IN PARTNERSHIP WITH:
CNRS

Institut polytechnique de Grenoble

Université Joseph Fourier (Grenoble)

Université Pierre Mendes-France (Grenoble)

Activity Report 2015

Project-Team EXMO

Computer mediated exchange of structured knowledge

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

RESEARCH CENTER
Grenoble - Rhône-Alpes

THEME
Data and Knowledge Representation and Processing

Table of contents

Project-Team EXMO

Creation of the Project-Team: 2003 July 01

Keywords:

Computer Science and Digital Science:

3.1.7. - Open data
3.2.2. - Knowledge extraction, cleaning
3.2.4. - Semantic Web
3.2.5. - Ontologies
8.1. - Knowledge

Other Research Topics and Application Domains:

6.3.1. - Web
8.1.1. - Energy for smart buildings
9.7. - Knowledge dissemination
9.7.2. - Open data

1. Members

Research Scientist
Jérôme Euzenat [Team leader, Inria, Senior Researcher, HdR]

Faculty Members
Manuel Atencia Arcas [Univ. Grenoble II, Associate Professor]
Jérôme David [Univ. Grenoble II, Associate Professor]

Engineer
Nicolas Guillouet [Inria]

PhD Students
Armen Inants [Inria]
Tatiana Lesnikova [Univ. Grenoble I, then Inria]
Adam Sanchez Ayte [Inria, granted by ANR Lindicle project]

Administrative Assistant
Marion Ponsot [Inria]

2. Overall Objectives

2.1. General Objectives

The semantic web blends the communication capabilities of the web with knowledge representation. Expressing formalised knowledge on a computer is useful, not exclusively for the need of the computer, but for communication. The goal of EXMO is the development of theoretical, experimental and software tools for communicating formalised knowledge.

There is no reason why knowledge expressed on the web should be in a single format or by reference to a single vocabulary (or ontology). In order to interoperate, the representations have to be matched and transformed. We currently build on our experience of alignments as representing the relationships between ontologies. Such alignments may be used for generating knowledge transformations (or any other kind of mediators) used for interoperating or interlinking data. We focus on the design of an alignment infrastructure and on the investigation of alignment properties when they are used for reconciling ontologies or interlinking data.

On a longer term, we study how a semantic web made of interrelated ontologies and datasets evolves and structures itself depending on its use. In particular, we aim at understanding how it influences and is influenced by its use in interpersonal communication.

EXMO's work is naturally applied in all contexts in which ontologies are used for expressing knowledge that has to be communicated. It is more directly focussed on the infrastructure of the semantic web and the web of data.

3. Research Program

3.1. Knowledge representation semantics

We work with semantically defined knowledge representation languages (like description logics, 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 description of resources; 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 the SPARQL query language and alignment languages, in order to establish the properties of computer manipulations of the representations.

3.2. Ontology matching and 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 [4]. 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, if any, holding between these entities.

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

- 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 correspondence.

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 collection 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 select the local models that 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 instantiation). Confidence measures are usually given a value between 0 and 1 and are used for expressing preferences between two correspondences.

3.3. Data interlinking

Links are important for the publication of RDF data on the web. We call data interlinking the process of generating links identifying the same resource described in two data sets. Data interlinking parallels ontology matching: from two datasets (d and d') it generates a set of links (also called a link set, L).

We have extended the notion of database keys in a way which is more adapted to the context of description logics and the openness of the semantic web. We have introduced the notion of a link key [4], [1] which is a combination of such keys with alignments. More precisely, a link key is a structure $\langle K^{eq}, K^{in}, C\rangle$ such that:

- K^{eq} is a set of pairs of property expressions;
- K^{in} is a set of pairs of property expressions;
- C is a correspondence between classes.

Such a link key holds if and only if for any pair of resources belonging to the classes in correspondence such that the values of their property in K^{eq} are pairwise equal and the values of those in K^{in} pairwise intersect, the resources are the same.

As can be seen, link key validity is only relying on pairs of objects in two different data sets. We further qualify link keys as weak, plain and strong depending on them satisfying further constraints: a weak link key is only valid on pairs of individuals of different data sets, a plain link key has to apply in addition to pairs of individuals of the same data set as soon as one of them is identified with another individual of the other data set, a strong link key is a link key which is also a key for each data set, it can be though of as a link key which is made of two keys.

Link keys can then be used for finding equal individuals across two data sets and generating the corresponding owl:sameAs links.

