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INSTITUT NATIONAL DE RECHERCHE EN INFORMATIQUE ET EN AUTOMATIQUE

Project-Team EXMO

Computer-mediated communication of structured knowledge

THEME SYM C

Activity Report

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1. Team

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2. Overall Objectives

Keywords: *system of networked ontologies*, *Alignment API*, *CPRDF*, *CPSPARQL*, *OLA*, *OWL*, *PRDF*, *PSPARQL*, *Path RDF*, *RDF*, *XSLT*, *content representation*, *context*, *knowledge representation*, *knowledge transformation*, *multimedia document adaptation*, *ontologies*, *ontology alignment*, *ontology alignment management*, *property preservation*, *semantic peer-to-peer system*, *semantic social network*, *semantic web*, *semantics of knowledge representation*, *semiotics*.

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.

However, there is no reason why this 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 can 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.

2.2. Highlights of the year

This year, three PhD theses have been defended: Sébastien Laborie on multimedia document adaptation, Faisal Alkhateeb on querying RDF with path patterns and Antoine Zimmermann of the semantics of networked ontologies. This is quite the achievement of work we had launched four years ago.

3. Scientific Foundations

3.1. Knowledge representation semantics

We usually work with semantically defined knowledge representation languages (like description logics [32], 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 offers the description of 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, in order to establish the properties of computer manipulations of the representations.

3.2. Ontology alignment

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 $\langle e, e^{'}, r, n\rangle$ 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.
- n is a degree of confidence in this particular correspondence (which will be omitted here).

Given the semantics of the two ontologies provided by their consequence relation, we define an interpretation of the two ontologies as a triple made of an interpretation for each ontology and an equalising function (γ) which maps the domain of each of the models to a common domain on which the relations are interpreted. Such a triple $\langle m, m^{'}, \gamma\rangle$ is a model of the aligned ontologies o and $o^{'}$ if and only if, for each correspondence $\langle e, e^{'}, r\rangle$ of the alignment A, $m\models o$, $m^{'}\models o^{'}$ and $\langle \gamma(m(e)), \gamma(m^{'}(e^{'}))\rangle \in r^{\gamma}$.

This definition is extended to a system of networked ontologies which is a set of ontologies and associated alignments. A model of such a system of networked ontologies is a tuple of local models and an equalising function such that each alignment is valid for the models and the equalising function 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 a system of networked ontologies, 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 pair-wise 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.

3.3. Transformations and properties

A transformation (τ) is an algorithmic manner to generate a representation ($\tau(o)$) from another one (o), not necessarily in the same language. We focus on transformations made by composition of more elementary transformations for which we only know the input, output and assumed properties. These transformations may have been generated from an alignment or by any other means.

A transformation system is characterised by a set of elementary transformations and a set of composition operators. A transformation flow is the composition of elementary transformation instances whose input/output are connected by channels. A transformation flow is itself a transformation.

The design of information systems like transformation flows requires the ability to express such flows and to determine their properties. A property is a boolean predicate about the transformation, e.g., "preserving information" is such a predicate - it is true or false of a transformation - which is satisfied if there exists an algorithmic mean to recover o from $\tau(o)$.

We consider more closely preservation properties that can allow the preservation (or anti-preservation) of an order relation between the source representations and the target representations. For instance, one can identify:

- Syntactic properties: based on the organisation of syntactic elements, like the completion ($\tau(o) \leq o$, in which $\leq$ denotes structural subsumption between representations);
- Semantic properties: based on the concepts of model and consequence, like consequence preservation ($\forall o \subseteq L, \forall \delta \in L, o\models_{L}\delta \Rightarrow \tau(o)\models_{L'}\tau(\delta)$);
- Semiotic properties: based on the interpretation of the manipulated objects as signs, like interpretation preservation (let σ be the interpretation rules and $\models_{L,i}$ be the interpretation of individual i, $\forall o \subseteq L, \forall \delta \in L, \forall i, j, o, \sigma\models_{L,i}\delta \Rightarrow \tau(o), \tau(\sigma)\models_{L',j}\tau(\delta)$).

