IN PARTNERSHIP WITH:
CNRS

Institut polytechnique de Grenoble

Université Pierre Mendes-France (Grenoble)

Université Joseph Fourier (Grenoble)

Activity Report 2012

Project-Team EXMO

Computer mediated exchange of structured knowledge

IN COLLABORATION WITH: Laboratoire d'Informatique de Grenoble (LIG)

RESEARCH CENTER
Grenoble - Rhône-Alpes

THEME
Knowledge and Data Representation and Management

Table of contents

Project-Team EXMO

Keywords: Ontology Matching, Semantic Web, Knowledge Representation, Artificial Intelligence, Ambient Computing

Beginning of the Team: 2003-07-01, End of the Team: 2013-01-31.

1. Members

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Faculty Member
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Armen Inants [since December 1st]
Tatiana Lesnikova [Université Joseph-Fourier, since October 1st]
Melisachew Wudage Chekol [co-supervised with WAM]

Post-Doctoral Fellows
Jose Luis Aguirre Cervantes [FP7 SEALS, until October 31st]
Manuel Atencia [Université Joseph-Fourier (with Hadas team)]
Cássia Trojahn dos Santos [FP7 SEALS, until February 29th]

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2. Overall Objectives

2.1. General Objectives

We assume that expressing formalised knowledge on a computer is useful, not especially for the need of the computer, but for communication. In future information systems, formalised knowledge will be massively exchanged. EXMO's goal is the development of theoretical and software tools for enabling interoperability in formalised knowledge exchange. EXMO contributes to an emerging field called the semantic web which blends the communication capabilities of the web with knowledge representation.

There is no reason why knowledge should be expressed in a single format or by reference to a single vocabulary (or ontology). In order to interoperate, these representations will have to be matched and transformed. Moreover, in the communication process computers can add value to their memory and medium role by formatting, filtering, classifying, consistency checking or generalising knowledge.

We currently build on our experience of alignments as representing the relationships between two ontologies on the semantic web.

Ontology alignments express correspondences between entities in two ontologies. They allow maximising sharing on the semantic web: various algorithms can produce alignments and various uses can be made of these alignments. Such alignments can be used for generating knowledge transformations (or any other kind of mediators) that will be used for interoperating. In order to guarantee properties of these transformations, we consider the properties of alignments and generate transformations preserving them.

Our current roadmap focusses on the design of an alignment infrastructure and on the investigation of alignment properties (and especially semantic properties) when they are used for reconciling ontologies.

On a longer term, we want to explore "semiotic" properties, i.e., properties which concern the interpretation of the communicated representation by a human user. This goal should require an analysis of the extra-semantic rules that govern the choice of subsets of models.

Anticipated applications are in transformation system engineering (in which the information system is seen as a transformation flow) and semantic web infrastructure.

3. Scientific Foundations

3.1. Knowledge representation semantics

We usually work with semantically defined knowledge representation languages (like description logics [28], conceptual graphs and object-based languages). Their semantics is usually defined within model theory initially developed for logics. The languages dedicated to the semantic web (RDF and OWL) follow that approach. RDF is a knowledge representation language dedicated to the annotation of resources within the framework of the semantic web. OWL is designed for expressing ontologies: it describes concepts and relations that can be used within RDF.

We consider a language L as a set of syntactically defined expressions (often inductively defined by applying constructors over other expressions). A representation ($o \subseteq L$) is a set of such expressions. It is also called an ontology. An interpretation function (I) is inductively defined over the structure of the language to a structure called interpretation domain (D). This expresses the construction of the “meaning” of an expression in function of its components. A formula is satisfied by an interpretation if it fulfills a condition (in general being interpreted over a particular subset of the domain). A model of a set of expressions is an interpretation satisfying all these expressions. An expression (δ) is then a consequence of a set of expressions (o) if it is satisfied by all of their models (noted $o \models \delta$).

