# An Ontology-centered Approach for Designing an Interactive Competence Management System for IT Companies

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*The paper presents a generic framework for an intelligent information system of competence management based on ontologies for information technology companies. In a first step it will be applied in an information technology (IT) small enterprise and then its applicability will be verified for other organizations of the same type. The work presented in the paper is performed under the project "CONTO – Ontology-based Competencies Management in Information Technology" funded by the Romanian Ministry of Education and Research, involving two universities, a research institute and an IT private company. A competence management system (CMS), in our vision has to achieve three functions: (a) to support the complete and systematic acquisition of knowledge about the competence of the members of an enterprise; (b) to provide the knowledge about competences and their owners; (c) to apply the available knowledge to serve a purpose. The core of the competence management information system is an ontology that plays the role of the declarative knowledge repository containing the basic concepts (such as: company-job, competence, domain, group, person etc.) and their relationships with other concepts, instances and properties. The Protégé environment was used for the development of this ontology. The structure of the ontology is conceived so that description logics can be used to represent the concept definitions of the application domain in a structured and formally well-understood way. Knowledge acquisition is performed in our approach by enriching the ontology, according to the requirements of the IT company. An advantage of using an ontology-based system is the possibility of the identification of new relations among concepts based on inferences starting from the existing knowledge. The user can choose to query instances of one type of concept. The paper also presents some use-cases.*
***Keywords:*** *Competencies, Ontology, Competence Management System, IT*

## 1 Introduction

The paper presents a generic framework of an intelligent information system for competence management based on ontologies for information technology companies. In a first step it will be applied in an information technology (IT) small enterprise and then its applicability will be verified for other organizations of the same type. The work presented in the paper is performed under the project "CONTO – Ontology-based Competencies Management in Information Technology" funded by the Romanian Ministry of Education and Research, involving technical, economics universities, a research institute and an IT private company.

An ontology is, in the context of intelligent, knowledge-based systems, a declarative knowledge base containing the concepts and the relations that exist in a given domain, it is "a *specification of a conceptualization*. That is, an 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. This definition is consistent with the usage of ontology as "set-of-concept-definitions, but more general" [1]. The name is obviously inspired from philosophy, where it means a "branch of metaphysics concerned specifically with what (kinds of) things there are" [2].

From a knowledge representation perspective, ontologies are semantic networks that state what kinds of concepts exist and what relations (e.g. abstractionparticularization or “part-of”) hold among them. If a concept is a particularization of another concept, it has all the features of the more abstract concept and, maybe, some particular ones.

A competence management system (CMS) can be seen as a part of a Human Resource Management system, which gives it the ability to store dispersed and unstructured corporate knowledge, such as corporate competencies characteristics.

**Related work**

Usually, the competence management deals with the processes at the level of an organization, by reporting strictly to the internal environment. Significant references include: [7], [8], [9], [10], [11], [12], [13], [14], [15], [16], [17], [18], [24].

For example, the results of CRAI (*Competency Resource Aspect Individual)* approach [24] are organized in three components:

• the *CRAI model*, which provides a formal representation of individual competencies, both acquired and required;

• a *set of guidelines* to deploy the CRAI model into a specific organization for building its competence information system and to evolve the represented required and acquired competencies;

• a *set of enquiries* that can mainly be used for evaluating various differences, including the gap, between required and acquired competencies.

**Our vision**

A CMS, in our vision, has to achieve three functions:

- to support the complete and systematic acquisition of knowledge about the competence of the members of an enterprise;
- to provide the knowledge about competences and their owners;
- to apply the available knowledge to serve a purpose.

The business information model of a company can be defined using an ontology. Concepts are defined and related to each other, similar with classes in a UML class diagram [5]. Each slot can be associated with a control that allows a person to enter and manipulate data values. For example, an ontology designer could associate a business process definition editor control with the slot that is designated to hold the semantic process flow. Hence, based on principles of object-orientation, there would be an association between the object type and a tool that can be used to create or modify an object of that type.

To help semantic unification advance, organizations are well advised to think about pursuing an ontology-centric approach. In essence, the ontology-centric approach helps shift focus from a function-oriented, tool-centric view, towards a semantic-oriented, ontology-centric view. Table 1 identifies major characteristics of both approaches.

