LIG

2 - Réalisations de l'Unité de Recherche

2.2 - EXMO

(Traitement de Données et Connaissances à Grande Echelle)

2.2 Equipe EXMO - Axe Traitement de Données et de Connaissances à Grande Echelle

2.2.1 Scientific Presentation

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, representations have to be matched and transformed. We 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. More precisely our work may be grouped in three areas:

- Developing different aspects of ontology matching, including evaluation, alignment semantics and new types of matchers;

- Data interlinking, with or without relations to ontology matching;

- Analysis of semantic web queries.

On a longer term, we want to 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.

Our 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.

Staff members on 1/1/2014

- Manuel Atencia, MCF, Univ. Grenoble Alpes, F-38000 Grenoble, France

- Jérôme David, MCF, Univ. Grenoble Alpes, F-38000 Grenoble, France

- Jérôme Euzenat, DR, Inria

Team evolution

Exmo benefited in 2013 from the recruitment of Manuel Atencia as Maître de conférence.

During the period, severel people have participated in the team as post-doctoral researchers: Cássia Trojahn dos Santos (2009-2012), Manuel Atencia (2009), François Scharffe (2009-2010), Giuseppe Pirró (2010-2011), Jose-Luis Aguirre Cervantes (2012), Luz-Maria Priego (2013-2014). Three PhD theses have been defended (Jérôme Pierson, Melisachew Wudage Chekol and Zhenjie Fan).

2.2.2 Scientific and Technological Results

Synthesis of publications

	2009	2010	2011	2012	2013	2014	total
Journal papers (e.b., int.)	1		3	2	2	3	**11**
Monographs					1		**1**
Book chapters	1		1	2		1	**5**
Conference communication (p.c., int.)	3	6	5	6	2		**22**
Workshop and other communications	4	6	4	6	3		**23**
Editorship	2	2	1	2	3		**10**
PhD thesis	1		1		1		**3**

Ontology matching and alignments

Ontology matching is the task of finding correspondences between the entities of two ontologies [14]. Its result is expressed as an alignment. An alignment is a set of relations, e.g., equivalence, subsumption, between entities, e.g., concepts, from two different ontologies.

We have pursued our work on this topic in different directions.

Evaluation and test generation Evaluation of ontology matching algorithms involves to confront them with test ontologies and to compare results. For assessing the degree of achievement of current ontology alignment algorithms we have co-organised, since 2004, a series of evaluation events and set up the Ontology Alignment Evaluation Initiative. Year after year, we have seen the fields as a whole evolve towards [12]:

- more participants in open benchmarks;

- more matchers able to process all tests;

- increased performance in terms of precision and recall;

- matchers are faster and more scalable.

We contributed to automating ontology matching evaluation in the framework of the SEALS project (see §2.2.4). This involved [19]:

- designing and developing a web-based evaluation service that allows for participants to run their own evaluations and manipulate the results in a direct feedback cycle;

- providing better result visualisation facilities through graphic evaluators in the Alignment API and the implementation of an OLAP-based tool for manipulating evaluation results;

- supporting participants to implement the standard interface for running their tools in the evaluation service.

We have also provided a modular test generation framework enabling to generate ontology matching tests from different seed ontologies and with different levels of difficulty [13]. We showed that we were able to reproduce the OAEI Benchmark both with the original seed ontology and with other ontologies. We also discussed the properties of this test experimentally.

Weighted alignment semantics 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 the semantics of absolute correspondences, and we have provided properties that relate correspondence entailment with description logic constructors [3].

Context-based matching Context-based matching finds correspondences between entities from two ontologies by relating them to other resources. We designed a general view of context-based matching by analysing such existing matchers. This view is instantiated in a path-driven approach that (a) anchors the ontologies to external ontologies, (b) finds sequences of entities (path) that relate entities to match within and across these resources, and (c) uses algebras of relations for combining the relations obtained along these paths. Parameters governing such a system were identified and made explicit.

We conducted experiments with different parameter configurations in order to assess their influence. In particular, experiments confirm that restricting the set of ontologies reduces the time taken at the expense of recall and F-measure. Increasing path length within ontologies increases recall and F-measure as well. In addition, algebras of relations allow for a finer analysis, which shows that increasing path length provides more correct or non precise correspondences, but marginally increases incorrect correspondences [17].

