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SEMSE: Semantic Metadata Search
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Abstract

The development of the Semantic Web depends on agreed and unambiguous knowledge representations, on the availability and accessibility of knowledge, as well as on retrieval capabilities. The scarce agreement on knowledge representation and the lack of techniques to process semantic structures in web search engines makes it impossible a contextualized conceptual retrieval. These limitations imply that users must previously know the existence and location of this knowledge to be able to retrieve it. In consequence, different ad-hoc knowledge representations and metadata vocabularies, scarcely formalized and agreed on, have been published, which makes it difficult reuse and interoperability. The proposal has as its main goal the elaboration of web system to manage and retrieve heterogeneous semantic schemas by means of a multilevel ontological structure and the alignment with a reference ontology that makes it possible the conceptual retrieval and reuse of knowledge.

Keywords: Semantic Search Engines, Semantic Web, Interoperability, Knowledge Representation, Metadata Vocabularies, Ontologies

1 Project Goal

The SEMSE proposal incorporates a semantic layer to the representation of metadata schemas[1]. The existence of this layer avoids ambiguous conceptual representations and will enhance the conceptual retrieval techniques based on the semantics and the content of the schema elements. In order to achieve this goal the following work packages (WP) were defined:

1. *Coordination Work-package [WP1]:* This package aims the planning and monitoring of the whole project. This phase has periodic (monthly) milestones. It lasts the whole project.
2. *Ontological base development [WP2]:* This package aims design the best ontological structure suitable to enhance the representation and retrieval of concepts from different schemas. It is formed by the following activities:

a) Ontological representation of schemas. It is in charge of stating the schemas representation structure that allows disambiguating semantic complexity, as well as structural ambiguity.

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[1] The term schema includes different semantic resources, such as ontologies, metadata vocabularies, etc.

b) Evaluation of the reference ontology. We analyze existing top-level ontologies and their relevance to the system requirements. The result of the study decides between two alternatives: the development of a new application ontology or the reuse of an existing one.
c) Evaluation of the mapping method. This activity defines the proper mapping method between the schemas and the reference ontology.

3. *Development of the management platform and alignment process [WP3]:* This package is twofold: the development of a management platform, and the implementation of the process for mapping between schema and the reference ontology concepts. It consists of the following activities:
a) Assesment and selection of ontology management systems.
b) Development of the management subsystem for semantic schemas and reference ontology. It also provides the control mechanisms in the updating, monitoring and reviewing of schemas.
c) Development of the conceptual retrieval subsystem for schemas and semantic documents. It is planned as a Web Open Access platform.
d) Search and selection of the initial set of schemas to be included in the system as the kick off kit. The selection criteria will be based on popularity, scope and overlap of elements.
e) Alignment between the schemas and the reference ontology. This activity will be in charge of performing the alignment between schemas and the reference ontology.

4. *Search engine and indexers development [WP4]:* This package developes the software that crawls, searches, analyzes and indexes the semantic documents generated from schemas. It consists of:
a) Development of a search spider. A crawler to navigate the web in order to find documents generated from the schemas that are already stored in the system.
b) Development of a documents parser/indexer. Semantic documents will be analyzed, indexed and stored in a database.

5. *Results dissemination and promotion of the resource [WP5]:* The design of the management platform is grounded on usability, open source and collaboration. These factors need promotion in order to disseminate the resource. This package includes the publication of the developed processes, methods and tools, as well as the results, development of patents and resource publicizing.

The schedule of targets and estimates are shown in *Table 1: Project Schedule.*

WP	Activities/Tasks	Start Month	End Month
WP1	Coordination	M1	M36
WP2	Ontological base development	M1	M10
T2.1	Ontological representation of schemas	M1	M2
T2.2	Evaluation of the reference ontology	M2	M5
T2.3	Evaluation of the mapping method	M5	M10
WP3	Development of the management platform and alignment process	M11	M30
T3.1	Assesment and selection of ontology management systems	M11	M17
T3.2	Development of the management application	M20	M30
T3.3	Development of the conceptual retrieval subsystem	M20	M30
T3.4	Search and selection of the initial set of schemas	M17	M17
T3.5	Alignment between the schemas and the reference ontology	M17	M19
WP4	Search engine and indexers development	M17	M30
T4.1	Development of a search spider	M17	M26
T4.2	Development of a documents parser/indexer	M26	M30
WP5	Results dissemination and promotion of the resource	M2	M36

Table 1: Project Schedule

2 Successful stage accomplished in the project

The following subsections describe the current results achieved in the project when pursuing the goals described in the previous section.

2.1 Ontological base development. In this stage, the semantic structure for information representation and retrieval has been created. It has been refined during the project's progress.

2.1.1 Ontological representation of schemas. The transformation of schemas into ontologies (called semantic schemas) has two representations: (1) *semantically qualified schemas* address to include semantics into the schema maintaining compatibility with the original schema through the inclusion of semantic qualifiers defined in the *semantic qualifiers schema*. (2) *specific ontologies* address to capture the semantics of each concept, cover aspects as synonymy and multilinguism and are based on the concepts (classes) and properties (slots) described in the SEMSE ontology [24].