4. Application Domains

4.1. Semantic web technologies

The main application context motivating our work is the "semantic web" infrastructure.

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 enables 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" [21] complements the web, with formal knowledge representation spanning across sites. Taking advantage of this semantic web requires 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 considers more specific uses of semantic web technologies in wider context (typically in the smart city context, §9.2.1.1).

5. Highlights of the Year

5.1. Highlights of the Year

Our work on alignment revision (§7.3.2) has been published in *Artificial intelligence* [7].

6. New Software and Platforms

6.1. Alignment API

Participants: Jérôme Euzenat [Correspondent], Jérôme David, Nicolas Guillouet, Armen Inants.

We have designed a format for expressing alignments in a uniform way [2]. The goal of this format is to share available alignments on the web. It should help systems using alignments, e.g., mediators, translators, to take advantage of any matching algorithm and it will help matching algorithms to be used in many different tasks. This format is expressed in RDF, so it is freely extensible.

The API itself [2] is a JAVA description of tools for accessing the common format. It defines five main interfaces (OntologyNetwork, Alignment, Cell, Relation and Evaluator).

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 algebras of relations;
- a library of sample matchers;
- a library of renderers (XSLT, RDF, SKOS, SWRL, OWL, C-OWL, 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 wrappers 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.

In 2015, we further integrated the implementation of link keys and their transformations into SPARQL queries (§3.3). We developed the transformation aspect of the EDOAL language. Finally, we provided the interface with alignment algebras into the API implementation (§7.1.2).

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. It has been used this year in the Ready4SmartCities project (§9.2.1.1) [14], [20].

The Alignment API is used in the Ontology Alignment Evaluation Initiative data and result processing (§7.1.1). It is also used by more than 50 other teams worldwide.

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

6.2. The OntoSim library

Participants: Jérôme David [Correspondent], Jérôme Euzenat.

OntoSim is an API 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 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. OntoSim provides a framework for designing various kinds of similarities. In particular, we distinguish similarities in the ontology space from those in the alignment space. The latter ones use 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 TFIDF), 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.

In 2015, OntoSim only supported a maintenance upgrade.

OntoSim is based on an ontology interface allowing for using ontology parsed with different APIs. It is written in JAVA and is available, under the LGPL licence, at http://ontosim.gforge.inria.fr.

7. New Results

7.1. Ontology matching and alignments

We pursue our work on ontology matching and alignment support [4] with contributions to evaluation and the use of algebras of relations within alignments.

7.1.1. Evaluation

Participant: Jérôme Euzenat [Correspondent].

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 [3].

This year, we also handed out the organisation of OAEI 2015 to Ernesto Jiménez Ruiz (University of Oxford). We used again our generator for generating new version of benchmarks. The Alignment API was used for manipulating alignments and evaluating results [8].

The participating systems and evaluation results were presented in the 10th Ontology Matching workshop [13], held Bethleem (PA US). More information on OAEI can be found at http://oaei.ontologymatching.org/.

7.1.2. Algebras of alignment relations

Participants: Armen Inants [Correspondent], Jérôme Euzenat.

Qualitative calculi are central in qualitative binary constraint satisfaction problems. All formalisms developed so far are homogeneous – they assume a single universe. We had previously shown the advantages of using a homogeneous qualitative calculus for expressing ontology alignment relations between concepts.

They make it possible to aggregate alignments disjunctively or conjunctively and to propagate alignments within a network of ontologies. The previously considered algebra of relations contains taxonomical relations between classes only. We have tackled the problem of combining two or more calculi over disjoint universes into a single calculus [9]. The problem is important because ontology matching deals with various kinds of ontological entities: concepts, individuals, properties. We have designed an algorithm for combining two homogeneous calculi with different universes into a single calculus. This has been applied to alignment relations [9] combining algebras for relations between concepts and individuals. It is, first, able to deal with empty classes, and, second, incorporates all qualitative taxonomical relations that occur between individuals and concepts, including the relations "is a" and "is not". We have proved that this algebra is coherent with respect to the simple semantics of alignments.

The proposed algebras of relations and others have been integrated within the Alignment API (§6.1).

This work is part of the PhD of Armen Inants.

7.2. 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 important 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. We consider this problem from different perspectives.

7.2.1. Interlinking cross-lingual RDF data sets

Participants: Tatiana Lesnikova [Correspondent], Jérôme David, Jérôme Euzenat.