Our goal is to study transformations based on transformation properties rather than on representations or transformation structures. This does not deal only with semantics but considers various properties, e.g., content or structure preservation, traceability, and confidentiality. However, we more specifically address semantic properties. We also consider properties of transformation systems (given a transformation system, is information preservation decidable and at what cost?). We try to characterise, given a particular type of property, which transformations leave them invariant and what is the action of composition operators.

4. Application Domains

Two application contexts motivate and spur our work: the "semantic web" infrastructure (§4.1) and transformation system engineering (§4.2).

4.1. Semantic web technologies

Internet technologies support organisations 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" [33] 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.

The semantic web idea is essentially based on the notion of ontology (that can be quickly described as conceptual schemes or knowledge bases). Even if a standard knowledge representation language emerges, it will still be necessary to import and exchange ontologies in such a way that the semantics of their representation language is taken care of. We work on finding correspondences between various knowledge representation languages and ontologies (see §6.1) in order to take advantage of them in ontology merging and bridging or message translation. Bringing solutions to this problem is part of the ambition of *Exmo*.

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 [7]. 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.

4.2. Transformation system engineering

Computerisation and networking lead organisations to exchange information in machine-readable form. E-commerce generates a continuous flow of such documents. As transmitted information is neither addressed nor adapted to all the members of an organisation, it is necessary to transform document structure and content. Similarly, web sites are generated from databases or primary funds and e-commerce documents are applied various transformations before goods are shipped. Additionally, the Object Management Group Model-Driven Architecture (MDA) considers that a part of software development can be reduced to the composition of transformations from (platform independent) domain models to other (platform dependent) models in function of platform description models. This is considering any implementation as adaptation.

Interoperability requirements have led to the definition of the structured document representation language XML which helps handling the syntax of documents straightforwardly. Other languages, such as XSLT or Omnimark, enable the implementation of standalone transformations.

However, this view of transformations is only partial and local. It seems unavoidable that, in the future, we will have to deal with complex transformation flows automating the combination of transformations, some of which coming from external sources. This will require the global understanding of the behaviour of the flow of transformations. This calls for real "transformation system engineering" which should address the following issues:

- the lack of global consideration of transformations: they are processed in relation with other transformations, e.g., Transmorpher or XProc;
- the need to consider properties of transformations and especially their semantic properties: this will require the semantic analysis of the transformations;
- the design of transformation flows from external resources (as it is in software engineering): this will require the ability to consider the properties of imported transformations.

Transformation system engineering will require tools, methodologies and formal methods. As a matter of fact, it will be necessary to check that a particular transformation system does not export sensitive information or that the transformation process terminates. For that purpose, the transformation flow must be expressed in a parsable way and the expected properties of the flow must be expressed (see §3.3). *Exmo* is concerned by tools and formal methods and aims at combining them in solutions for transformation flow design environments.

In the recent years, we turned our interest more specifically towards alignment management [24] which remains tied to transformation system engineering: it is still about composing alignments, satisfying properties and generating transformations from alignments.

5. Software

Exmo's work can be implemented in software: we have proposed an API for expressing ontology alignment (§5.1) which is the basis for several systems and we have designed and developed a query evaluator for the PSPARQL query language (§5.2).

5.1. Alignment API: manipulating ontology alignments

Participants: Jérôme Euzenat [Contact], Chan Le Duc.

We have designed a format for expressing alignments in a uniform way [1]. The goal of this format is to be able to share on the web the available alignments. It should help systems using alignments, e.g., mergers, 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 (for RDF/XML), an OWL ontology and an RDF Schema.