Distance between ontologies Measuring similarity or distances between ontologies can be very important in various tasks. In particular, it is useful to know quickly if two ontologies are close or remote before deciding to match them. To that extent, a distance between ontologies must be efficiently computable.

We have distinguished two kinds of ontology measures: ontology space measures which are strictly based on the comparison of the content of ontologies and alignment space measures which are based on how ontologies are related through alignments. We have introduced two sets of alignment space measures relying on the existence of path between ontologies (path-based measures) or on the ontology entities that are preserved by the alignments (preservation-based measures). This reflects the possibility to perform actions such as instance import or query translation. Our experiments have shown that preservation-based measures are correlated with the best ontology space measures. Moreover they show a linear degradation with the alteration of alignments, witnessing their robustness [11].

All these measures are implemented in the OntoSim library (§2.2.4), which has been used in experiments.

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 establish links between these data, both for the web of data and for the semantic web that it contributes to feed.

Our work on data interlinking proposes new interlinking techniques and takes advantage of alignments in data interlinking.

Key-based We have proposed a method for analysing web datasets based on key dependencies. Keys are sets of properties which uniquely identify individuals (instances of a class). We have refined 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 also refined the notion of a linkkey introduced in [14] in weak, plain and strong linkkeys. Then we have shown how such keys, together with ontology alignments, or linkkeys may be used for deducing equality statements (links) between individuals across data sources in the web of data.

However, ontologies are usually not equiped with key descriptions, and never with linkkey assertions (which would hold across ontologies). These can be extracted from data by assuming that keys holding for specific data sets, may hold universally. We have extended classical key extraction techniques for extracting linkkeys.

In order to better deal with web data of variable quality, we have introduced the definition of a pseudo-key [4]. We have also designed and implemented an algorithm for discovering pseudo-keys. Experimental results show that, even for a large dataset such as DBpedia, the runtime of the algorithm is still reasonable. This work has allowed to detect automatically duplicates within wikipedia.

Similarity-based We have proposed a general framework for analysing the task of linking data and we have shown how the diverse techniques developed for establishing these links fit in the framework [18]. We have also proposed an architecture allowing to associate various interlinking systems with systems developed for ontology matching that present many commonalities with link discovery techniques.

In the context of the Datalift project, we have developed a data interlinking module based on this framework [15]. It generates data interlinking scripts from ontology alignments. For that purpose, we have integrated existing technologies within the Datalift platform: the Alignment API (§2.2.4), for taking advantage of the EDOAL language and Silk, developed by Frei Universtität Berlin, for processing linking scripts. So far, we can generate Silk scripts from ontology alignments in order to produce links.

We have further developed an algorithm able to determine potential attribute correspondences of two classes depending on their features. For that purpose, we use k-means or k-medoïds clustering to identify groups of properties which can be compared. This provides property correspondences used to construct a Silk script which generates an initial link set. Some of the links are presented to users who assess their validity. We then use an improvement of the disjunctive version space supervised learning method to learn a better script from the assessed links. Such a technique can be iterated until fully satisfactory links are found [16].

Analysis of semantic web queries

In the continuation of our previous work on path-based RDF querying [1, 2] and WAM (now Tyrex)'s work on μ-calculus interpretation of XPath, we are addressing SPARQL queries over RDF with similar techniques. We consider query containment, i.e., determining whether, for any graph, the answers to a query are contained in those of another query. This problem is very important for query optimisation purposes. In the SPARQL context, it can be equally useful for distributing federated queries or for implementing schema-based access control.

We have reduced SPARQL query containment to satisfiability in the μ-calculus. To that extent, we proposed an encoding of RDF graphs as labelled transition systems and SPARQL queries and ontologies as propositional μ-calculus formulas. They allow to translate query evaluation to graph traversing through the modalities of the logic. We have proved the correctness of the encoding [5].

It is then possible to use solvers of this logic to test query containment of SPARQL queries under RDFS and OWL schema constraints [7], with paths [6] or under particular entailment regimes [8]. We have also implemented the proposed techniques on top of a general μ-calculus solver.