RDF data sets are being published with labels that may be expressed in different languages. Even systems based on graph structure, ultimately rely on anchors based on language fragments. In this context, data interlinking requires specific approaches in order to tackle cross-lingualism. We proposed a general framework for interlinking RDF data in different languages and implemented two approaches: one approach is based on machine translation, the other one takes advantage of multilingual references, such as BabelNet. This year we investigated the second approach [10], finding that results were not as good as the translation approach. We also conducted evaluations on TheSoz, Agrovoc and Eurovoc thesauri.

This work is part of the PhD of Tatiana Lesnikova developed in the LINDICLE project (§9.1.1).

7.2.2. An iterative import-by-query approach to data interlinking

Participant: Manuel Atencia Arcas [Correspondent].

We modelled the problem of data interlinking as a reasoning problem on possibly decentralised data. We described an import-by-query algorithm that alternates steps of sub-query rewriting and of tailored querying of data sources [11]. It only imports data as specific as possible for inferring or contradicting target owl:sameAs assertions. Experiments conducted on a real-world dataset have demonstrated in practice the feasibility and usefulness of this approach for data interlinking and disambiguation purposes.

Additionally, and in line with the problem of dealing with uncertainty in linked data, we have proposed a probabilistic mechanism of trust that allow peers in a semantic peer-to-peer network to select the peers that are better suited to answer their queries, when query reformulation based on alignments may be unsatisfactory due to unsoundness or incompleteness of alignments [5].

This work was carried out in collaboration with Mustafa Al-Bakri and Marie-Christine Rousset (LIG).

7.2.3. Link key extraction

Participants: Jérôme David [Correspondent], Manuel Atencia Arcas, Jérôme Euzenat.

Ontologies do not necessarily come with key descriptions, and never with link key assertions (§3.3). Keys can be extracted from data by assuming that keys holding for specific data sets, may hold universally.

Following the work of last year on link key extraction [1] and the characterisation of the approach in formal concept analysis, we have fully characterised the results of our algorithm as formal concepts. We have also plans for extending both the approach and its formal concept analysis description through (i) applying it to full link keys as described in §3.3, (ii) applying it to join and hierarchical key extraction, and (iii) applying it to hierarchical key extraction.

This work has been developed partly in the LINDICLE project (§9.1.1). Formal concept analysis aspects are considered with Amedeo Napoli (Orpailleur, LORIA).

7.3. Dynamic aspects of networks of ontologies

Huge quantities of data described by ontologies and linked together are made available. These are generated in an independent manner by autonomous providers such as individuals or companies. They are heterogeneous and their joint exploitation requires connecting them.

However, data and knowledge have to evolve facing changes in what they represent, changes in the context in which they are used and connections to new data and knowledge sources. As their production and exchange are growing larger and more connected, their evolution is not anymore compatible with manual curation and maintenance. We work towards their continuous evolution as it is critical to their sustainability.

Two different approaches are currently explored.

7.3.1. Evolution of ontology networks and linked data

Participants: Adam Sanchez Ayte [Correspondent], Jérôme David, Jérôme Euzenat.

We are considering the global evolution of knowledge represented by interdependent ontologies, data, alignments and links. Our goal is to be able to maintain such a structure with respect to the processes which are involved in its construction: logical inference, ontology matching, link key extraction, link generation, etc.

Our initial work is focused on how data and ontology changes cause alignment evolution, in particular when the alignment have been produced through instance-based matching using links between data. In this regard, we are developing techniques for circumscribing the elements and relationships affected by the change as well as evaluating the need for change propagation, i.e, most of the time a simple change will not trigger link key recomputation (§7.2.3).

This work is part of the PhD thesis of Adam Sanchez Ayte developed in the LINDICLE project (§9.1.1).

7.3.2. Revision in networks of ontologies

Participant: Jérôme Euzenat [Correspondent].

We reconsidered the belief revision problem in the context of networks of ontologies (§3.2): given a set of ontologies connected by alignments, how to evolve them such that they account for new information. In networks of ontologies, inconsistency may come from two different sources: local inconsistency in a particular ontology or alignment, and global inconsistency between them. Belief revision is well-defined for dealing with ontologies; we have investigated how it can apply to networks of ontologies. We formulated revision postulates for alignments and networks of ontologies based on an abstraction of existing semantics of networks of ontologies. We showed that revision operators cannot be simply based on local revision operators on both ontologies and alignments. We adapted the partial meet revision framework to networks of ontologies and show that it indeed satisfies the revision postulates [7]. Finally, we considered strategies based on network characteristics for designing concrete revision operators.