A computer must determine if a particular expression (taken as a query, for instance) is the consequence of a set of axioms (a knowledge base). For that purpose, it uses programs, called provers, that can be based on the processing of a set of inference rules, on the construction of models or on procedural programming. These programs are able to deduce theorems (noted $o \vdash \delta$). They are said to be sound if they only find theorems which are indeed consequences and to be complete if they find all the consequences as theorems. However, depending on the language and its semantics, the decidability, i.e., the ability to create sound and complete provers, is not warranted. Even for decidable languages, the algorithmic complexity of provers may prohibit their exploitation.

To solve this problem a trade-off between the expressivity of the language and the complexity of its provers has to be found. These considerations have led to the definition of languages with limited complexity – like conceptual graphs and object-based representations – or of modular families of languages with associated modular prover algorithms – like description logics.

EXMO mainly considers languages with well-defined semantics (such as RDF and OWL that we contributed to define), and defines the semantics of some languages such as multimedia specification languages and alignment languages, in order to establish the properties of computer manipulations of the representations.

3.2. Ontology alignments

When different representations are used, it is necessary to identify their correspondences. This task is called ontology matching and its result is an alignment. It can be described as follows: given two ontologies, each describing a set of discrete entities (which can be classes, properties, rules, predicates, etc.), find the relationships, e.g., equivalence or subsumption, if any, that hold between these entities.

An alignment between two ontologies o and o' is a set of correspondences $\langle e, e', r\rangle$ in which:

- e and e' are the entities between which a relation is asserted by the correspondence, e.g., formulas, terms, classes, individuals;
- r is the relation asserted to hold between e and e'. This relation can be any relation applying to these entities, e.g., equivalence, subsumption.

In addition, a correspondence may support various types of metadata, in particular measures of the confidence in a correspodence.

Given the semantics of the two ontologies provided by their consequence relation, we define an interpretation of two aligned ontologies as a pair of interpretations $\langle m, m'\rangle$, one for each ontology. Such a pair of interpretations is a model of the aligned ontologies o and o' if and only if each respective interpretation is a model of the ontology and they satisfy all correspondences of the alignment.

This definition is extended to networks of ontologies: a set of ontologies and associated alignments. A model of such an ontology network is a tuple of local models such that each alignment is valid for the models involved in the tuple. In such a system, alignments play the role of model filters which will select the local models which are compatible with all alignments.

So, given an ontology network, it is possible to interpret it. However, given a set of ontologies, it is necessary to find the alignments between them and the semantics does not tell which ones they are. Ontology matching aims at finding these alignments. A variety of methods is used for this task. They perform pairwise comparisons of entities from each of the ontologies and select the most similar pairs. Most matching algorithms provide correspondences between named entities, more rarely between compound terms. The relationships are generally equivalence between these entities. Some systems are able to provide subsumption relations as well as other relations in the support language (like incompatibility or instanciation). Confidence measures are usually given a value between 0 and 1 and are used for expressing preferences between two correspondences.

4. Application Domains

4.1. Application Domains

The main application context motivating our work is the "semantic web" infrastructure (§4.1.1), but it can be applied in any context where semantic technologies are used: semantic social networks, ambient intelligence, linked data, etc. [2].

4.1.1. Semantic web technologies

Internet technologies support organisations and people in accessing and sharing knowledge, often difficult to access in a documentary form. However, these technologies quickly reach their limits: web site organisation is expensive and full-text search inefficient. Content-based information search is becoming a necessity. Content representation will enable computers to manipulate knowledge on a more formal ground and to carry out similarity or generality search. Knowledge representation formalisms are good candidates for expressing content.

The vision of a "semantic web" [29] supplies the web, as we know it (informal) with annotations expressed in a machine-processible form and linked together. In the context where web documents are formally annotated, it becomes necessary to import and manipulate annotations according to their semantics and their use. Taking advantage of this semantic web will require the manipulation of various knowledge representation formats. Exmo concerns are thus central to the semantic web implementation. Our work aims at enhancing content understanding, including the intelligibility of communicated knowledge and formal knowledge transformations.