In order to experimentally assess implementation strengths and limitations, we provided a first SPARQL containment test benchmark [9]. We studied the query demographics on DBPedia logs to design benchmarks for relevant query containment solvers. We tested available solvers on their domain of applicability on three different benchmark suites and found that (i) tested solutions are overall functionally correct, (ii) in spite of its complexity, SPARQL query containment is practicable for acyclic queries, (iii) state-of-the-art solvers are at an early stage both in terms of capabilities and implementation. The benchmarks, results and software are available at http://sparql-qc-bench.inrialpes.fr.

2.2.3 Visibility and attractivity

International collaboration

Besides international cooperation through European (Oxford, Mannheim, UP Madrid, Zurich in SEALS, Open U. in NeOn) and ANR (Tsinghua) projects, we have more informal but fruitful collaboration with:

- Bilatteral project (STAR) with Yeungnam university (Jason Jung);

- Billateral project with UFPE, Recife (Fred Freitas) on ontology modules;

- Genova (Angela Locoro) on context based matching;

- Praha (Ondrej Zamazal) on patterns and matching evaluation;

- Trento (Pavel Shvaiko) on ontology matching;

- Trento (Luciano Serafini, Chiara Ghidini) and U. Rutgers (Alex Borgida) on weighted alignment semantics;

- Researchers from Oxford, Trento, Mannheim, Linköping, Milano, Amsterdam, Galway and Open university participate in the OAEI campaign that we animate.

Expertise and recruitment comittees

Jérôme Euzenat has been reviewing grant demands for NWO (NL, 2009), ANR Verso (2010), EU FP7, FCT (PT), SFI and IRCSET (IE, 2011). He has reviewed a book proposal for the MIT press in 2010. Jérôme David has reviewed ANR Blanc bilatteraux (2013).

Jérôme David has been member of the recruitment committee of Université Pierre Mendès France for the associate professor position 27MCF291 (2012). Jérôme Euzenat has been member of the recruitment committee of Rennes 1 university for the associate professor position 27MCF1058 (2010), of Grenoble-INP for the associate professor position 27MCF674 (2010), of the University of Caen for the professor position 27PR2055 (2012).

Editorial boards

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

- Jérôme Euzenat is founding member of the "Semantic Web Science Association" (steering committee for the ISWC conference series). He has been part of the committee for the whole period.

Chairs

- Jérôme David has been tutorial chair (with Irwin King) of the 21st International World Wide Web Conference (WWW 2012).

- Jérôme Euzenat has 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 co-workshop chairperson (with Valentina Presutti) of the 6th European Semantic Web Conference (ESWC 2009) held in Herssounisos, Greece.

Programme committees

- Jérôme Euzenat has been programme committee member for ISWC (2009, 2011, 2012, 2013, 2014), WWW (2009, 2010, 2011, 2012, 2013), IJCAI (2009, 2011, 2013), K-Cap (2011, 2013), Context (2011, 2013), ECAI (2010, 2014), AAAI (2012), ESWC (2013, 2014), EKAW (2010, 2012), FOIS (2010, 2012), AIMSA (2010), RFIA (2010), ER (2011, 2012), OntoBras (2013), LMO (2009)

- Cássia Trojahn dos Santos has been programme committee member for (ISWC 2009, 2011). the International Workshop on Evaluation of Semantic Technologies (iWest 2010, 2012), the Ontology Matching workshop (OM 2009, 2010, 2011, 2012), the Brazilian Symposium in Information and Human Language Technology (STIL 2011).

- Jérôme David has been programme committee member for ISWC (2009), ESWC (2013), MobiWIS (2011, 2012), IC (2013), the Ontology matching workshop (OM 2009, 2010, 2011, 2012, 2013), Artificial Intelligence meets the Web of Data workshop (2012) and Downscaling the Semantic Web workshop (2012), the Web Social workshop of the Extraction and Gestion de Connaissances conference (EGC 2010) the Graph Based Structures for Knowledge Representation and Reasoning Workshop (GKR@IJCAI 2013).