8. Bilateral Contracts and Grants with Industry

8.1. Collaboration with Meaning engines

EXMO collaborates with the meaning engine start-up company whose goal is to help improve the knowledge of corporate knowledge, e.g., catalogs, costumer data, through linked data principles (the application of semantic web technology for publishing data). Among their prospective costumers are music aggregators as well as banks. We have benefited from the position of Nicolas Guillouet for developing generic connectors based on our Alignment API. They introduce two novel features: using the notion of link keys to identify identical items in a data flow and performing hybrid integration which either identifies or creates objects from the incoming flows. In fact, hybrid integration is a type of knowledge evolution that provides new interesting research problems.

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR Lindicle

Program: ANR-Blanc international 2

Project acronym: LINDICLE

Project title: Linking data in cross-lingual environment

Duration: January 2013 - December 2016

Coordinator: Inria EXMO/Jérôme David

Participants: Jérôme Euzenat, Manuel Atencia Arcas, Jérôme David, Tatiana Lesnikova, Adam Sanchez Ayte, Armen Inants

Other partners: Tsinghua university (CN)

See also: http://lindicle.inrialpes.fr

Abstract: The LINDICLE project investigates multilingual data interlinking between French, English and Chinese data sources (see §7.2).

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

9.2.1.1. Ready4SmartCities

Title: ICT Roadmap and Data Interoperability for Energy Systems in Smart Cities

Programm: FP7

Duration: October 2013 - September 2015

Coordinator: D'Appolonia SPA

Partners:

Aec3 Ltd (United Kingdom)

Ait Austrian Institute of Technology (Austria)

Ethniko Kentro Erevnas Kai Technologikis Anaptyxis (Greece)

Centre Scientifique et Technique Du Batiment (France)

D'appolonia Spa (Italy)

Empirica Gesellschaft für Kommunikations- und Technologie Forschung Mbh (Germany)

Politecnico di Torino (Italy)

Universidad Politecnica de Madrid (Spain)

Teknologian Tutkimuskeskus Vtt (Finland)

Inria contact: Jérôme Euzenat

See also: http://ready4smartcities.eu

READY4SmartCities operates in a European context where other initiatives are currently running in order to create a common approach on Smart Cities, Such initiatives, even if of fundamental importance for the EU, have some relevant gaps not allowing them to fully cover fundamental aspects for Smart Cities, i.e. to define a common data framework allowing full interoperability among different city system, as well as a consistent vision on how ICT can support energy systems in smart cities. Within this context READY4SmartCities cover a unique role thanks to its specific mission of bringing together relevant stakeholders including engineering specialists, ICT software and equipment providers, RES providers, energy companies (including ESCOs – Energy Service Companies), construction sector companies, as well as local and regional authorities. In co-operation with these stakeholders, the aim is to deliver:

A new energy data ecosystem that will accommodate cross-domain data (climatic, occupation, pollution, traffic, activity, etc.) and will allow the exploitation of such data at global scale; by identifying the set of ontologies relevant to energy-efficiency in Smart Cities and the different requirements and guidelines on how to use (publish and interchange) data described according to those ontologies.

An holistic and shared vision, allowing feasible step-by-step action plans for city authorities and other relevant stakeholder groups to develop and use ICT-based solutions for energy system in urban and rural communities towards future Smart Cities, and thus, leading to reduced energy consumption and CO2 emissions.

9.3. International Initiatives

9.3.1. Informal International Partners

EXMO (and other colleagues from Oxford, Trento, Mannheim, Linköping, Milano, Amsterdam, Galway and the Open university) organises yearly the Ontology alignment evaluation initiative (OAEI).

9.3.2. Participation in other international programs

Jérôme Euzenat is benefiting from a special visiting researcher grant from the Brazilian Ciência sem Fronteiras program on "Methodology and algorithms for ontology refinement and matching" (2015-2017). He will be working with the team of Fernanda Baião and Kate Revoredo at the Universidade Federal do Estado do Rio de Janeiro (UNIRIO). Together, we investigate methods for evolving ontologies and alignments which involve users and agents. The goal of the project is to design methods and algorithms for both revising ontologies to represent the evolution of knowledge in a reliable manner and obtaining better quality alignments.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

Kate Revoredo and Fernanda Baião (Federal University of the State of Rio de Janeiro) visited EXMO in May 2015, working on learning alignments to evolve alignments.