**Table 1.** The characteristics of the tool-centric and the ontology-centric approach

| Characteristic | Tool-centric Approach | Ontology-centric Approach |
|---|---|---|
| Semantics | Implicit semantics | Explicit labelling |
| Extensibility | Generally uses a tool’s functions. Underlying information model is transparent. | Information model is visible. The object type determines the tool used for creation and manipulation of data values |
| Extensibility | Generally limited, tool dependent | Unlimited |
| Repository Information Model | Generally not disclosed, disclosure is at the vendor’s discretion | Defined by the user organization |
| Information exchange among tools | Generally difficult and error-prone, due to differing semantics. | Information exchange not necessary among ontologies |
| Audience | Persons who want to create or manipulate objects of a type that the tool supports. | Unlimited |

Figure 1 shows the modules and their interaction with other parts of our concept. As central database we have a Human Resource-Data Warehouse (HR-DW). In this HR-DW most of the HR data from legacy-systems is integrated in one place.

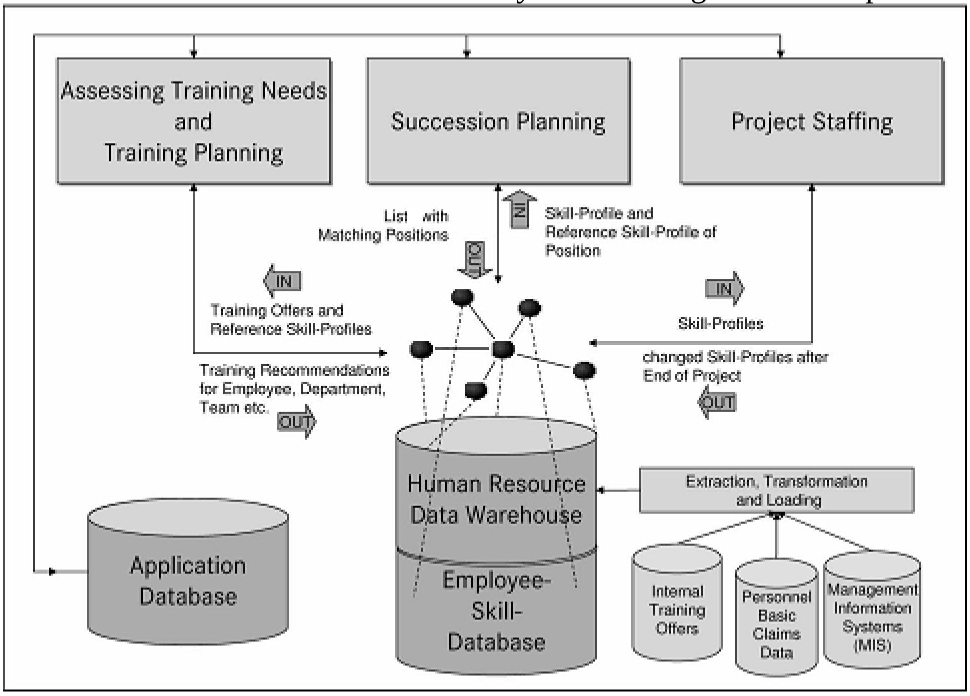


**Fig. 1.** The overall architecture of the system [25]

On top of the HR-DW as a meta-layer between the database and the application modules resides the central domain ontology. It consists mainly of the competency catalogue and some further enriching information sources like organizational structure, reference position catalogue etc. To proof that the concept works, we already implemented the module "Project Staffing", which shows representatively for the other two modules that an ontology-based matching on competency profiles does work.

The paper continues with a section describing the structure, the integrity and inference of the ontology, knowledge acquisition and conceptualization for our CMS ontology; some use-cases are also presented. The paper ends with some conclusions and further development ideas.

## 2 The ontology of the prototype

### 2.1 The structure of the ontology

The most important component of the prototype is the *ontology* that plays the role of the declarative knowledge repository containing the basic concepts (such as: company-job, competence, domain, group, person etc.) (see figure 2) and their relationships with other concepts, instances and properties. The Protégé environment [3] was used for the development of this ontology.

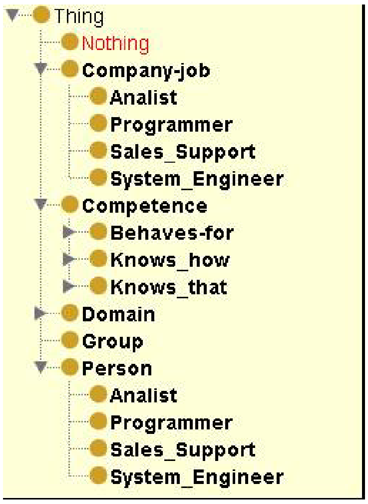


**Fig. 2.** Basic concepts of the CMS ontology

The part for the *Software Engineering* concepts (the sub concepts of "Technical-domain" in the domain ontology, see Figure

3) was built using the *Guide to the Software Engineering Body of Knowledge* [19].
The project plans the configuration of an ontology for the business partner in the project.