- Manuel Atencia has been programme committee member of ISWC (2011, 2013), the International work conference on artificial neural networks (IWANN 2011), the Ontology matching workshop (OM 2013), the Graph Based Structures for Knowledge Representation and Reasoning Workshop (GKR@IJCAI 2013).

- François Scharffe has been programme committee member for Ingénierie des Connaissances conference (IC 2010), the Ontology matching workshop (OM 2009, 2010, 2011).

- Giuseppe Pirrò has been programme committee member IASTED International Conferences on Parallel and Distributed Computing and Systems (PDCS 2010).

Organisation

- Jérôme Euzenat organises yearly (with Pavel Shvaiko) the "Ontology matching" workshop at the ISWC conference (2009-2013).

- Exmo (and other colleagues) organises yearly the Ontology alignment evaluation initiative (OAEI 2009-2013).

- François Scharffe has organised (with Eva Blomqvist, Kurt Sandkuhl and Vojtech Svátek) the 1st Workshop on "Ontology Patterns" (WOP 2009).

- François Scharffe has organised (with Valentina Presutti and Vojtech Svátek) the "Knowledge Injection to and Extraction from Linked Data" workshop of the 17th EKAW, Lisboa (PT), 2010.

2.2.4   Social, economical, and cultural impact

Main contracts and grants

ANR ContInt platform Datalift   (10/2010-3/2014) Exmo coordinates with LIRMM the Datalift project whose goal is to produce a platform for publishing governmental data as linked data. Exmo is particularly involved in the generation of links between datasets.

ANR Blanc International Lindicle   (1/2013-12/2016) Exmo carries out with Tsinghua university (Knowledge engineering group), Beijing (CN), the Lindicle project whose goal is to investigate multilingual data interlinking between French, English and Chinese data sources.

ANR Verso DataRing   (2009-2011) Exmo has participated in the DataRing project about peer-to-peer data sharing for online communities. We worked more directly with Hadas (Marie-Christine Rousset and Manuel Atencia) on trust in semantic peer-to-peer networks.

FP7 INFRASTRUCTURE SEALS (2009-2012)   Exmo was a partner of the SEALS European commission infrastructure project whose goal is to provide the infrastructure for evaluating semantic technologies. Jérôme Euzenat was vice-coordinator in charge of the research area and Cássia Trojahn led the work package on ontology matching evaluation. More particularly, Exmo has provided an infrastructure for evaluating ontology matching systems and algorithms, integrated in the SEALS platform.

FP7 support action Ready4SmartCities   : Optimising Energy Systems in Smart Cities (10/2013-9/2015) Exmo is a partner of the FP7 Ready4SmartCities coordination and support action which aims at increasing awareness and interoperability for the adoption of ICT and semantic technologies in energy system to obtain a reduction of energy consumption and CO_2 emission at smart cities communities level through innovative relying on RTD and innovation outcomes and ICT-based solutions. We are particularly interested in promoting the use of semantic technologies in this context. We are more particularly in charge of displaying the benefits of maintaining alignments between available ontologies.

Software diffusion

The Alignment API   The Alignment API (http://alignapi.gforge.inria.fr) is a software platform made of alignments formats, including the expressive alignment format EDOAL, an API and reference implementation, a library of matchers plus the Alignment server [10]. The Alignment API is used in the Ontology Alignment Evaluation Initiative data and result processing (§2.2.2). It is also used by more than 40 other teams worldwide.

The *OntoSim* library   OntoSim (http://ontosim.gforge.inria.fr) is a library offering similarity and distance measures between ontology entities as well as between ontologies themselves (see §2.2.2). It materialises our work towards better ontology proximity measures.

Industry cooperation

Besides cooperation with various companies in projects (ATOS, Mondeca, Ontoprise, etc.), we have had two more precisely focussed cooperation with small companies:

Mondeca   Exmo has been subcontractor of the Mondeca company in a project for the office for the official publications of the european union (OPOCE) which aims at developing a matching environment for thesauri (2010-2011). Exmo's role was the integration of the Alignment API technology within Mondeca's thesaurus edition environment and the development and evaluation of new matchers adapted to thesauri matching. Concerned thesauri are large multilingual vocabularies expressed in SKOS, such as Eurovoc.

