An Approach to Ontology Development in Human Resources Management

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Abstract
The evolution from resource-based economy to knowledge-based economy has essential implications in the Management, Marketing, Artificial Intelligence, etc. and also in the Web field. Due to this evolution we can speak today of Semantic Web and everything that involves this concept. In this paper, we propose to explore the benefits that may have in practice the application of Semantic Web technologies for the systematic organization of knowledge, which may occur in human resources domain by developing a specific ontology. This ontology will provide support for modeling a common vocabulary for those who will share information about human resources by defining concepts, attributes and relationships between those concepts. The ultimate purpose of this ontology development will be the augmentation of effectiveness in the applied field.

Keywords: Semantic Web, ontology, human resource management

Introduction
Even though the web has appeared for two decades, its expansion is still overwhelming. At first, the web was seen as a way to connect people, specifically to inform them about different things through the published documents and the web pages. The Web offered to the people new opportunities for learning and communication, with the click of a mouse.

Search engines continually index Web documents, so providing a few keywords, the searched information can be provided quickly. But this information has meaning only for a human being; computer or another software application cannot give a meaning to this information - a task that people can ordinarily do quite well but is a tall order for computers, which cannot tell if "head" means the leader of an organization or the thing on top of a body (Frauenfelder, 2001). The web in its current form has very little metadata and no means to encode semantics. So the Semantic Web idea is not only to furnish linked documents to each other but also to recognize the semantic of the information in those documents and to provide connected data (Frauenfelder, 2001).

To model the semantic level of knowledge, which may occur in human resources management, for an IT company which works on projects, we use an ontology, the main subject of this article. This ontology will provide support for modeling a common vocabulary for those who will share information about human resources, will align human resource development with company goals, will identify and make use of employee competencies, by defining concepts, attributes and relationships between those concepts.

Human resources constitute the main element of work within organizations; they decisively influence the effectiveness of using the material resources, the financial resources and the informational resources. Human resources management is a complex activity targeted by the efficient use of personnel in the organization, aiming to achieve both, company objectives and employee needs (Cornescu et al, 2004).
In this document in section 2 will be presented the problem context and statement, which contains a brief introduction in semantic web field and the advantages that has in practice the use of ontology in the human resources management. In section 3 will be introduced the design details for the proposed ontology, followed by the presentation of implementation details. And then in the following sections the evaluation, conclusions and future work of this paper.

Problem Context and Statement

Context
Nowadays the organizations are focused more on the human capital for a harmonious economic development. Human resources management refers to efficient use of human resources to enhance organizational performance (Cornescu et al., 2004).

The Semantic Web is like a bridge between silos of disconnected standards. “The Semantic Web isn’t just a fancy software vocabulary: It’s a foundational data language upon which any other data language can be built”, specifically is a language for metadata provides an accurate way to describe and define data by using more data. In business software systems, these new formats provide a way to more easily connect and exchange data with many systems, and the Semantic Web also provides new ways to model complex data environments that can be more simply maintained over time. (Pollock, 2009)

The Semantic Web idea was to provide an open infrastructure that facilitates the communication between software agents. This infrastructure is based on formal domain representations (ontologies) that are linked to each other on the Web. These formal representations provide the applications with a common terminologies and understanding. The W3C has developed the Web Ontology Language (OWL), which is a standard that allows the ontologies to be represented on the Web (Knublauch, 2004).

Ontologies have become the cornerstone of the Semantic Web. As described in (Buraga, 2004), the subject of ontology is the study of categories of things that exist or may exist in a particular area of interest. The result of such a study, called ontology, is a catalog of types of things that are assumed to exist in a domain of interest. In other words an ontology describes the concepts in the domain and also the relationships that hold between those concepts.

A similar ontology, is presented in (Schmit and Kunzmann, 2007), where is elaborated a reference model for ontology-based approaches to competency-oriented human resource development. This conceptual model is one that is in the center with the idea of integrating management competencies and offering learning opportunities for employees. Other significant references with similar ideas can be found in (Niculescu and Trausan-Matu, 2009), (Dorn et al., 2007) and (Gómez-Pérez et al., 2007).

A lot of research papers and books about semantic web and ontologies were found. For example in (Berners et al., 2001) are presented and described the basic concepts, that govern the world of semantic web.