In addition, Exmo also considers a more specific use of semantic web technologies in semantic peer-to-peer systems, social semantic networks and ambient intelligence (see §6.3). In short, we would like to bring the semantic web to everyone's pocket. Semantic peer-to-peer systems are made of a distributed network of independent peers which share local resources annotated semantically and locally. This means that each peer can use its own ontology for annotating resources and these ontologies have to be confronted before peers can communicate. In social semantic networks, relationships between people are infered from relationships between knowledge they use. In ambient intelligence, applications have to reconcile device and sensor descriptions provided by independent sources.

Exmo's work can be implemented in software: in particular, we have developed an API for expressing ontology alignment (§5.1) and a library of ontology distances and similarities OntoSim (§5.2).

5. Software

5.1. Alignment API

We have designed a format for expressing alignments in a uniform way [1]. The goal of this format is to be able to share available alignments on the web. It should help systems using alignments, e.g., mediators, translators, to take advantage of any alignment algorithm and it will help alignment algorithms to be used in many different tasks. This format is expressed in RDF, so it is freely extensible, and has been defined by a DTD (Document Type Description for RDF/XML), an OWL ontology and an RDF Schema.

The API itself [1] is a JAVA description of tools for accessing the common format. It defines five main interfaces (OntologyNetwork, Alignment, Cell, Relation and Evaluator) and proposes the following services:

- Storing, finding, and sharing alignments;
- Piping matching algorithms (improving an existing alignment);
- Manipulating alignments (thresholding and hardening);
- Generating processing output (transformations, axioms, rules);
- Comparing alignments.

We provide an implementation for this API which can be used for producing transformations, rules or bridge axioms independently from the algorithm which produced the alignment. The proposed implementation features:

- a base implementation of the interfaces with all useful facilities;
- a library of sample matchers;
- a library of renderers (XSLT, SWRL, OWL, C-OWL, SEKT mapping language, SPARQL);
- a library of evaluators (various generalisation of precision/recall, precision/recall graphs);
- a flexible test generation framework which allows for generating evaluation datasets;
- a library of wrapper for several ontology API;
- a parser for the format.

To instanciate the API, it is sufficient to refine the base implementation by implementing the `align()` method. Doing so, the new implementation will benefit from all the services already implemented in the base implementation.

We have developed on top of the Alignment API an Alignment server that can be used by remote clients for matching ontologies and for storing and sharing alignments. It is developed as an extensible platform which allows to plug-in new interfaces. The Alignment server can be accessed through HTML, web service (SOAP and REST) and agent communication interfaces.

The Alignment API is used in the Ontology Alignment Evaluation Initiative data and result processing (§6.1.1). It is also used by more than 30 other teams worldwide.

The Alignment API is freely available since december 2003, under the LGPL licence, at http://alignapi.gforge.inria.fr.

5.2. The OntoSim library

OntoSim is a library offering similarity and distance measures between ontology entities as well as between ontologies themselves. It materialises our work towards better ontology proximity measures.

There are many reasons for measuring a distance between ontologies. For example, in semantic social networks, when a peer looks for a particular information, it could be more appropriate to send queries to peers having closer ontologies because it will be easier to translate them and it is more likely that such a peer has the information of interest [12]. OntoSim provides a framework for designing various kinds of similarities. In particular, we differentiate similarities in the ontology space from those in the alignment space. The latter ones make use of available alignments in an ontology network while the former only rely on ontology data. OntoSim is provided with 4 entity measures which can be combined using various aggregation schemes (average linkage, Hausdorff, maximum weight coupling, etc.), 2 kinds of vector space measures (boolean and TF.IDF), and 4 alignment space measures. It also features original comparison methods such as agreement/disagreement measures. In addition, the framework embeds external similarity libraries which can be combined to our own.

OntoSim is based on an ontology interface allowing for using ontology parsed with different APIs.

OntoSim is written in Java and is available, under the LGPL licence, at http://ontosim.gforge.inria.fr.