Meaning engines Meaning Engines is a start-up company whose goal is to use the web of data principles (the application of semantic web technology for publishing data) for integrating goods catalogs. We are working with them for developing generic connectors based on our alignment technology (during the whole period).

Popularising

- 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 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, 25/09/2012.

- Jérôme Euzenat gave a presentation on *Les données liées ouvertes (linked open data): publier des données réutilisables* at the open data days of the FREMIT Federation, IMT/IRIT, Toulouse (FR), 5/11/2013.

- Jérôme Euzenat coordinated the CNRS development days (JDEV) sessions on *web programming*, 4 presentations, 6 tutorials, 5 worshops, 80 participants, Palaiseau, 4-6/9/2013.

- Jérôme Euzenat gave a presentation on *Communication et adaptation: la fabrique de la communication flexible* au Cycle de conférences Canopé (ex-CRDP) «La culture partagée», Grenoble (FR), 2/04/2014

2.2.5   Team Organization and life

Team life

Exmo is a rather small team so most of the communication occurs daily among the four offices that we occupy. In addition, we have an internal blog for sharing advices and thoughts and reporting visits.

We hold monthly more formal seminars where team members present their work to the others and more occasional seminars from visitors.

Recommandations from the previous evaluation

The previous evaluation invited us to "reconsidérer sa politique de recrutement et à chercher les voies susceptibles d'améliorer ses capacités à recruter." Given the little grip that we have on the recruitment process, it was not clear what we could do (the second part of the recommendations mentioned "Les tutelles"). Thanks to Université Pierre Mendes-France, we have had the excellent opportunity to recruit Manuel Atencia.

The evaluators, mentioned that this would allow us to address complementary topics. This is what we did through a voluntary movement towards data interlinking (see §2.2.2). We are confident that this topic will prove fruitful in the next few years. In the meantime, we are already thinking about the evolution of the goals of the Exmo team (see §2.2.7).

2.2.6   Training through research, educational involvement

Nombre de thèses soutenues:

- PhD (defended): Jérôme Pierson, Une infrastructure de gestion de contexte pour l'intelligence ambiante, 5/10/2009, supervisors: Jérôme Euzenat and Fano Ramparany

- PhD (defended): Melisachew Wudage Chekol, Graph queries for the semantic web, 19/12/2012, supervisors: Jérôme Euzenat and Nabil Layaïda

- PhD (defended): Zhengjie Fan, Ontology-based data interlinking, 4/4/2014, supervisors: Jérôme Euzenat and François Scharffe

- PhD (in progress): Mustafa Al-Bakri, Modélisation et calcul de la confiance dans les réseaux pair-à-pair de partage de données, supervisors: Marie-Christine Rousset and Manuel Atencia

- PhD (in progress): Tatiana Lesnikova, Multilingual data interlinking, supervisors: Jérôme Euzenat and Jérôme David

- PhD (in progress): Armen Inants, Ontology alignment algebra, supervisor: Jérôme Euzenat

- PhD (in progress): Adam Sanchez Ayte, Ontology alignment and data interlinking evolution on the web of data, supervisor: Jérôme Euzenat and Jérôme David

Our previous doctoral students are associate professors (Sébastien Laborie in Pau, Antoine Zimmermann at École des mines de Saint-Étienne and Faysal Alkhateeb at Yarmouk) or engineer (Jérôme Pierson at Hurence). Some post-doctoral students in the team also found associate professor positions (Cássia Trojahn in Toulouse, Chan Le Duc in Paris).

Jérôme Euzenat is, with Éric Gaussier, coordinator of the "AI and the web" option of the M2R in computer science and applied mathematics.

2.2.7 Strategy and Research Project

The semantic web is nowadays a gigantic network of ontologies related together by alignments expressing data which are linked together across datasets. It is successful in many respects: huge amounts of data are now published, linked and exploited at web scale; key web players (e.g., google, facebook) are now exploiting the same technologies to create very large knowledge graphs for answering search queries or recommending products to consumers and consumers to companies.