2.1.2 Evaluation of the reference ontology. Various foundation ontologies have been assessed in order to establish the degree of compatibility with the system requirements and the cost of use versus the development of an own resource. As result, a mixed approach has been adopted: in a non exclusive manner PROTON [46] has been chosen as foundation ontology and it has been incrementally developed as new semantic schemas have been included through an application ontology that allows modification, improvement and expansion.

2.1.3 Evaluation of the mapping method. A manual alignment between concepts has been done, minimizing mapping errors. The mapping has been resolved using an independent mapping ontology. Thereby, specific and reference ontologies are independent of relationships between concepts; it makes maintenance, expansion and modification easier in the ontological base.

2.2 Development of the management platform and alignment process. In this stage two parallel objectives were addressed; on one hand, the development process of the management platform; on the other hand, the alignment process between specific and reference ontologies.

2.2.1 Assessment and selection of ontology management systems. Twenty-five (25) applications including servers and editors have been evaluated [36] in relation to advantages and disadvantages when retrieval and semantic alignment takes place. As result, Jena [48] was selected as the ontology management framework and for the development of the specific support platform.

2.2.2 Development of the management subsystem. The requirements specification of this subsystem is summarized as follows: a web portal supporting multiple roles (users, experts and engineers), that allows the management of the proposed ontological base, as well as the control process in updating and reviewing semantic schemas. The deliverables have been published on the project's web: URD [39] and SRD [39]. The development is under progress in collaboration with Everis Spain SL.

2.2.3 Development of the retrieval subsystem. The requirements specified can be summarized as: a Web Open Access platform that allows the conceptual retrieval of semantic schemas and documents. The results have to be returned once the positioning algorithms have been applied. The main queries defined are: retrieval by concept; retrieval of schemas in which a concept is represented; retrieval of documents making use of any of the schemas that define the search concept; retrieval of documents in which there is a concept given a particular schema; and retrieval by the metadata assigned to the schemas. Similarly to the management subsystem, the complete set of requirements can be checked on the requirements documents mentioned above.

2.2.4 Schema selection and search. At first, it has been performed an heterogeneous selection of schemas with partial overlapping. The result of the selection is an initial set of schemas comprised by: dcelements [49], vcard-rdf [50], foaf [51], doac [52], doap [53] and pim [54]. As of today, the addition of a second set of schemas form the process management scope is being evaluated.

2.2.5 Alignment between schemas and the reference ontology. For each selected schema it has been generated its semantically qualified representation and its representation as a specific ontology. The next step consisted on the manual alignment of the concepts in the specific ontologies with the ones in the reference ontology, in terms of their semantics. The process has involved the restructuration and extension of the reference ontology, and it has been carried out with an application ontology [24].
2.3 Development of a search and indexing engine. This third phase aims searching, analyzing and indexing the semantic documents generated from the schemas included in the system.
2.3.1 Development of a search spider. It has been developed a crawler which, relying on search engines and term dictionaries, explores the web locating documents based on schemas stored in the system. Once located, it retrieves and stores them for later analysis and indexing.
2.3.2 Development of an analyzer/indexer of documents. It is being developed an analyzer/indexer which validates and processes the documents for their later indexing in a database. The indexed information includes, for each document, the elements that appear on it and a link to the schema that defines them. This way, it is possible to obtain information as to what documents contain what elements, documents generated from a schema or, for instance, what correlation there is between elements of different schemas.
2.4 Dissemination of results and promotion of the resource. Web technologies, such as Java Server Faces [44], have been used in order to favor usability. The chosen development process – incremental– is also in this line, which facilitates the addition and adaptation of functionality on the basis of future suggestions from the users. There are also the processes of publishing, etc.
2.5 Supporting activities. Besides the previous phases, it has been necessary to implement various infrastructures to support the coordination and development of the project, amongst which we can summarize; *Project's Web Portal* facilitates the group coordination, publication, organization and the promotion of the project; *Version Control System* based on Subversion (SVN) leverages the collaborative development process; *Application Server* based on Glassfish allows the deployment of different versions of the system; *Persistence Server* based on PostgreSQL it has facilitated the development of the platform and has simplified the administration and management tasks.

3 Result Indicators

The development team is formed by 6 female researchers and 9 male researchers of the Universidad Carlos III de Madrid, 14 of which are full time, and without any support personnel. The team members have taken part in other European projects and are currently involved in various international projects. Team members are also reviewers for some international Journals in ISI databases such as: Applied Ontologies, Information Processing & Management, IEEE Transactions on Software Engineering, IEEE Computer, and El Profesional de la Información.
Degree of following the proposed objectives: the project follows the original objectives as indicated by the chart presented (see Table 1) and sometimes going ahead of the provisions presented originally.
Relevance and originality of the obtained results: The study of the editors of ontologies is one of the first results of this research. It was not possible to find another study to analyze with the desired depth and detail this type of tools [37]. The study focused on finding metrics to measure the popularity of semantic resources [24] [42]. The study continued with some vocabularies of metadata [38] [25], finding inconsistencies in formalizations such as the abstract model of the DCMI [27].