**Fig. 3.** Concepts in the technical domain of CMS

The structure of the ontology is conceived so that description logics [26] can be used to represent the concept definitions of the application domain in a structured and formally well-understood way (see figure 4).

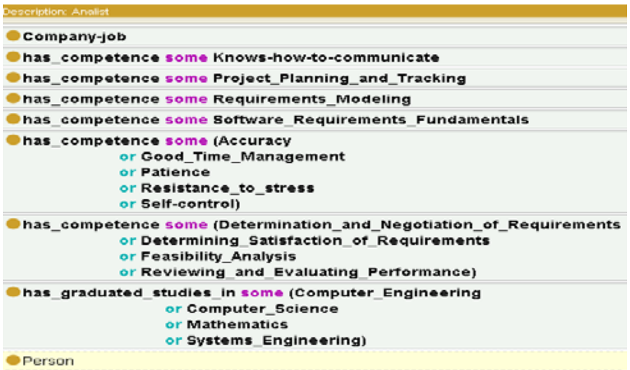


**Fig. 4.** Usage of Description Logics in the representation of concept definitions

## 2.2 Integrity and inference of the ontology

Additionally to the representation of concepts, relationships and properties, the ontology contains also rules for integrity validation and inference. The inference rules allow describing implicit factual knowledge about the competencies of the employees. In the knowledge base the knowledge about the competencies of the organization and the employees are hosted. The inference engine will serve to derive the implicit knowledge. For this purpose the inference engine will access the ontology and the knowledge base. Inferred knowledge is saved in the knowledge base (see figure 5).

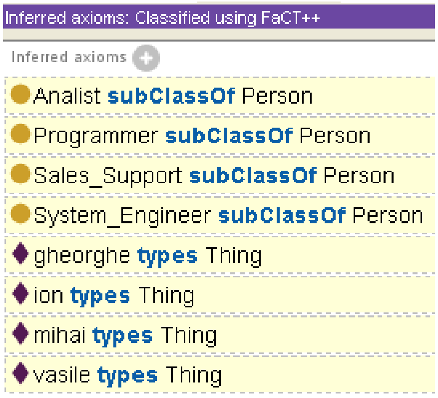


**Fig. 5.** Inferred axioms classified using FaCT++

## 2.3 Knowledge acquisition

Knowledge acquisition is performed in our approach by enriching the ontology, according to the requirements of the IT company. For example, Figure 6 illustrates an example of knowledge acquisition: CV for person Gheorghe.

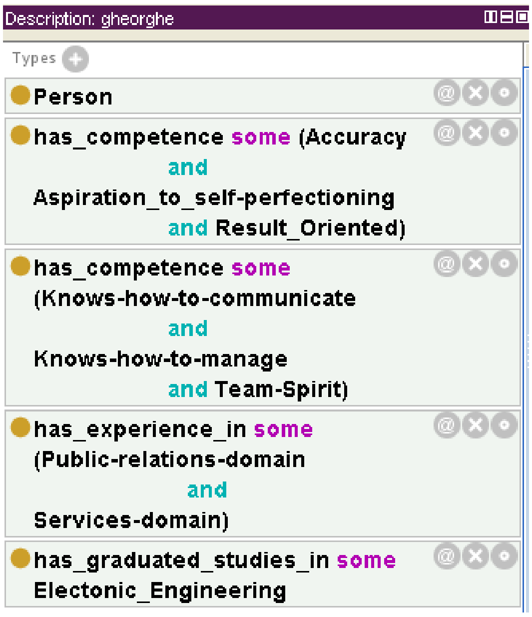


**Fig. 6.** An example of knowledge acquisition: CV for person Gheorghe

The phase knowledge acquisition denotes that the project team collects all the relevant information that the ontology needs to conceptualize. Because the activities of acquisition and structuring of knowledge accompany each other, the phases of knowledge acquisition and conceptualization have to be done within an iterative loop. There are different sources that can be used to create a knowledge base. First of all the employees and their superiors of an organization can be interviewed about the employees´ skills. Another way could be to extract knowledge from electronic documents to ascertain skills. In all cases it is important to pay attention to the fact that knowledge about knowledge (meta knowledge) will be raised.

## 2.4 The conceptualization phase

Conceptualization is a process in which a human uses the ontology building tools and the previous phases to build a sound conceptual system of the considered domain. On the one hand the ontology contains a conceptual system of the domain (terminology) and on the other hand it contains rules for interpretation and the use of the concepts (see figure 7). Not only have the members of the project team conceptualized, but also the users, who have been interviewed during the phase of knowledge acquisition. The conceptualization is not accompanied by a certain language or a technical requirement.