The structure of the semantic web, inherited from its logical foundations, is relatively rigid. However, it has to be able to evolve, otherwise it will become an obstacle to communication rather than a facilitator. One important question of the coming years is thus to provide this flexibility and fluidity to the semantic web by serendipitously allowing stakeholders to communicate efficiently through it.

We want to consider how agents (people or programs) may effectively communicate though having heterogeneous views of the world, e.g., because they have different experiences. This does not necessarily require to drop the logical heritage, which is very useful for drawing safe conclusions and highlighting conflicts. This certainly should make it more alive: able to adapt when it becomes an obstacle, but able to do it rationally, i.e., by taking into account the reasons for being so and the reasons for conflicting. Instead of creating the ultimate ontology, our objective is the design of an unstable and dynamic knowledge structure.

So, we consider groups of agents who want to communicate. Each one has its own representation of the world, called an ontology but which is simply a logical theory about the world. For communicating, they will adjust their models or relations between their models, as represented by links and alignments. They may take advantage of this evolving background knowledge that we have described as the semantic web.

We plan to investigate the behaviour of formal adaptation methods under long term evolution strategies. This is a whole research program but it already raises many questions such as:

- By which mechanisms, is it possible to articulate symbolic and interaction-based techniques so that they show convergence to a representation enabling successful communication?

- Under which conditions and with which mechanisms can multiple knowledge models coexist? I.e., what are the models and in which contexts, is it possible that ontologies do not merge?

- Is it possible to guarantee, through some process, a given level of interoperability?

- How such models can gradually evolve or co-evolve?

We plan to tackle this problem with three different investigation angles that complement each others:

- A theoretical approach which studies the mechanisms by which it is possible to evolve the semantic web. There is already a solid grounding for this in the artificial intelligence literature and in particular the work in revision and argumentation. These works remain to be extended to networks of ontologies, alignments and linked data as found on the semantic web.

- An experimental approach based on the theories of cultural evolution showing how, by continuously trying and failing to communicate, agents reach an agreement on, or maintain correspondences between, their representation of the world.

- A social science approach in which observed social communication models could be used as inspiration and as reference for human and social plausibility.

This work is primarily fundamental research, however, in a world where most artifacts, including scientific theories, are designed by teams from different horizons, it could have applications for supporting this design process.

2.2.8 Self assesment

The strengths of the Exmo team are its focus at the edge of a handful of topics. We have, in the last period, maintained our global volume of publication but largely reinforced journal publications at a very good level (JWS, JoDS, TKDE, KAIS, MTAP, SWJ). Exmo has been successful and impactful on ontology matching these past years. The development of the ontology matching field is still ongoing: we have a large attendance to the ontology matching workshop and the OAEI evaluations. The reference book that we wrote in 2007 received an amplified edition in 2013. The new data interlinking topic is attracting interest and generating new ideas. Globally the team, of now three permanent people, is well regarded and the PhD students that we have trained have reached a good visibility.

Exmo's main weakness is clearly the small size of the team whose work could easily be outpaced by a team with more resources. So far we had the strategy to collaborate through European or ANR projects. However, agencies are progressively narrowing down such projects towards applicative goals. It is thus not particularly easy to find adequate projects for developing longer term research.

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Summary

	2006	2007	2008	2009	2010	2011	2012	2013	2014	**Total**
International peer reviewed journal [ACL]	0	0	0	1	0	3	2	3	2	11
International peer-reviewed conference proceedings [ACT]	2	1	0	5	5	6	8	4	1	32
Short communications [COM] and posters [AFF] in conferences and workshops	0	0	0	2	3	0	2	1	0	8
Scientific books and chapter [OS]	0	0	1	1	0	1	2	1	0	6
National peer-reviewed conference proceedings [ACTN]	0	0	0	0	1	0	1	0	0	2
Book or Proceedings editing [DO]	0	0	0	2	2	1	3	1	0	9
Invited conferences [INV]	0	0	0	0	1	1	0	0	0	2
Doctoral Dissertations and Habilitations Theses [TH]	0	0	1	1	0	0	1	0	1	4
Other Publications [AP]	0	0	0	4	9	10	9	3	1	36
Total	2	1	2	16	21	22	28	13	5	110