Proceedings of I-KNOW '05
Graz, Austria, June 29 - July 1, 2005

An Ontology-Based Framework for Representing Organizational Knowledge

Andrea Gualtieri
(Department of Electronics, Informatics and Systems (DEIS), University of Calabria, Via Pietro Bucci cubo 3/c, 87036 Arcavacata di Rende (CS), Italy
Exeura s.r.l., University of Calabria, 87036 Arcavacata di Rende (CS), Italy
gualtieri@exeura.it)

Massimo Ruffolo
(Institute of High Performance Computing and Networking – Italian National Research Council - ICAR-CNR, University of Calabria, 87036 Arcavacata di Rende (CS), Italy
Exeura s.r.l., University of Calabria, 87036 Arcavacata di Rende (CS), Italy
ruffolo@icar.cnr.it)

Abstract: This paper describes an ontology-based organizational knowledge representation framework focused on the specification of a two kinds of ontologies: the top level ontology containing concepts characterizing the typical organizational background and COKE ontologies representing so called *core organizational knowledge entities*. The framework constitutes an abstract representation of organizational knowledge providing a semantic support for designing knowledge management infrastructure able to interoperate with systems already existing in an organization. Moreover, the annotation of COKE w.r.t. the top level ontology allowed by the framework facilitates their semi-automatic handling, retrieval and evolution monitoring.

Keywords: Knowledge Representation and Reasoning, Ontology, Interoperability, Knowledge Management, Knowledge Management System
Categories: H.2.3, H.3.0, D1.6

1 Introduction

Knowledge Management (KM) can really increase the efficiency and effectiveness of the organizational business processes. KM can contribute to the creation of value and to the intangible assets and intellectual capital growth within the enterprises. Therefore efficient KM Systems (KMS) and coherent KM strategies are needed to support the organizations in managing knowledge created, stored, distributed and applied within the business process. In particular, specific methods and instruments for organizational knowledge elicitation and representation are required for KMS and KM strategies design and implementation.

Many different kinds of organizational knowledge are wide spread within enterprises under different forms and distributed in several sources (humans and systems) inside and outside the organization. The classical distinction and generally accepted classification, due to Polanyi [Polanyi, 96], [Polanyi, 97] and extended by Nonaka [Nonaka, 94], [Nonaka&Takeuchi, 95] identifies: "tacit and implicit knowledge", that is the knowledge resulting from personal learning processes, present within each organization in terms of its members' personal knowing; "explicit

knowledge", generally shared and publicly accessible within the organization through formal storing and processing infrastructures. Explicit knowledge can also be classified basing on the following forms: "structured" (available in database), “semi-structured" (available in intranet and internet web sites: HTML pages, XML documents, etc.) and "unstructured" (available as textual documents: project documents, procedures, white papers, templates, etc.).

The traditional information systems present two basic problems: first they are able to process only a small portion of the whole organizational knowledge (i.e. explicit knowledge under structured form); second they use heterogeneous models and techniques for representing knowledge and manipulate them.

A KMS must be able to support the generation, discovery, capture, store, distribution and application of a wide variety of knowledge (i.e. explicit knowledge under structured, semi-structured and unstructured forms and individual and social aspects of implicit knowledge) through related knowledge-based services. Moreover, a KMS needs capability to interoperate with already existing organizational information systems. To satisfy these requirements a KMS needs knowledge representation capabilities, that can be provided by ontology languages, able to allow the specification of the different organizational knowledge forms and kinds and to carry out an abstract representation of organizational entity supporting interoperability among different systems and organizational areas.

In the last years many enterprise models aimed to give a formal representation of the structure, activities, processes, information, resources, people, behaviours, goals, and constraints of a business, government, or other enterprise has been proposed in literature [Fox&Gruninger, 98]. All these models consist of an ontology based on a vocabulary along with some specification of the meaning or semantics of the terminology within the vocabulary. For example, the Toronto Virtual Enterprise Ontology (TOVE) [Fox, 92] is an ontology providing a shared terminology for the enterprise that defines the meaning (semantics) of each term in a precise and an unambiguous as possible manner using first-order logic; IDEF Ontologies [Fillion et al., 1995] intended to provide a rigorous foundation for the reuse and integration of enterprise models; CIMOSA [Heuluy, 97] aimed to provide an appropriate integration of enterprise operations by means of efficient information exchange within the enterprise with the help of information technology.