9.4.2. Visits to International Teams

9.4.2.1. Research stays abroad

Tatiana Lesnikova and Jérôme Euzenat visited Tsinghua University from March 30 to April 15, 2015 within the LINDICLE project (§9.1.1) on multilingual data interlinking and key extraction.

10. Dissemination

10.1. Promoting Scientific Activities

10.1.1. Scientific events organisation

10.1.1.1. General chair, scientific chair

- Jérôme Euzenat was organiser of the 10th Ontology matching workshop of the 14th ISWC, Bethleem (US), 2015 (with Pavel Shvaiko, Ernesto Jiménez Ruiz, Oktie Hassanzadeh and Michele Cheatham),

10.1.1.2. Member of the organizing committees

- Jérôme David has been member of the organisation committee of the “Web of data summer school”, Saint-Étienne (FR).
- Jérôme Euzenat was part of the Ontology alignment evaluation initiative (OAEI) organising team.

10.1.2. Scientific events selection

10.1.2.1. Member of conference program committees

- Manuel Atencia and Jérôme Euzenat were programme committee members of the “International Joint Conference on Artificial Intelligence (IJCAI)”, 2015.
- Jérôme Euzenat was programme committee member of the 14th “International semantic web conference (ISWC)” 2015.
- Manuel Atencia, Jérôme David and Jérôme Euzenat have been programme committee members for the 12th “European Semantic Web Conference (ESWC)”, 2015.
- Jérôme Euzenat was programme committee member of the “International and Interdisciplinary Conference on Modeling and Using Context (Context)” 2015.
- Jérôme Euzenat was programme committee member of the “Pacific-rim conference on multi-agent systems (PRIMA)”, 2015
- Jérôme Euzenat was programme committee member of the “Brazilian conference on ontological research (OntoBras)”, 2015.
- Jérôme David was programme committee member of the "Semantic Publishing Challenge" (colocated with ESWC 2015) 2015.
- Jérôme David and Jérôme Euzenat were programme committee members of the “knowledge engineering (ingénierie des connaissances)” conference 2015.
- Jérôme David was programme committee member of the 10th “Ontology matching workshop (OM)”, 2015.

10.1.2.2. Reviewer

- Jérôme David and Adam Sanchez-Ayte have been reviewers for the “International Joint Conference on Artificial Intelligence (IJCAI)”, 2015.
- Jérôme David has been a reviewer for the 4th “International semantic web conference (ISWC)” 2015.
- Tatiana Lesnikova has been a reviewer for the 12th “European Semantic Web Conference (ESWC)”, 2015.
- Tatiana Lesnikova and Jérôme Euzenat have been reviewers for the 10th “Language Resources and Evaluation Conference (LREC)”, 2016.

10.1.3. Journal

10.1.3.1. Member of editorial boards

- Jérôme Euzenat is member of the editorial board of *Journal of web semantics* (area editor), *Journal on data semantics* and the *Semantic web journal*.

10.1.3.2. Reviewer - Reviewing activities

- Jérôme David has been reviewer for the *Semantic web journal*.
- Jérôme Euzenat has been reviewer for *Applied ontologies*.
- Jérôme Euzenat has been reviewer for the *ACM transactions on the Web*.

10.1.4. Scientific expertise

- Jérôme Euzenat has been evaluator for European projects (FP7, H5: Smart cities and sustainability communication networks, content and technology), 2015

10.1.5. Research administration

Jérôme Euzenat has been scientific coordinator of the evaluation seminar for the “Data and knowledge representation and processing” theme of Inria, 2015.

10.1.6. Seminars

- Jérôme Euzenat, Data interlinking with link keys, Seminar Tsinghua university, Beijing (CN), 08/04/2015 (oral presentation)
- Jérôme David and Jérôme Euzenat, A link key approach to data interlinking, Seminar Xerox Europe Research centre, Meylan (FR), 23/04/2015 (oral presentation)

10.2. Teaching - Supervision - Juries

10.2.1. Teaching

10.2.1.1. Responsibilities

- Jérôme David has been coordinator, with Benoît Lemaire, of option “Web, Informatique et Connaissance” of Master “Ingénierie de la Cognition, de la Création, et des Apprentissages” (UPMF, UJF & INPG);
- Manuel Atencia and Jérôme David are coordinators of option “Web, Informatique et Connaissance” of Master “Ingénierie de la Cognition, de la Création, et des Apprentissages” (UPMF, UJF & INPG);
- Jérôme Euzenat is, with Éric Gaussier, coordinator of the “AI and the web” option of the M2R in computer science and applied mathematics (UJF & INPG).