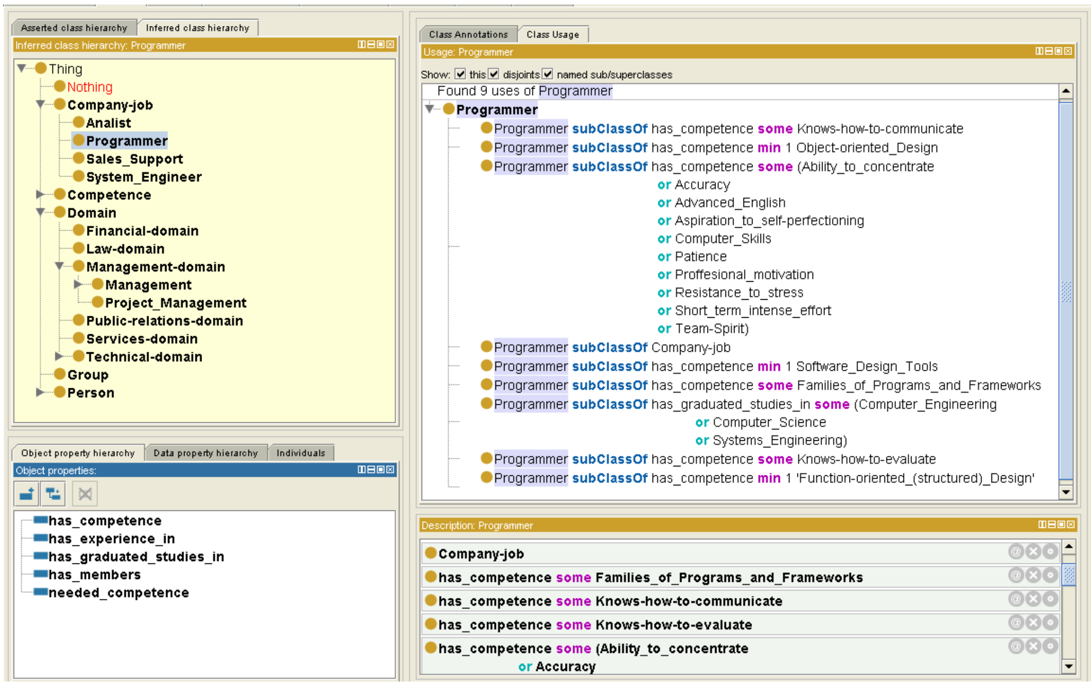


**Fig. 7.** A fragment of the conceptualized structure of the ontology

## 2.5 Queries

The user can choose to query instances of one type of concept, based on the relations that are displayed for him/her in a dropping menu (see figure 8). In addition to choosing relations modeled in the ontology, the user may also query inferred relations that are not explicitly stored in the knowledge base. The second type of search is browsing the ontology. The ontology skeleton is seen as a tree and its nodes are hyperlinks referring to other concepts or to instances. Starting from the main concepts, the user can get particular information about any instance of any other concept.

On the one hand the knowledge base can be queried directly. On the other hand the possibility to work with the inference engine exists to get results of better quality in actuality and reliability. Querying the knowledge base directly without using the inference engine means a fast result of high performance. It is planned that the possibility to work with the inference engine can be chosen by the user. That means normally the user queries directly. Only in the case of not getting a satisfying answer with a direct query he/she uses the inference engine to get better quality.