All these ontologies attempt to describe in detail the whole organizational knowledge and structure. The resulting models are less flexible and not easily applicable in the very dynamic contest of a real enterprise.

This paper describes an ontology-based framework for specifying organizational knowledge. The framework aims to represent so called Core Organizational Knowledge Entities (COKE) in an ontology expressed using a novel ontology representation language based on disjunctive logical programming. The Framework is organized as a two level family of ontologies: the first level (top level) ontology represents the set of concepts characterizing organizational background; the second level ontologies formally represent the COKE (i.e. human resources, business processes, technical resources, knowledge objects). The resulting formal representation of organizational knowledge aims at contributing as theoretical base in supporting the analysis and design of Knowledge Management Systems (KMS) in two manner: first ontologies represent an abstract representation of organizational

knowledge providing a semantic layer allowing interoperability between existing systems and the KMS, second COKE can be easily annotated w.r.t. top level ontology using semi-automatic mechanisms, so their evolution can be better captured and handled.

Currently, the proposed framework is under development in a research project named "KMS-Plus" in which are involved five Italian IT companies. KMS-Plus, started in December 2004 as a "pre-competitive development" project financed by Italian Ministry of University and Research, aims to realize, before November 2006, a semantic-aware KMS supporting business processes through an integrated view of dynamic and static aspects of enterprise knowledge.

The work is organized as follow: in section 2 is described the knowledge representation language used to formalize top level and COKE ontologies; in section 3 the ontology-based framework is explained in detail.

2 The Knowledge Representation Language

The proposed framework is under implementation using the DLP+ ontology representation language [Leone, 04] developed as an extension of the Disjunctive Logic Programming (DLP). DLP extends Datalog allowing disjunction in the rules' heads. Nowadays DLP is widely recognized as a valuable tool for knowledge representation and reasoning. The first important merit of DLP over normal (i.e., disjunction-free) logic programming is its capability to model incomplete knowledge [Leone et al., 97]. The presence of disjunction in the heads of the rules makes DLP inherently non-monotonic, that is, new information can invalidate previous conclusions. The second merit is the availability of the powerful reasoning engine DLV [Faber&Pfeifer, 96] which supports a completely declarative style of programming based on a bottom-up evaluation of the stable model semantics of disjunctive logic programs. DLV+ the system implementing the DLP+ language has been obtained as an extension of DLV.

Roughly speaking, DLP+ supports the notions of class, instance, property, relation, local and global constraint and axiom. Classes are concepts of the world being modelled. Each class can be characterized by a number of properties. The instances of a concept can be explicitly stated or inferred by its definition.

Classes can be partially ordered by two types of built-in relations: *Isa* and *PartOf*. These relations can be exploited to generate taxonomic structures among concepts. If C *Isa* D holds, then we say that C is a subclass of D. The predefined class Object is the super class of all classes. When a property is defined for a class, it holds for all its sub-classes, unless overwritten by more specific properties. Multiple inheritance is also supported. Other kinds of (non-taxonomic) relations can also be explicitly specified to relate concepts to each other within the ontology.

Global and local constraints and axioms are used to express the semantics of both classes and relations. An axiom is either a (possibly disjunctive) logic rule, a constraint can be strong (used to state inviolable conditions) or weak (used to express desiderata). Rules may have negative heads (true negation); negation by failure (in rule bodies) is also allowed.

The interoperability between DLP+ and standard semantic web formalisms is guarantied by a transformation engine able to translate portions of DLP+ ontology in the OWL language [W3C, 04].

3 The Ontology-Based Framework

The proposed ontology-based framework is organized as a set of ontologies as described in figure 1. The top level ontology (topic ontology) contains concepts characterizing organizational background knowledge. These concepts are used for annotating COKE.

The COKE ontologies formally represent human resources, business processes, knowledge objects, technical resources constituting the main elements characterizing the organizational structure and playing a fundamental role in business activities execution. All the ontologies are strictly connected by relations between their own elements and are represented using the DLP+ language.

The framework give an abstract representation of COKE's allowing semantic interoperability among the various type of information systems used in the organization. More in detail, the framework provides a uniform representation of knowledge handled by the systems already existing in the organization such as document and project management systems, ERP and CRM systems. Connecting such systems to the framework using ad hoc software modules handled knowledge object can be better stored, managed and retrieved.