10.2.1.2. Courses

Licence: Jérôme David, Algorithmique et programmation par objets, 90h, L2 MASS, UPMF, France

Licence: Manuel Atencia, Introduction aux technologies du Web, 60h, L3 MASS, UPMF, France

Licence: Jérôme David, JavaEE, 25h, Licence Pro. SIL, UPMF, France

Licence: Jérôme David, Introduction à Python, Licence ESSIG, 24h, UPMF, France

Master: Jérôme David, Programmation Java 2, 30h, M1 IC2A, UPMF, France

Master: Jérôme David, Documents XML, 30h, M1 IC2A, UPMF, France

Master: Manuel Atencia, Langages et technologies du Web 1, 30h, M1 IC2A, UPMF, France

Master: Manuel Atencia, Langages et technologies du Web 2, 30h, M1 IC2A, UPMF, France

Master: Jérôme David, JavaEE, 30h, M2 IC2A, UPMF, France

Master: Jérôme David, Développement Web Mobile, 30h, M2 IC2A, UPMF, France

Master: Manuel Atencia, Web Sémantique, 30h, M2 IC2A, UPMF, France

Master: Jérôme Euzenat, Semantic web: from XML to OWL, 22heqTD, M2R, Université Joseph Fourier & INPG, France

Post-graduate level: Jérôme Euzenat, "Data interlinking", 3h+3h, Tutorial+Practical, "linked data for smart cities" summer school, Cercedilla (ES), 2015

Post-graduate level: Jérôme Euzenat, "Data interlinking", 1h, Tutorial, Web intelligence summer school, Saint-Étienne (FR), 2015

Post-graduate level: Jérôme Euzenat, "Dynamic interoperability: from ontology matching to cultural knowledge evolution", 3h, Tutorial, ESSENCE summer school, Edinburgh (UK), 2015

Post-graduate level: Manuel Atencia, Jérôme David, Philippe Genoud, "What is this thing called linked data?", 6h, Tutorial, ACM Document engineering symposium, Lausanne (CH), 2015

10.2.2. Supervision

- PhD in progress: Tatiana Lesnikova, Cross-lingual RDF 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
- PhD in progress: Adam Sanchez Ayte, Ontology alignment and data interlinking evolution on the web of data, 1/12/2013, supervisor: Jérôme Euzenat and Jérôme David

10.2.3. Juries

- Jérôme Euzenat has reviewed the PhD dissertation of Amélie Gyrard, Designing cross-domain semantic web of things applications, Telecom ParisTech, 24/04/2015, supervisors: Christian Bonnet and Karima Boudaoud
- Jérôme Euzenat has been external examiner of the PhD dissertation of Mathew Joseph, Query answering over contextualized RDF/OWL knowledge with expressive bridge rules: decidable classes, Universitá degli studi di Trento, 29/04/2015, supervisor: Luciano Serafini
- Jérôme Euzenat has been external examiner of the PhD dissertation of Esther Lozano Hontecillas, A semantic approach to problem-based learning with conceptual models, Universidad Politécnica de Madrid, 30/06/2015, supervisors: Asunción Gómez-Pérez and Jorge Gracia
- Jérôme Euzenat has reviewed the PhD dissertation of Benoit Christophe, Semantic-based middleware to support nomadic users in IoT-enabled smart environments, Université Pierre et Marie Curie, 07/09/2015, through VAE
- Jérôme Euzenat has been external examiner of the PhD dissertation of José Angel Ramos Gargantilla, Descubrimiento de mappings en recursos geoespaciales, Universidad Politécnica de Madrid, 22/09/2015, supervisors: Asunción Gómez-Pérez and Mariano Fernandez Lopez
- Jérôme Euzenat has reviewed the HDR dissertation of Freddy Lécué, Semantics for scalable machine reasoning in the web of data, Université de Nice-Sophia Antipolis, 06/11/2015

10.3. Popularization

- Jérôme Euzenat gave a talk to the Grilog networking business meeting "Big data" on "Publication et exploitation des données avec les technologies sémantiques (Publishing and exploiting data with semantic technologies)", Meylan (FR), 2015-04-28.

