describing the content of on-line information sources;
- Generic or common sense ontologies that aim capturing general knowledge about the world, providing basic notions and concepts for things like: time, space, state event, etc.;
- Representational ontologies do not commit themselves to any particular domain (frames);
- Method and task ontologies. Task ontologies provide terms specific for particular tasks and method ontologies provide terms specific to particular problem-solving methods. These ontologies provide a reasoning point of view on domain knowledge.

Concerning our own purposes we will make a choice in order to satisfy the requirements of our model given in example.

3 Considerations on Competence Modeling

Concerning the competences there are many works that develop and details specific concepts [12], [10]. One of the major problem that occurs is that the comparing compentences [9]. The IEEE Reusable Competency Definitions [10] provide a model for the representation of competences, the objective being referencing and cataloging a competency but not classifying it. The model does not provide any means to specify the relationships between the competencies. The relationships must be taken into account that the competences are (is composed) from competency proficiency level and context. Different scales qualitative and quantitative are useful in order to represent proficiency levels.

One of the possibilities is that to represent as an ordered list the proficiency level scale. In such list the minimum value (subsumed by any other in the list) is given by the first element and the maximum is given by the last one. Therefore the order in the list represent presumption relationships, that is, the first element is subsumed by the second one and so on. In order to improve the interoperability and matching among scales, an optional field is included for mapping to the universal scale (e.g., *[0,1]*). The reason why this mapping field is optional is that even though it would be useful to include it, in some context it may not be possible to find a suitable mapping or it may not even be necessary.

Competence descriptions can refer to specific items of these scales in order to represent the proficiency level required/acquired. Algorithms could take relationships among proficiency levels into account in order to find out how much training/learning is required to reach a determined employee/learner proficiency level [3].

The context can be defined: interrelated conditions in which something exists or occurs or the circumstances and conditions which surround.

Regarding the competences, context may refer to different concepts like:

- the specific occupation in which a competence is required;
- a set of topics within a domain;
- even the personal settings related to the student.

These are contexts which may be part of a competence. Context descriptions cannot be defined in general, but these depend on the scope and the purpose of the competence descriptions to which they are attached. In addition, the context definitions may be reused.

Modeling contexts is a complex task; it may coincide with modeling the whole domain knowledge of an institution. Competences generally can be described [6] as reusable domain knowledge. Any model representing competences describes what a competence is and how it is composed of sub-competences. Due to the fact

that the competences are referenced in different situations like: certifications, job descriptions and personalizing relevant competences for their business that are included in job offers projects descriptions.

Based on these the competence must be adequate represented and described in order to:

- how a competence may be achieved (ex: by acquiring some sub-competences);
- to which level each competence should be acquired;
- whether sub-competences must be all achieved or simply a subset of them;
- if the sub-competences must be acquired in a specific order.

Another significant problem is that the capability of the model to represent aggregate and alternative structures of the competence. The aggregation allows that the competence is composed from several sub-competences all of them required. Alternative competence can be viewed as a set of competences and there can be possible to specify by a numeric interval what the number of alternatives that must be acquired is. Due to the multiple usages of the model, it is also important that the equivalence relationships between the competences to be well defined understood and used by all users.

4 Management of Competences Using a MAS

The competences are frequently used in the relations between the universities and the future students, between the companies and the future employees. Our model intend to allow to the universities, students, employees and companies to construct and maintain their own competences; to evaluate their competences; to match their own competences with the other competences and to search the desired competences in appropriate domains. Comparing the competences for an efficient usage it is intended to offer a tool that make an exhaustive analysis concerning the competences. It will mainly based on the details that are given for a competence the components of the competence. Here the specific agent will compare the occurrence of the competence components scoring the matching between the two competences also the order of components will be taken into the account; the resources used for gaining a competence, the effort that must be fulfilled by the student in order to gain certain competence. The students that intend to obtain some qualification (and some competences) can make some suppositions concerning the financial effort and their own effort and time and it will be offered in an adequate manner. The details concerning the compentences in the domain, their description and their comparioson are given in [4], [5], [8].