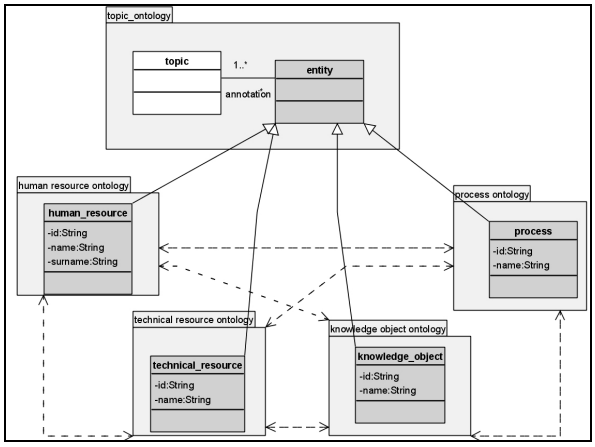

Figure 1: The Organizational Knowledge Framework

3.1 The Top Level Ontology

The top level ontology or topic ontology contains concepts characterizing the typical organizational background. It specifies the explicit and implicit organizational declarative knowledge concerning the concepts characterizing an application domain: e.g. an IT enterprise background is founded on concepts coming from computer

science field. As top level ontology it provides the other COKE ontologies with concepts to formally annotate their contents.

3.2 The COKE Ontologies

COKE Ontologies contain the formal representation of human resources and their organization in groups, processes and their activities, knowledge objects constituting elements produced or used in business processes, technical resources in term of instruments used during business process execution.

The Human Resource Ontology represents individuals working in the organization (knowledge workers) and social groups they are involved in. Each individual profile is represented in term of implicit, explicit, individual and social knowledge, organizational role, social group membership, required technical resources. Each social group (community of practice, project team, organizational group, etc.) profile is represented in term of its members profiles.

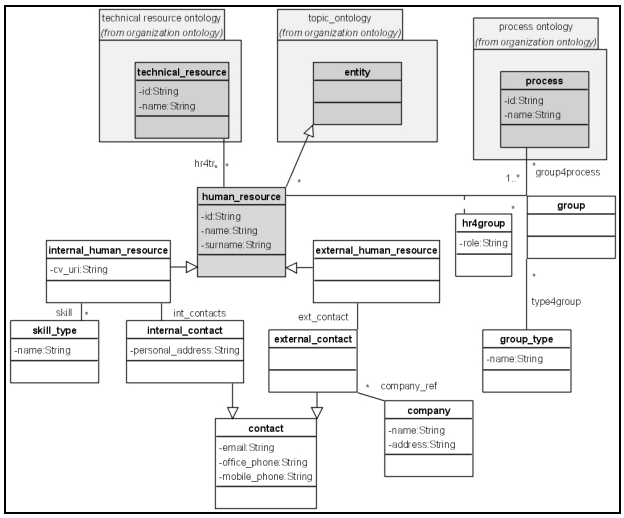

Figure 2: The Human Resource Ontology

The Business Processes Ontology contains procedural knowledge related to the managerial, operational and decisional processes. Each of them is described in terms of activities, sub-processes, transition states and conditions, involved actors, treated topics, etc. This can be a simple representation of business process or a complex ontology where the workflow structure and the taxonomic and non-taxonomic relations between processes are represented using the DLP+ language [Leone, 04]. The business process ontology exploits an interesting capability of DLP+ language allowing the expression of relations between classes, that enables the representation of process meta-model, process schemas and process instances.