In the continuation of our previous work, in 2012, we developed our work on evaluation of ontology matching and especially in running new experiments and generating new tests (§6.1.1). We introduced a new semantics for weighted correspondences (§6.1.2). We also continued our work on ontology matching for linking data (§6.2) and the use of the μ-calculus for evaluating RDF path queries (§6.3.1).

6. New Results

6.1. Ontology matching and alignments

We pursue our work on ontology matching and alignment support with contributions to evaluation and alignment semantics.

6.1.1. Evaluation

Evaluation of ontology matching algorithms requires to confront them with test ontologies and to compare the results. Since 2004, we run the Ontology Alignment Evaluation Initiative (OAEI) which organises evaluation campaigns for assessing the degree of achievement of actual ontology matching algorithms [2].

This year, we ran two evaluation campaigns named 2011.5 and 2012. This was justified by the will to complete full evaluations using the support of the SEALS platform. Hence, the main activities carried out in 2012 were related to the automation of the evaluation. This involved providing participants with a better way to bundle their tools so that they can be evaluated both offline and within the SEALS platform. It also required to support more organisers to provide test case within the plaform.

This work has been used in the OAEI 2012 evaluation campaign. OAEI 2012 offered 9 different test sets (7 of which under the SEALS platform). This issue brought the following results:

- More participants than ever (21);
- All ontology matchers running on the SEALS platform (18);
- Increased performances in terms of precision and recall;
- Matchers are now very scalable and can deal with the largest available ontologies (9 systems able to deal with the very large medical ontology SnoMed);

We have also introduced as a data set, the benchmark for multilingual ontology matching developed last year [6]. It has pushed matcher developers to address multilingual issues.

The participating systems and evaluation results were presented in the 7th Ontology Matching workshop, that was held in Boston, MA, US [22], [7]. More information on OAEI can be found at http://oaei.ontologymatching.org/.

6.1.2. Semantics for weighted correspondences

Alignment correspondences are often assigned a weight or confidence factor by matchers. Nonetheless, few semantic accounts have been given so far for such weights. We have proposed a formal semantics for weighted correspondences between different ontologies. It is based on a classificational interpretation of correspondences: if o and o' are two ontologies used to classify a common set X, then alignments between o and o' are interpreted as encoding how elements of X classified in the concepts of o are re-classified in the concepts of o', and weights are interpreted as measures of how precise and complete re-classifications are. This semantics is justifiable for extensional matchers. We have proven that it is a conservative extension of a semantics of absolute correspondences, and we have provided properties that relate correspondence entailment with description logic constructors [8].

This work has been made in cooperation with Alexander Borgida (Rutgers University) and Chiara Ghidini and Luciano Serafini (Fondazione Bruno Kessler).

6.2. Data interlinking

The web of data uses semantic web technologies to publish data on the web in such a way that they can be interpreted and connected together. It is thus critical to be able to establish links between these data, both for the web of data and for the semantic web that it contributes to feed.

6.2.1. Keys and pseudo-keys detection for web datasets cleansing and interlinking

We have proposed a method for analysing web datasets based on key dependencies. For this purpose, we have adapted the classical notion of a key in relational databases to the case of RDF datasets [9], [16]. In order to better deal with web data of variable quality, we have introduced the definition of a pseudo-key. We have also provided an RDF vocabulary for representing keys and pseudo-keys and designed and implemented an algorithm for discovering them. Experimental results show that, even for a large dataset such as DBpedia, the runtime of the algorithm is still reasonable. We are currently working on two applications: data cleansing, i.e., detection of errors in RDF datasets and recovery, and datasets interlinking.

The algorithm is publicly available at https://gforge.inria.fr/projects/melinda/.

6.2.2. Data interlinking from expressive alignments

In the context of the DATALIFT project (see §7.1.1), we are developing a data interlinking module. Based on our analysis of the relationships between ontology matching and data interlinking [15], our goal is to generate data interlinking scripts from ontology alignments. For that purpose, we have integrated existing technologies within the DATALIFT platform: the Alignment API, for taking advantage of the EDOAL language and SILK, developed by Frei Universtität Berlin, for processing linking scripts. So far, we have generated SILK script from ontology alignments in order to produce links.