The model based on a multi-agent system constituted from appropriate agents that will fulfill these objectives. The agents of our model are Competence Creation Agent (CCA), Evaluator Agent (EvA) and Broker Agent (BrA) and it is represented in Figure 1 as it was geiven in [4], [5], [8].

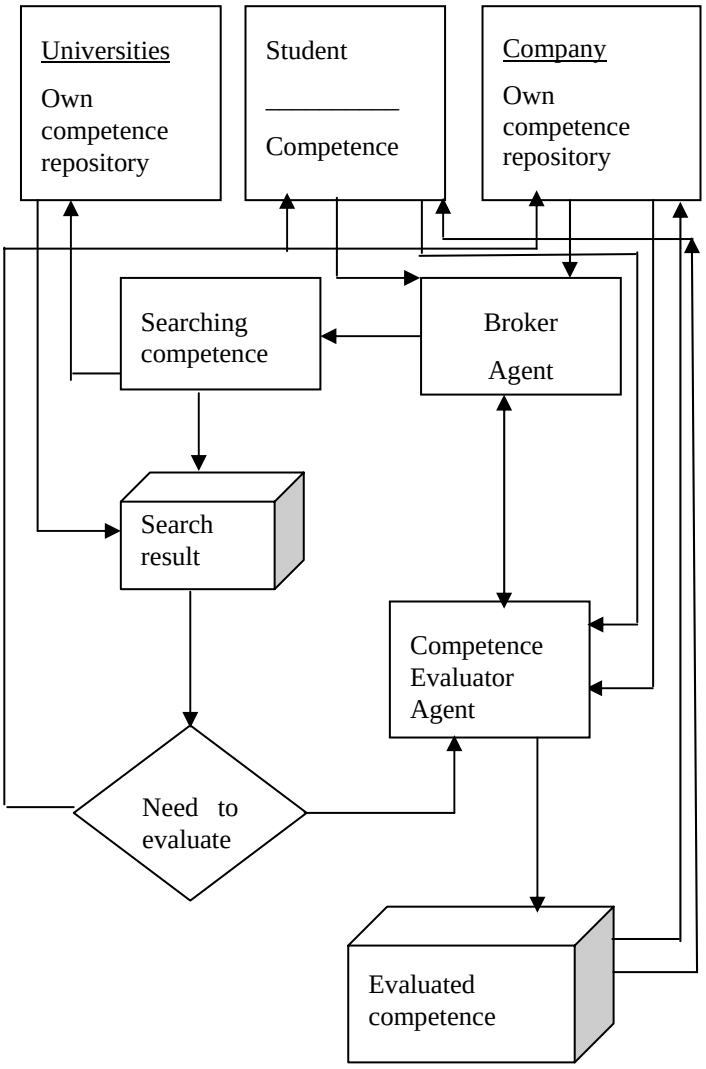

Figure 1
The multi-agent system for the proposed model

The user can be a university, a company, a student or an employee. The user can submit to the CCA requirements to create competences from basic sub-competences. The CCA creates and furnish the competences to the user that can place them into a Competence Repository or use immediately in new requirements. In Figure 2 is illustrated how the CCA interact with the users.