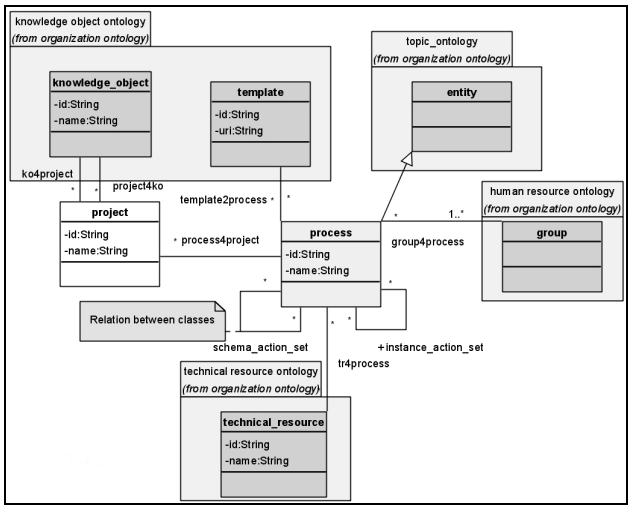

Figure 3: The Business Process Ontology

The Knowledge Objects Ontology maps the structure of logical objects (e. g. database schema, database tables, textual documents, web pages, etc.) containing explicit knowledge under structured, semi-structured or unstructured form [AAAI, 00]. These are used in the business processes and handled by the human resources through knowledge-based tools. Knowledge objects retrieval, management and handling is facilitated by the annotation on the topic ontology concepts.

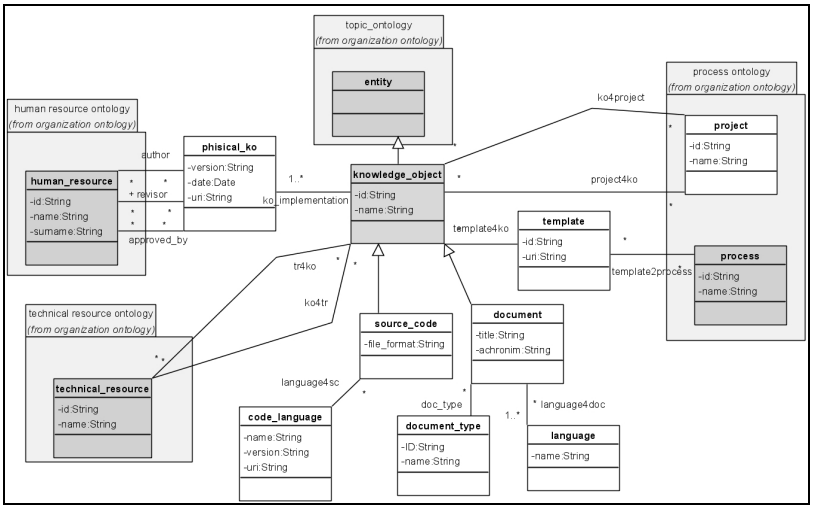

Figure 4: The Knowledge Object Ontology

The Technical Resources Ontology identifies the tools by which knowledge objects are created, acquired, stored and retrieved. The execution of a query to the top level ontology can be executed using a specific tool able to retrieve all the elements related with a specific concept. Element can be filtered to obtain a specific COKE related to the query. For example a query result can contain people knowing a given concept or systems containing knowledge objects related to some concepts. This allows the management of implicit and explicit knowledge stored in structured, semi-structured or unstructured machine-readable forms.

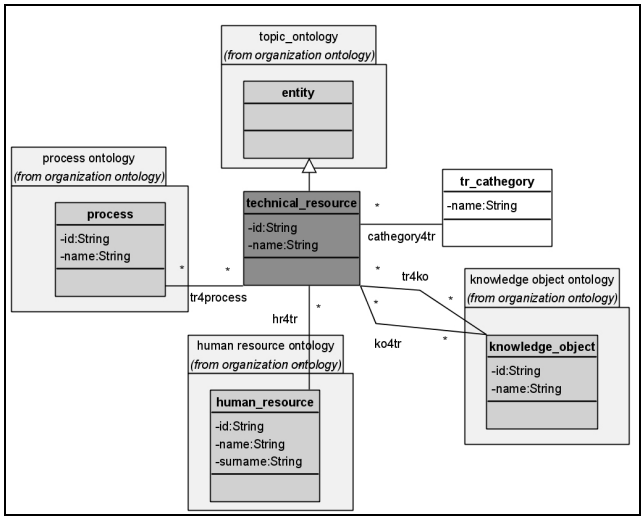

Figure 5: The Technical Resource Ontology

4 Conclusions and Future Works

This work describes an ontology based framework for organizational knowledge representation providing an abstract definition of COKE's enabling the dynamic capture of business processes changes and evolutions. Moreover the framework allows the automatic annotation of COKE's to enterprise relevant concepts allowing semantic retrieval and management capabilities. Future works regard the definition and implementation of the annotation mechanisms, the representation of time in the ontology, the definition of process implementation model able to allow the process enactment using existing workflow systems.

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