The API itself is a *Java* description of tools for accessing the common format. It defines four main interfaces (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 have provided a first 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);
- a library of evaluators (precision/recall, generalised precision/recall, precision/recall graphs and weighted Hamming distance);
- 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.

We have developed this year two plug-ins for accessing the Alignment server from other environments. They both use the web service interface. From the NeOn Toolkit environment in which the plugin is integrated, users can exploit the Alignment server for computing, manipulating and managing alignments between ontologies [30]. The plugin offers an interface from which users can get ontologies from Ontology Navigator (that is another plugin of the NeOn Toolkit) and call functions of the Alignment server with these ontologies as input. We also have integrated more matchers in the Alignment server, some of which available through web services as well [29]. The WebContent platform does not offer any interaction capabilities but it can also invoke the server to retrieve alignments.

The *Alignment API* is used in the Ontology Alignment Evaluation Initiative data and result processing. It is also used as input or output by several alignment tools (among which OLA that we develop jointly with the Université du Québec à Montréal [21] or Aroma [16]).

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

5.2. PSPARQL Query evaluator

Participants: Faisal Alkhateeb, Jérôme Euzenat [Contact].

PSPARQL is a query language for RDF that we designed by extending SPARQL with regular expressions. CPSPARQL extends PSPARQL with constraints on path steps (see §6.2.1). We have implemented a PSPARQL query evaluator in Java. This evaluator can parse SPARQL, PSPARQL and CPSPARQL queries, parse RDF documents written in the Turtle language, evaluate the query and then return the answer set.

The algorithm follows the backtrack technique developed in our work. The evaluation of regular expression patterns is used for computing the satisfiability set of a given regular expression, to take into account the multiple appearances of a given variable in different places of the query, i.e., to take into account the current mappings.

This evaluator passed 435 test cases out of the 440 in the W3C Data Access Working Group SPARQL first test base. The 5 missed tests are those that use the DESCRIBE result form which is not implemented.

The PSPARQL query evaluator is available for download as well as an online test servlet under http://psparql.inrialpes.fr.

6. New Results

The results in 2008 are mainly related to the use of our semantics of alignments in evaluation, modules, and alignment language (§6.1) and system of networked ontologies (§6.2.2), the extension of the PSPARQL language (§6.2.1) and the adaptation of the interactive structure in multimedia documents (§6.3).

6.1. Ontology matching and alignment

We pursue our work work on ontology matching and alignment support [2][10] with basic contributions.

6.1.1. Benchmarking

Participants: Jérôme Euzenat [Contact], Jérôme David.

In order to evaluate ontology matching algorithms it is necessary to confront them with test ontologies and to compare the results. Since five years, we run the Ontology Alignment Evaluation Initiative which organises evaluation campaigns for assessing the degree of achievement of actual ontology matching algorithms [13]. This year's event has been held in Karlsruhe, Germany [28]. 13 different teams entered the evaluation which consisted of 8 different sets of tests. This is still a very sucessful and lively event.

On the research side, we have pursued our investigations on generalising precision and recall based on the new semantics of alignments. We analyzed the limits of the semantic evaluation measure that we introduced last year. From this study, we proposed two new sets of evaluation measures [15]. The first one is a semantic extension of relaxed precision and recall. The second one consists of bounding the alignment space to make ideal semantic precision and recall applicable.

6.1.2. Ontology distances

Participants: Jérôme David [Contact], Jérôme Euzenat.

There are many reasons for measuring a distance between ontologies. 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 quickly computable.

We have studied constraints applying to such measures [9] and reviewed several possible ontology distances. Then we evaluated experimentally some of them [14]. We carried out experiments on 12 measures in the ontology space against 111 ontologies. This allowed us to identify a triple-based distance of our own associated with a minimum weight maximal graph matching as the most accurate measure, but measures based on the vector space model of information retrieval as the most efficient measures.

6.1.3. Alignment formats and algebra

Participants: Jérôme Euzenat [Contact], Antoine Zimmermann.