11. Bibliography

Major publications by the team in recent years

[1] MANUEL. ATENCIA, JÉRÔME. DAVID, JÉRÔME. EUZENAT. *Data interlinking through robust linkkey extraction*, in "Proc. 21st european conference on artificial intelligence (ECAI), Praha (CZ)", Amsterdam (NL), TORSTEN. SCHAUB, GERHARD. FRIEDRICH, BARRY. O'SULLIVAN (editors), IOS press, 2014, pp. 15-20, ftp://ftp.inrialpes.fr/pub/exmo/publications/atencia2014b.pdf

[2] JÉRÔME. DAVID, JÉRÔME. EUZENAT, FRANÇOIS. SCHARFFE, CÁSSIA. TROJAHN DOS SANTOS. *The Alignment API 4.0*, in "Semantic web journal", 2011, vol. 2, n^o 1, pp. 3-10, http://dx.doi.org/10.3233/SW-2011-0028

[3] JÉRÔME. EUZENAT, CHRISTIAN. MEILICKE, PAVEL. SHVAIKO, HEINER. STUCKENSCHMIDT, CÁSSIA. TROJAHN DOS SANTOS. *Ontology Alignment Evaluation Initiative: six years of experience*, in "Journal on data semantics", 2011, vol. XV, n^o 6720, pp. 158-192, http://dx.doi.org/10.1007/978-3-642-22630-4_6

[4] JÉRÔME. EUZENAT, PAVEL. SHVAIKO. *Ontology matching*, 2nd, Springer-Verlag, Heidelberg (DE), 2013, http://book.ontologymatching.org

Publications of the year

Articles in International Peer-Reviewed Journals

[5] M. ATENCIA, M. AL-BAKRI, M.-C. ROUSSET. *Trust in networks of ontologies and alignments*, in "Knowledge and Information Systems", January 2015, vol. 42, n^o 2, pp. 353-379 [*DOI :* 10.1007/S10115-013-0708-9], https://hal.inria.fr/hal-01171782

[6] J. DAVID, L. LHOTE, A. MARY, F. RIOULT. *An average study of hypergraphs and their minimal transversals*, in "Journal of Theoretical Computer Science (TCS)", September 2015, vol. 596, pp. 124-141 [*DOI :* 10.1016/J.TCS.2015.06.052], https://hal.archives-ouvertes.fr/hal-01086638

[7] J. EUZENAT. *Revision in networks of ontologies*, in "Artificial intelligence", 2015, vol. 228, pp. 195-216, euzenat2015a [*DOI :* 10.1016/J.ARTINT.2015.07.007], https://hal.archives-ouvertes.fr/hal-01188763

International Conferences with Proceedings

[8] M. CHEATHAM, Z. DRAGISIC, J. EUZENAT, D. FARIA, A. FERRARA, G. FLOURIS, I. FUNDULAKI, R. GRANADA, V. IVANOVA, E. JIMÉNEZ-RUIZ, P. LAMBRIX, S. MONTANELLI, C. PESQUITA, T. SAVETA, P. SHVAIKO, A. SOLIMANDO, C. TROJAHN DOS SANTOS, O. ZAMAZAL. *Results of the Ontology Alignment Evaluation Initiative 2015*, in "10th ISWC workshop on ontology matching (OM)", Bethlehem, United States, No commercial editor., October 2015, pp. 60-115, cheatham2016a, https://hal.archives-ouvertes.fr/hal-01254907

[9] A. INANTS, J. EUZENAT. *An algebra of qualitative taxonomical relations for ontology alignments*, in "14th International semantic web conference (ISWC)", Bethleem, United States, M. ARENAS, Ó. CORCHO, J. HEFLIN, K. THIRUNARAYAN, S. STAAB, E. SIMPERL, M. STROHMAIER, M. D'AQUIN, K. SRINIVAS, P. GROTH, M. DUMONTIER (editors), Lecture notes in computer science, Springer Verlag, October 2015, vol. 9366, pp. 253-268, inants2015a, https://hal.archives-ouvertes.fr/hal-01188792

[10] T. LESNIKOVA, J. DAVID, J. EUZENAT. *Interlinking English and Chinese RDF data using BabelNet*, in "15th ACM international symposium on Document engineering (DocEng)", Lausanne, Switzerland, P. GENEVÈS, C. VANOIRBEEK (editors), Proc. 15th ACM international symposium on Document engineering, ACM press, September 2015, pp. 39-42, lesnikova2015b [*DOI :* 10.1145/2682571.2797089], https://hal.archives-ouvertes.fr/hal-01188837