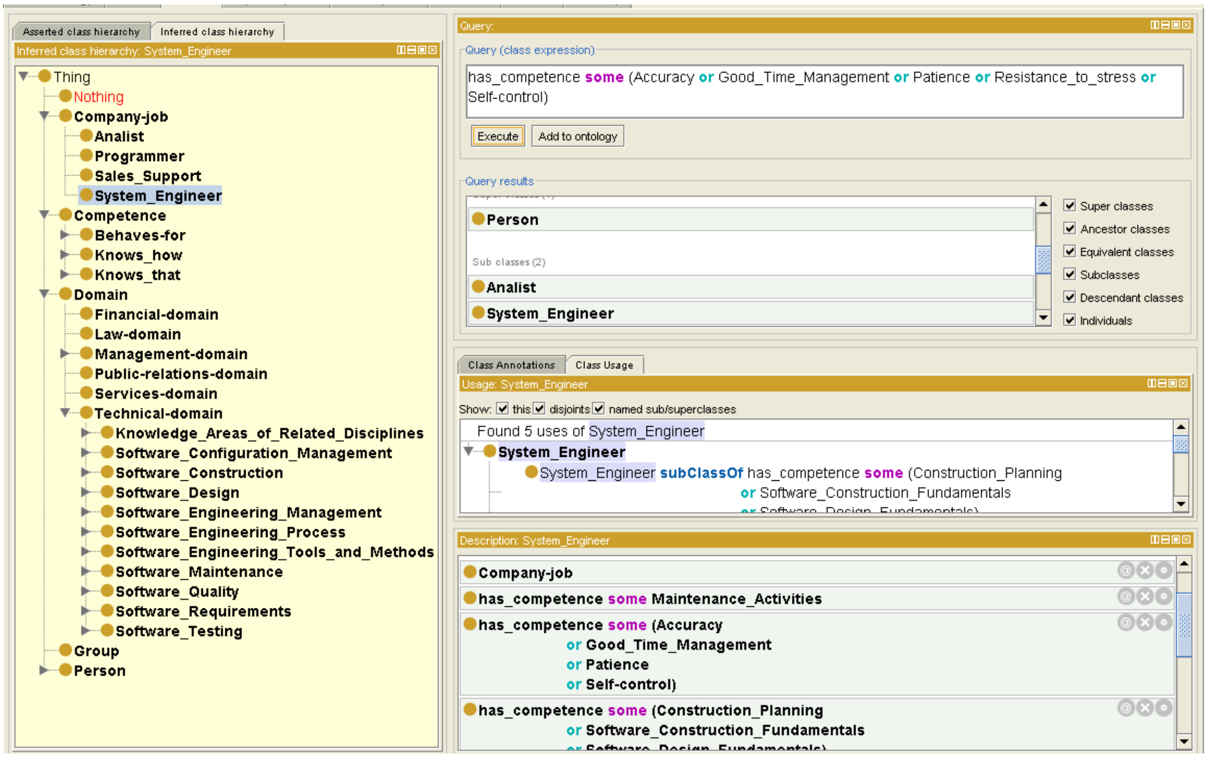


**Fig. 8.** Querying instances of one type of concept

## 2.6 Usage scenarios

The aim of the ontology development is specified in the first step of the project process model. The requirements inquiry defines the area of application. By developing use cases and scenarios, different use situations can be described. The identified requirements have systematically to be objected to support the phase of evaluation later on. If there has been identified a large and complex number of requirements, it can be reasonable to use a requirements engineering tool to support their management. The inquiry of the users and the analysis of the peripherals can be regarded as completed when the developers or users agree to it.

One use scenario is the determination of which person is adequate to the jobs of the company:

*Query*: has_competence some (Accuracy or Good_Time_Management or Patience or Resistance_to_stress or Self-control)

*Query results*: Thing, Person, Analist, System_Engineer, Gheorghe

Gheorghe is a person that may get the job "Analist" or "System_Engineer".

Other scenario is the identification of competencies that are not covered by the existing personnel in a company:

*Query*: has_competence some Project_Planning_and_Tracking

*Query results*: Thing, Person, Analist

The competence of "Project_Planning_and_Tracking" has to be carried out by the person(s) that occupies (occupy) the "Analist" job.

## 5 Ontology evaluation

Although ontology evaluation techniques are improving as more measures and methodologies are proposed, the literature contains few specific examples of cohesive evaluation activity that links ontologies, applications and their requirements, and measures and methodologies [20], [21], [22].

We didn't use a methodology of acquisition of knowledge, we conceptualized the system and we also gave rules for interpretation and the use of the concepts.

## 4 Conclusions and further developments

In the phase of implementation, the formal account of the ontology will be developed. The implementation phase consists of the formal representation of the conceptualization and the integration of the ontology-based application in the system environment. The ontology engineers have to choose an appropriate language considering functionality and capability of the ontology and the constraints of the given information systems in the enterprise. After representing the ontology the result has to be implemented into an information system (e.g. with a graphical user interface) so that users can fetch knowledge about skills from it. Besides, it is intended that the skills management system explain new knowledge about skills from documents or databases that are already used by an enterprise. Using an XML-based [6] representation, the data between external applications and the knowledge management system can be exchanged. Another possibility of use of our competence management information system is to link this ontology to competence management ontology for project management and to deduce the optimal for teams building, as minimum of gap in educational needs.

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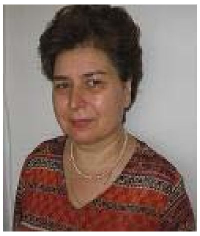

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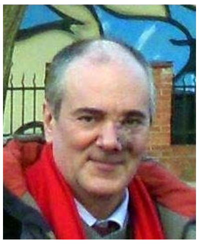

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