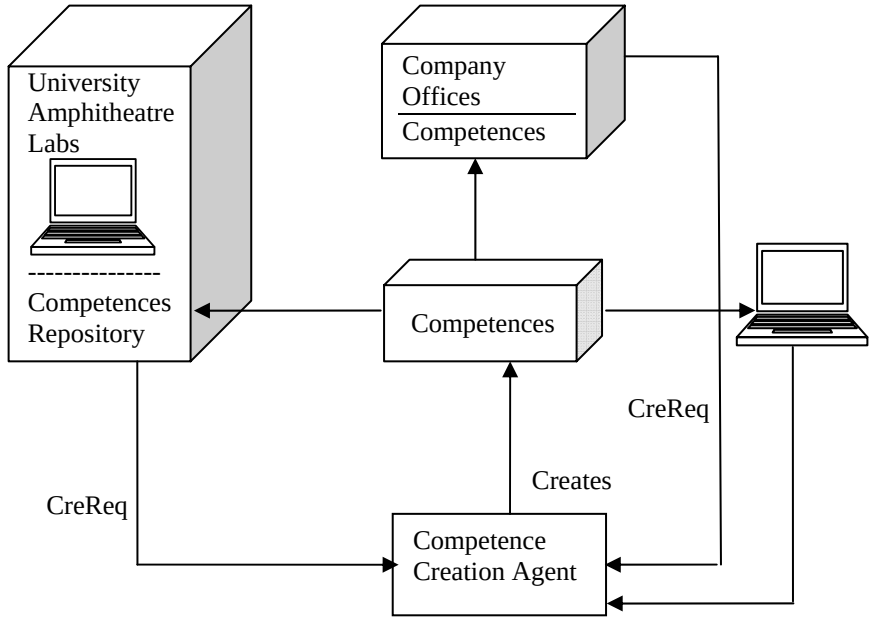

Figure 2
The interaction of the CCA with the users

Every user can construct its own Competence Repository. When a user (student, employee, company) want to find some competence that is placed in a university or company he must furnish the generic competence and eventually the sub-competences, the conditions that allow acquiring the competence and other own requirements concerning the competence.

All these requirements are taken by the BrA that search (usually on the Internet) and tries to match the user requirement with those that were found. The matching can be in a wide range as was presented above, starting from a simple matching (the competence name) through a complex one where a lot of actions are executed by the EvA: matching of competences with appropriate scores; matching the sub-competences and scoring the matching; matching of conditions and giving the scores in some order (preferred by the user or a predefined system order).

The interdependence between the agents and user is shown in Figure 3.

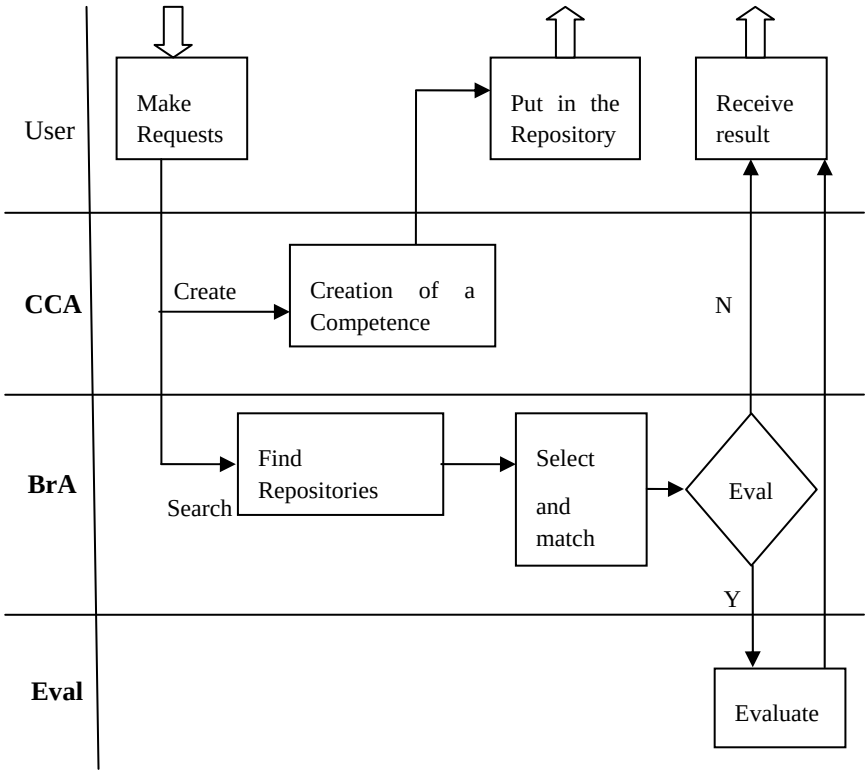

Figure 3
The collaboration between the users and the agents

The system work as follows. The companies and universities have their Competence Repositories that are posted as web pages. The users: students, employees, applicants, the universities and companies can define the requirements that are addressed to the system. The system agents try to satisfy the requirements in different levels of details and complexity, as was stated above.