Conferences without Proceedings

[11] M. AL-BAKRI, M. ATENCIA, S. LALANDE, M.-C. ROUSSET. *Inferring Same-as Facts from Linked Data: An Iterative Import-by-Query Approach*, in "Proceedings of the Twenty-Ninth AAAI Conference on Artificial Intelligence (AAAI 2015)", Austin, Texas, United States, January 2015, https://hal.inria.fr/hal-01113463

Scientific Books (or Scientific Book chapters)

[12] M. ROSOIU, J. DAVID, J. EUZENAT. *A linked data framework for Android*, in "The Semantic Web: ESWC 2012 Satellite Events", E. SIMPERL, B. NORTON, D. MLADENIC, E. D. VALLE, I. FUNDULAKI, A. PASSANT, R. TRONCY (editors), Springer Verlag, 2015, pp. 204-218 [*DOI :* 10.1007/978-3-662-46641-4_15], https://hal.archives-ouvertes.fr/hal-01179146

[13] P. SHVAIKO, J. EUZENAT, E. JIMÉNEZ-RUIZ, M. CHEATHAM, O. HASSANZADEH. *Proc. 10th ISWC workshop on ontology matching (OM)*, No commercial editor., 2016, pp. 1-239, shvaiko2016a, https://hal.archives-ouvertes.fr/hal-01254905

Research Reports

[14] S. BIROV, S. ROBINSON, M. POVEDA VILLALÓN, M. C. SUÁREZ-FIGUEROA, R. GARCÍA CASTRO, J. EUZENAT, B. FIES, A. CAVALLARO, J. PETERS-ANDERS, T. TRYFERIDIS, K. ZOI TSAGKARI. *Ontologies and datasets for energy measurement and validation interoperability*, Ready4SmartCities, September 2015, 135 p. , birov2015a, https://hal.inria.fr/hal-01247616

[15] J. DAVID, J. EUZENAT, M. ATENCIA. *Language-independent link key-based data interlinking*, Lindicle, March 2015, n^{o} 4.1, 21 p. , david2015a, https://hal.archives-ouvertes.fr/hal-01180925

[16] J. EUZENAT, J. DAVID, A. LOCORO, A. INANTS. *Context-based ontology matching and data interlinking*, Lindicle, July 2015, 21 p. , euzenat2015c, https://hal.archives-ouvertes.fr/hal-01180927

[17] M. HUKKALAINEN, M. HANNUS, K. PIIRA, E. GRAHN, H. HOANG, A. CAVALLARO, R. GARCÍA CASTRO, B. FIES, T. TRYFERIDIS, K. ZOI TSAGKARI, J. EUZENAT, F. JUDEX, D. BASCIOTTI, C. MARGUERITE, R.-R. SCHMIDT, S. BIROV, S. ROBINSON, G. VOGT. *Innovation and research roadmap*, Ready4SmartCities, September 2015, 63 p. , hukkalainen2015a, https://hal.inria.fr/hal-01248107

[18] T. LESNIKOVA, J. DAVID, J. EUZENAT. *Algorithms for cross-lingual data interlinking*, Lindicle, June 2015, n^{o} 4.2, 31 p. , lesnikova2015a, https://hal.archives-ouvertes.fr/hal-01180928

[19] J. PETERS-ANDERS, M. HUKKALAINEN, B. FIES, S. BIROV, M. WEISE, A. CAVALLARO, J. EUZENAT, T. TRYFERIDIS. *Community description*, Ready4SmartCities, August 2015, 60 p. , petersanders2015a, https://hal.inria.fr/hal-01248108

[20] M. WEISE, M. POVEDA VILLALÓN, R. GARCÍA CASTRO, J. EUZENAT, L. M. PRIEGO, B. FIES, A. CAVALLARO, J. PETERS-ANDERS, K. ZOI TSAGKARI. *Ontologies and datasets for energy management system interoperability*, Ready4SmartCities, August 2015, 149 p. , weise2015a, https://hal.inria.fr/hal-01247606

References in notes

[21] T. BERNERS-LEE, J. HENDLER, O. LASSILA. *The Semantic Web*, in "Scientific American", May 2001, vol. 284, n^{o} 5, pp. 34–43