This work is part of the PhD of Zhengjie Fan, co-supervised with François Scharffe (LIRMM).

6.3. Ontology networks

Dealing with the semantic web, we are interested in ontology networks, i.e., sets of distributed ontologies that have to work together. One way for these systems to interact consists of exchanging queries and answers. For that reason, we pay particular attention to query systems.

6.3.1. Path queries and μ-calculus

Querying the semantic web is mainly done through the SPARQL language [18]. We designed one of its extensions, PSPARQL (Path SPARQL) which provides queries with paths of arbitrary length. We continue this work by connecting it to the work of the WAM team on static analysis of XPATH expressions. More specifically, we consdider query contrainment, i.e., determining whether, for any graph, the answers to a query are contained in those of another query. This is achieved by reducing this problem to satisfiability in the μ-calculus. In this work, RDF graphs are considered as transition systems and important fragments of RDFS and SPARQL as propositional μ-calculus formulas. It is then possible to use solvers of this logic to test query containment of SPARQL queries under RDFS and OWL schema constraints [11], with paths or under particular entailment regimes [10]. We have also implemented the proposed techniques and provided a first benchmark for query containment available under http://sparql-qc-bench.inrialpes.fr.

This work is part of the PhD of Melisachew Wudage Chekol [4], co-supervised with Nabil Layaïda (WAM).

7. Partnerships and Cooperations

7.1. National Initiatives

7.1.1. ANR Datalift

Program: ANT-ContInt

Project acronym: Datalift

Project title: Datalift

Instrument: platform

Duration: September 2010 - March 2014

Coordinator: INRIA Exmo/François Scharffe

See also: http://www.datalift.org

Abstract: EXMO coordinates with LIRMM the DATALIFT project whose goal is to produce a platform for publishing governmental data as linked data [17]. EXMO is particularly involved in the generation of links between datasets (see §6.2).

7.2. European Initiatives

7.2.1. FP7 SEALS

Title: Semantic Evaluation At Large Scale

Type: CAPACITIES (Infrastructures)

Defi: Scientific Data Infrastructure

Instrument: Combination of COLLABORATIVE PROJECTS and COORDINATION and SUPPORT ACTIONS (CPCSA)

Duration: June 2009 - June 2012

Coordinator: Universidad Politecnica de Madrid (ES)

See also: http://seals-project.eu

Abstract:

EXMO is a partner of the SEALS European commission infrastructure project whose goal is to provide the infrastructure for evaluating semantic technologies. Jérôme Euzenat has been vice-coordinator in charge of the research area.

More particularly, EXMO has been in charge of providing an infrastructure for evaluating ontology matching systems and algorithms, to be aggregated in the SEALS platform. This task involves:

- designing evaluation campaigns, including identifying criteria, metrics, datasets, and tools to be used in each campaign,
- designing and implementing services for automatic evaluation of systems and algorithms,
- analysing the results of evaluation campaigns and using them to produce detailed reports on both the effectiveness of the testing methodologies, and the systems that have been tested.

This year we have prepared the second SEALS evaluation campaign and designed a fully automated evaluation process (see §6.1.1).

7.3. International Research Visitors

7.3.1. Visits of International Scientists

Riccardo Albertoni (Universidad Politecnica de Madrid) visited EXMO from October 15th to October 22nd, 2012 working on similarity measures and their application to linked data.

Alexander Borgida (Rutgers University) visited EXMO from April 29th to May 11th, 2012 mostly working on weighted alignment semantics.

Jorge Gracia (Universidad Politecnica de Madrid) visited EXMO from June 4th to July 3rd, 2012, working more particularly on multilingual ontology/instance matching;

Daniel Vila (Universidad Politecnica de Madrid) visited EXMO from April 23rd to July 23rd, 2012 working on data interlinking and multilingual instance matching.