Statement
Semantic web technologies used for adding semantics to data are eXtensible Markup Language (XML), the Resource Description Framework (RDF) and the Web Ontology Language (OWL). XML allows the creation of tags for everyone. These tags can then be used for different applications, but the person who develops the application that uses the XML document must know the meaning of each tag. “RDF has a model framework based on the idea of a triple”. A complete RDF triple, or statement, must have the thing the statement describes, the properties of the thing the statement describes, the values of those properties the statement describes. OWL is build on XML and RDF standards and extend these standards with an larger vocabulary that provide more
terms for describing the concepts, attributes and the relationships between those concepts. (Pollock, 2009; Berners et al., 2001)

Using semantic web technologies to develop an ontology for human resources management, several benefits appear in the applied field. This ontology will provide a common vocabulary for specialists who deal with human resource management, will provide a common understanding of the structure of information among people or software agents will offer the possibility to reuse the domain knowledge and also to separate domain knowledge from operational knowledge.

An ontology representation of the Human Resource Management in the OWL would allow developers to combine it with other OWL ontologies, and would provide the benefit of being able to access generic reasoning tools. By describing the meaning of information about human resources and their logic separately from the underlying data and applications they allow for the creation of highly flexible and dynamic solutions. The knowledge contained in ontology can be shared and reused as well as enhanced or modified anytime.

Design Details
To illustrate all the submissions made so far, it is necessary to develop a prototype for the desired ontology; therefore we will continue to present the proposed model for an ontology that provides facilities to cope with human resources management in an IT company, which works on projects. For developing the application was chosen, the Protégé-OWL environment, which is one of the most widespread today.

Protégé-OWL is based on a different logical model which makes it possible for concepts to be defined as well as described. Complex concepts can therefore be built up in definitions out of simpler concepts. Furthermore, the logical model allows the use of a reasoner which can check whether or not all of the statements and definitions in the ontology are mutually consistent and can also recognize which concepts fit under which definitions. The reasoner can therefore help to maintain the hierarchy correctly. (Horrodge et al., 2007)

Basic ontology requirements are essentially the following: has to describe the basic concepts used in human resources management by an IT company working on projects, has to allow the querying of data stored in the knowledge base, and has to be able to match the right person for a job.

To achieve the proposed ontology, were consulted several ontology development methodologies proposed by various authors: (Buraga, 2004; Horrodge et al., 2007; Fernández López, 2002). There were indicated a number of common steps.

First was realized the ontology capture, which means that the necessary hierarchy of concepts for the human resource management in the IT domain was identified. It was established that the basic classes for the ontology are: the departments of the company, the education required for a job, the jobs available in the company, the employees of the company, the projects handled by the enterprise and the necessary skills for the employees to hold a job, which are presented in Figure 1.

It is not so important the words chosen for representing the concepts, but the concepts as such. After this first step, were identified the relationships between concepts (synonyms, equivalent) and was created the properties hierarchy and these properties were linked with the relevant concepts. In OWL are two main types of properties: object properties and data type

![Figure 1. Ontology Basic Classes](image)
properties. Object properties represent relationships between individuals and data type properties represent relationships between individuals and data values. For example we identified the following object properties for modeling the management of an employee:

- "hasEmployee", which can be used to achieve that a department or a project;
- "hasJob", which assign that a employee has a specific job;
- "isPartOf", which emphasizes the relationship of belonging, of a class to another class;
- "hasEducation", which record for a person the appropriate domain of education, etc.

A next step would be to establish property characteristics (functional, inverse, symmetric, transitive), establish relationships between properties (Inverse Properties, Disjoint Properties etc.), and define restrictions. These restrictions dictate which individuals get included in or excluded from a class.

The development of an ontology is generally a cyclic one, because anytime you can add, delete and modify concepts.

After the ontology capture was finalized the next step is to coding the ontology. This step consist of the explicitly representation of the concepts identified previously in a formal language, in our case OWL-DL (Web Ontology Language – Description Logic).

**Implementation Details**

Protégé OWL editor: enables the creation of ontologies for the Semantic Web and provides an intuitive and friendly interface. The class hierarchy (Figure 2.) was the first created. It presents the basic concepts that are relevant for approached domain.