The project team has also conducted research to improve the intercommunication with the user at the time of mapping concepts and returning to the user the results ordered by relevance. This research has resulted in an international patent [43].
The degree of utilization of various foundation ontologies has been studied from two different perspectives [42]: its use in different technical projects, and in different semantic search engines such as Swoogle, Falcons or Sindice. The crawler used in this study was developed for SEMSE.
Scientific and technological production: This project is related to several research areas such as aligning systems, usability, statistics of resources use, positioning, knowledge representation, web crawling, etc. Project planning was published in [25] [26]. A total of 18 undergraduate and graduate students are developing related research works. A summary of publications resulting from the project during the first two years is listed bellow in Table 2:

International Journals [1]-[15]	15 papers, 4 of them JCR published or accepted papers, 2 under review
Conference Communications [16]-[28]	10 international conferences, 3 national conferences
Book Chapters [28]-[32]	4, 2 of them in Spanish, 1 in Portuguese, 1 in English
Phd Thesis [33]-[36]	4 thesis, 2 of them under development
Degree's and Master's Thesis	14 thesis, 4 of them under development in collaboration with Everis
International Patents [43]	1, about resource positioning estimation

Table 2: Publications

Utility of the obtained results and their relation to the socio-economic environment: Collaborations about popularization of the subject were shown in the Sistema de Difusion Cientifica Madrid I+D and in the Cadena SER [2008-2009], Taller de Herramientas Cooperativas in the IX Semana de la Ciencia [2009]. In the professional domain, the Universidad Rey Juan Carlos included ontology applications in courses that offer a joint Master of Science in Enterprise Intelligence. In its first two years the project created a site [46] to facilitate and improve its interoperability among several semantic resources. This site is public and free to access and it is based in the Web 2.0.
There are several EPOs that have shown interest in this project. The team has collaborated with some companies to incorporate search engines to the collection of resources through web crawlers and conceptual retrieval of elements present in semantic schemas thus facilitating its usability. The semantic elements come from several sources, among them are UML models, ontologies, vocabularies of metadata, etc. In the period 2008–2010 there have been several projects that took advantage of this project, among them: the Erudito Project with the Albeniz Foundation for the semantic search of ontologies; semantic search of UML models with the Reuse Company; and semantic search in the legal field with Tirant (a judicial company).
Formation of human resources: Since February of 2009 the project has initiated collaboration with Everis Spain S.L., an international business and IT consulting company. This company offered four scholarships for students attending their last year of engineering studies and associated with the project SEMSE. Such scholarships have been directed jointly by the Universidad Carlos III de Madrid and by Everis Spain. Students are formed in technologies related with the Semantic Web.
Collaboration with other European and International Teams: We have collaborated with the Consiglio Nazionale delle Ricerche in the LOA (Laboratory for Applied Ontology) directed by N. Guarino realizing few studies to assess our approximation for the foundation ontologies. We have conducted a statistical study of the use of foundation ontologies, that was presented in a seminar organized by LOA [42] and in the University of Karlsruhe. We have also realized a study of term filtering mechanisms for the creation of ontologies. LOA organized in November 2009 a petition to the European Science Foundation to create a "Network on ontology and its application". In this petition there are about 50 companies of 11 countries of the European Union; our group, under the SEMSE project, sided with the petition.

During the period [2009–2010] a study is taking place with the University of Sao Paulo to create and reuse ontologies applied to the labour market. This research makes wide use of multilinguisms and the practical application of vocabularies in the automatic monitoring of the labour market.
The team has organized the following International Conferences: SKY 2010 – International Workshop on Software Knowledge (Herzlia, Israel), KREUSE 2009 – Second International Workshop on Knowledge Reuse (Falls Church, VA, USA) and KREUSE 2008 – First International Workshop on Knowledge Reuse (Beiging, China).
Team members are part of the Consulting Committee for the DCMI (Dublin Core Metadata Initiative) and chairmanship of the community DCMI Social Tagging.
In relation with the study of the project in the areas of management, representation and retrieval of knowledge, we have contacts with international teams resulting in research stays as follows: Höskolan på Åland (Finland) [2007-2009], Alvar Aalto University (Finland) [2010], ECA-University Sao Paulo (Brazil) [2008-2010], Göteborgs Universiteit (Sweden) [2009], Aland (Finland) [2008], LOA-CNR (Italy) [2009-2010], TKK (Finland) [2008], Coimbra University (Portugal) [2009], Piura University (Peru) [2008-2009], Reykiavik University (Iceland) [2010], Thessalonika University (Greece) [2009], Universidad Técnica Federico Santamaría (Chile) [2008], and Warsaw University of Technology (Poland) [2009].

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