7.3.2. Internships

Thinh Dong (2nd year master «Master Informatique: Fondements et Ingénierie» option «Knowledge Information System», U. Nice Sophia-Antipolis, 2012) on «Query generation from expressive ontology alignments».

8. Dissemination

8.1. Scientific Animation

- Jérôme Euzenat is founding member of the "Semantic Web Science Association" (steering committee for the ISWC conference series).
- Editorial board of *Journal of Web Semantics*, *Journal on Data Semantics* and *Semantic web journal* (Jérôme Euzenat).
- Jérôme David has been tutorial chair (with Irwin King) of the 21st International Worl Wide Web Conference (WWW).
- Jérôme Euzenat have been co-chairman (with Manfred Hauswirth and Josie Xavier Perreira) of the “Experiment and evaluation” track of the 11th “International Semantic Web Conference” (ISWC, Boston, MA US), 2012
- Jérôme Euzenat has been programme committee member for the 2012 issues of the conferences International Semantic Web Conference (ISWC), Worldwide Web Conference (WWW), National Conference on Artificial Intelligence (AAAI) International conference on Knowledge Engineering and Knowledge Management (EKAW), Formal Ontologies for Information Systems (FOIS), International Conference on Conceptual Modelling (ER).
- Jérôme David has been programme committee member of the International Conference on Mobile Web Information Systems (MobiWIS) 2012.

- Jérôme David has been programme committee member for the 2012 issues of the Ontology matching workshop (OM), Artificial Intelligence meets the Web of Data workshop (AImWD) and Downscaling the Semantic Web workshop (Downscale).
- Cassia Trojahn has been programme committee member for the 2nd International Workshop on Evaluation of Semantic Technologies (IWEST) and the 7th International Workshop on Ontology Matching (OM).
- Jérôme Euzenat has also been programme committee member for the ESWC international workshop on the "evaluation of semantic technologies (iWEST)", IJCAR workshop on "OWL reasoner evaluation", ECAI workshop on "Cooking with computers", ECAI workshop on "Artificial intelligence meets the web of data", ISWC workshop on "Knowledge evolution and ontology dynamics" (EvoDyn).
- Jérôme Euzenat has organised (with Pavel Shvaiko, Anastasios Kementsietsidis, Ming Mao, Natasha Noy and Heiner Stuckenschmidt) the 7th "Ontology matching" workshop of the 11th ISWC, Boston (MA US), 2012 [22].
- Jose Luis Aguirre, Jérôme Euzenat and Cássia Trojahn dos Santos have organised (with many other colleagues) the Ontology Alignment Evaluation Initiative 2012 at the "Ontology matching" workshop of the 11th ISWC, Berlin (MA US), 2012 [7].
- Cassia Trojahn dos Santos has organised the SEALS meeting welcoming 20 people for four days in Grenoble.
- Jérôme Euzenat has been consulted by the ISO OntoIOP working group (ISO/TC 37/SC 3 "Systems to manage terminology, knowledge and content") on alignment formats (2012).
- Invited conference on "The web of data as an AI playground", ECAI "AI and linked data" workshop, Montpellier (FR), 27/08/2012 (Jérôme Euzenat)
- Invited conference on "Distributed and dynamic knowledge for real", OntoBras conference, Recife (BR), 21/09/2012 (Jérôme Euzenat)
- Seminar on "Linked data from your pocket: The Android RDFContentProvider", Prague University of Economics, Prague (CZ), 11/12/2012 (Jérôme David)
- Seminar on "Ontology alignment metadata", Open ontology repository metadata workshop, Conference call, 24/04/2012 (Jérôme Euzenat)
- Seminar on "What you say is what I get; what you don't say is what I don't get", Dagstuhl seminar on «Cognitive approaches to the semantic web», Wadern (DE), 30/05/2012 (Jérôme Euzenat)
- Seminar on "Quelques questions sur les réseaux d'ontologies", Limos seminar, Clermont-Ferrand (FR), 14/06/20122 (Jérôme Euzenat)