OWL is built on RDF and RDFS (RDF Schema). It extends the RDF and the RDFS by adding more vocabulary terms for describing the concepts. For example when are created the classes, within the Classes Tab of Protégé OWL, “Functional_Job” (which is a subclass of “Job”) and its subclass “Tester”, this are created as RDF. And accessing the RDF/XML encoding available in Protégé OWL we can see that the classes are created as follows:

```
<!--http://www.hr-ontology.com/ontology/hr.owl#Tester -->
<Class rdf:about="&hr;Tester">
   <rdfs:subClassOf rdf:resource="&hr;Technical_Job"/>
</Class>

<!--http://www.hr-ontology.com/ontology/hr.owl#Technical_Job -->
<Class rdf:about="&hr;Technical_Job">
   <rdfs:subClassOf rdf:resource="&hr;Job"/>
</Class>
```

The first code specifies that “Tester” is an rdf class and has the URI “http://www.hr-ontology.com/ontology/hr.owl#Tester”. RDFS describe the property “subClassOf”, which is a build-in property and is specified that “Tester” is the “subClassOf” the resource <!--http://www.hr-ontology.com/ontology/hr.owl#Technical_Job --> (i.e. the class “Technical_Job”).

In OWL, the classes of individuals are defined by the relationships that those individuals participate in. For this reason we have to define the related restrictions for each concept. For example to describe the class “Administration_Manager”, some existential restrictions were created (Figure 3.).
An existential restriction describes the class of individuals that have at least one kind of relationship along a specified property to an individual that is a member of a specified class (Horrodge et al., 2007). For our example this means that for an individual to be an instance of the class “Administration_Manager” it is necessary to have interpersonal skill, technical skill and cognitive skill. Also it is necessary to speak English at an advanced level, to have experience more than 3 years. This instance may have more other properties, but this are required to be part of this class.

**Evaluation**

Evaluation of human resource management ontology is a quite difficult stage. An ontology can be evaluated against many criteria: coverage area addressed in the ontology, complexity and granularity of that coverage area, the consistency and completeness of the ontology and the representation language in which the ontology was modeled.

Using ontologies in practice has several benefits, due to the usage of Semantic Web technologies for the ontology development. The prototype proposed by us has the following strengths: may represent the basis for communication between people and/or between software agents, represents and organize the knowledge base of the company. The ontology also enables the
knowledge sharing within and between domains, provides support for searching and retrieving
data from the knowledge base, allows easier software development and knowledge maintenance,
and contributes to the semantic interoperability between applications.

Because the ontology was developed in OWL-DL the ontology can be processed by a reasoner.
The reasoner has tested whether a class is a subclass of another class, and thus makes an inferential
hierarchy of classes contained in the ontology. Also, the developed ontology is consistent,
because the reasoner verifies this automatically.

Another important strength is that the OWL ontologies, and implicit our ontology is based on
the open-world assumption. This means that we “cannot assume something does not exist until it is
explicitly stated that it does not exist”. The ontology can distinguish between data facts that are
provable and those that are satisfactory. A satisfactory query result can be useful to an application
because it tells the application that there’s some uncertainty in the answer.

Like any software development the presented ontology has some limitations. An ontology is a
good choice for solving problems having to do with the reusability, portability, and expressiveness
of data languages, but aren’t suited for solving a complete software problem. Any ontology based
on OWL has scalability limitations, so our ontology will be limited to a maximum number of
triples (300-500 million), the inferring process of data can take minutes or hours if the ontology
will be enriched with fact and implications. (Pollack, 2009)

Conclusions

The Semantic Web idea is to extend the web of linked documents with metadata and to enrich the
information’s with semantic for making data easier to work with.

The major objective of this paper consist in the development of a reliable ontology which will
provide support for modeling a common vocabulary for those who will share information about
human resources, will align human resource development with company goals, will identify and
make use of employee competencies, by defining concepts, attributes and relationships between
those concepts. This goal was achieved step by step by development of an human resource
management ontology for an IT company, which provides a knowledge base for the applied field,
offer possibility to query the employees implied in a project, to query the employees according to
their job, skills, etc., to select the right person for a particular job, to replace an employee of a
project with another employee that meets the needs of the project job.

This ontology is a prototype and there are several directions that can be investigated in future
research:

- Ontology development to store knowledge about the efficiency and performance of each
  employee, for a reward, more faithful to their work;
- Ontology integration with other related ontologies, such as one which offers learning
  opportunities for the employees and keep track of every passed lesson tacked by the
  employee.

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