5 Detailed Examples for Used Ontologeies

The necessary ontologies for the model of the system proposed in previous section are based on the following schemas and are illustrated with some examples. The following schema illustrates the specific elements used in course description and the competences and their components (subcompetences).

```
<?xml version="1.0" encoding="UTF-8"?>
<!--W3C scheme generated by XMLSpy v2007 sp2 (http://www.altova.com)-->
<xs:scheme xmlns:xs="http://www.w3.org/2001/XMLscheme">
 <xs:element name="subcomponent" type="xs:string"/>
 <xs:element name="subCompetences">
          <xs:complexType>
          <xs:sequence>
          <xs:element ref="subcomponent" maxOccurs="unbounded"/>
          </xs:sequence>
          </xs:complexType>
          </xs:element>
<xs:element name="objectives">
<xs:complexType>
          <xs:sequence>
          <xs:element ref="objective" maxOccurs="unbounded"/>
          </xs:sequence>
          </xs:complexType>
          </xs:element>
<xs:element name="objective" type="xs:string"/>
<xs:element name="name">
          <xs:simpleType>
          <xs:restriction base="xs:string"/>
          </xs:simpleType>
          </xs:element>
<xs:element name="courses">
          <xs:complexType>
          <xs:sequence>
          <xs:element ref="course" maxOccurs="unbounded"/>
          </xs:sequence>
          </xs:complexType>
          </xs:element>
<xs:element name="course">
          <xs:complexType>
          <xs:sequence>
          <xs:element ref="name"/>
          <xs:element ref="basic_competence"/>
          <xs:element ref="description"/>
          <xs:element ref="objectives"/>
```

```
        <xs:element ref="subCompetences"/>
        </xs:sequence>
        </xs:complexType>
        </xs:element>
        <xs:element name="description" type="xs:string"/>
        <xs:element name="basic_competence" type="xs:string"/>
</xs:scheme>
```

As an concrete example the Computer Network course is detailed based on previous schema.

```
<?xml version="1.0" encoding="UTF-8"?>
<courses xmlns:xsi="http://www.w3.org/2001/XMLScheme-instance"
xsi:noNamespaceSchemeLocation="scheme_A.xsd">
<course>
        <name> Computer Networks </name>
        <basic_competence>Using and administration of computer
networks</basic_competence>
        <description>administrating, configuring and maintaining
computer networks</description>
        <objectives>
        <objective>Course gives a general view of concepts in
computer networks, giving a synthesis the basic concepts concerning the
architectures, protocols, administration, interconnexion</objective>
        </objectives>
        <subCompetences>
                <subcomponent>computer network administration
                </subcomponent>
                <subcomponent>computer network configuring
                </subcomponent>
                <subcomponent>software installing </subcomponent>
                <subcomponent>user and resource management
                </subcomponent>
        </subCompetences>
    </course>
</courses>
```

As can it be seen in the example all the users should accept the proposed ontological elements. It is obviously to remark that between the subcompetences we can find some inappropriate features that here are presented (given) as subcompetneces for many of possible users. As an example of such possible inadvertences *can be the capability to communicate with other people* or *capability to work in a team* that can not have a general acceptance between all the possible users.

6 Future Work

Based on the real model that was describy and refinning the capabilities, some important features will be analyzed and developed. The relationships between the components of an ontology and the relationships between the related ontologies should be clearly stated and therefore formalized. Concerning the relationships between the ontology components, these must be refind due to the following:

- subsuming are incluzion i.e. one component subsumes another one (i.e. excellent subsumes advances in speaking english);
- part_of;
- is_a.

As it can be seen the inheritance from object oriented does not satisfy in the description of above kind of relationships.

On the future works will concentrate in order to allow to give all above features of relationships. Another direction of our future work will refine the quantifications of ontology component. These will be very useful in mathing of requirements with offers. The long term research will focus to the ability of model in order to match two defferent ontologies for the same domain. More explicitely, for example an ontology contains the knowledges of an specialist and another one ontology contains the capabilities of a specialist in the same domain. The model must offer the inference capabilities in order to express the quantified matching between the two ontologies. A such feature will use an intelligent system, able to make such kind of interences.

XML schemas for ontology representations will be extehded with new details which allow to extend capabilities of ontology description and usage. Using the XML representations of ontologies, will be improved a better tool for their processing.

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