8.2. Teaching - Supervision - Juries

8.2.1. Teaching

Licence: Jérôme David, Outils Informatique (c2i), 18, L1, UPMF, France

Licence: Jérôme David, Développement Mobile, 25, L3, UPMF, France

Licence: Jérôme David, Introduction à Java, 24, L3, UPMF, France

Licence: Jérôme David, Programmation Avancée, 20, L3, UPMF, France

Licence: Jérôme David, Introduction aux bases de données relationnelles, 8, L2, UPMF, France

Master: Jérôme David, Programmation Java 2, 30, M1-M2, UPMF, France

Master: Jérôme David, JavaEE, 30, niveau M2, UPMF, France

Master: Jérôme David, Développement Web Mobile, 30, M2, UPMF, France

Master: Jérôme David, Interface Homme Machine 2, 30, M2, UPMF, France

Master: Jérôme Euzenat, Semantic web: from XML to OWL, 27heqTD, M2R, Université Joseph Fourier & INPG, France

Post-graduate level: Jérôme Euzenat, Ontology matching, 4heqTD, European Summer School on Ontology Engineering and the Semantic Web, Spain

8.2.2. Supervision

PhD: Melisachew Wudage Chekol, Static analysis of semantic web queries [4], Université de Grenoble, 19/12/2012, supervisors: Jérôme Euzenat and Nabil Layaida

PhD in progress: Zhengjie Fan, Ontology-based data interlinking, 1/1/2011,supervisors: Jérôme Euzenat and François Scharffe

PhD in progress: Tatiana Lesnikova, Mulitilingual data interlinking, 1/10/2012, supervisors: Jérôme Euzenat and Jérôme David

PhD in progress: Armen Inants, Ontology alignment algebra, 1/12/2012, supervisor: Jérôme Euzenat

8.2.3. Juries

- PhD: David Rouquet, Multilinguisation d'ontologies dans le cadre de la recherche d'information translingue dans les collections d'images accompagnées de textes spontanés, Université de Grenoble, 6/4/2012, Valérie Bellynck and Christian Boitet
- PhD: Nathalie Abadie, Formalisation, acquisition et mise en œuvre de connaissances pour l'intégration virtuelle de bases de données géographiques: les spécifications au cœur du processus d'intégration, Université Paris-Est, 20/11/2012, Anne Ruas and Sébastien Mustière
- PhD: Anna Tordai, On combining alignment techniques, Vrije Universiteit Amsterdam, 2/12/2012, Guus Schreiber and Bob Wieliga
- PhD: Duy Hoa Ngo, Enhancing Ontology Matching Quality By Using Machine Learning, Graph Matching And Information Retrieval Techniques, Université de Montpellier 2, 14/12/2012, Zohra Bellahsène

8.3. Popularization

- Jérôme Euzenat gave a presentation on *Library resources and the web of data: the missing link* at the Millenium club (group of librarians) days, Montbonnot (FR), 28/03/2012.
- Jérôme Euzenat coordinated of the INTech technology watch seminar on *L'ouverture des données: technologies et usages (Open data: technology and use)*, 7 presentations, 12 demonstrations, 80 participants, Montbonnot, 5/6/2012.
- Jérôme Euzenat has been interviewed by Françoise Breton, "l'émergence d'un web des connaissances", published on the INRIA Grenoble Rhône-Alpes web site[1], 25/09/2012.

9. Bibliography

Major publications by the team in recent years

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[3] JÉRÔME. EUZENAT, PAVEL. SHVAIKO. *Ontology matching*, Springer-Verlag, Heidelberg (DE), 2007, http://book.ontologymatching.org.

Publications of the year

Doctoral Dissertations and Habilitation Theses

[4] MELISACHEW WUDAGE. CHEKOL. *Static analysis of semantic web queries*, Université de Grenoble, Grenoble (FR), 2012.

Articles in International Peer-Reviewed Journal

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