Sharing alignments across the web requires a language to express them. We have been developing for year a format for exchanging alignment across application which is used in the Alignment server, the Alignment API and the OAEI evaluation effort. This format is freely extensible.

In order to deal with uncertainty in relations between ontology entities, we have proposed to use algebra of binary relations instead of the generaly used ad hoc relations. We have shown that algebras of binary relations are a natural way represent disjunction of relations, to agregate matcher results, to compute composition and granularity change [18].

In addition, once we are able to ascribe a semantics to alignments [6], it is possible to carry out approximate reasoning that does not involve ontologies but alignments alone. This can be exploited for evaluating alignments [15] or for checking consistency or preprocessing a distributed set of alignments through the computation of its compositional, symmetric and union closure. Algebra of relations are then instrumental for computing composition of alignments.

6.1.4. Ontology modules

Participants: Jérôme Euzenat [Contact], Antoine Zimmermann.

The goal of the semantic web is to share knowledge. In this context, knowledge is expressed in interlinked chunks rather than large monolitic ontologies. Ontologies can be assembled from ontology modules like programme modules in software engineering.

We have designed a model of modules which combines an interface and an ontology implementation, in which a module can import other modules through alignments with their interface [22] [6]. This is a very natural way to do since alignments can be used to adjust the components in the ontologies. We have provided the semantics of such modules which is a combination of ontology semantics and our own alignment semantics.

This work is carried out in cooperation with Frederico Freitas (see §7.3.1) and in the framework of the NeOn project (see §7.2.1).

6.2. Systems of networked ontologies

Dealing with the semantic web, we are interested in systems of networked ontologies, 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.

6.2.1. Constrained Path RDF as a query language for RDF and RDFS

Participants: Faisal Alkhateeb [Contact], Jérôme Euzenat.

Though RDF itself can be used as a query language for an RDF knowledge base (using RDF semantic consequence), the need for added expressivity in queries has led to the definition of the SPARQL query language. SPARQL queries are defined on top of graph patterns that are basically RDF (and more precisely GRDF) graphs.

To be able to characterise paths of arbitrary length in a query, e.g. "does there exist a trip from town A to town B using only trains and buses?", we have already proposed the PRDF (for Path RDF) language effectively mixing RDF reasoning with database-inspired regular paths [4]. However, PRDF graphs do not allow expressing constraints on the nodes, e.g. "Moreover, one of the correspondences must provide a wireless connection.". To express these constraints, we propose an extension of PRDF, called CPRDF (for Constrained Path RDF [11]).

For these two extensions of RDF, we have provided an abstract syntax and an extension of RDF semantics. We characterise query answering (the query is a PRDF or a CPRDF graph, the knowledge base is an RDF graph) as a particular case of PRDF or CPRDF entailment that can be computed using some kind of graph homomorphism. Query answering thus remains an NP-hard problem in all these languages. Finally, we use these PRDF or CPRDF graphs as graph patterns in SPARQL, defining the PSPARQL and CPSPARQL extensions of that query language.

This year we have proposed a new approach for evaluating queries over a core fragment of RDFS. This approach mainly relies on rewriting any (CP)SPARQL query q into a semantically equivalent CPSPARQL query q' such that the evaluation of q' over an RDF graph G is equivalent to the evaluation of q over the RDFS closure of G. The efficiency of evaluating queries using this approach has been demonstrated through the use of the Lehigh University Benchmark (http://swat.cse.lehigh.edu/projects/lubm/) for generating RDFS graphs.

Finaly, we have proposed to use PSPARQL as a basis for a new language for processing alignments [17][8]. More precisely, we have proposed that for processing expressive alignments generated by patterns [19], we needed a mix of the rule language SPARQL++ and PSPARQL.

6.2.2. Reasoning with distributed systems of networked ontologies

Participants: Chan Le Duc [Contact], Antoine Zimmermann.

In order to effectively reason on distributed systems of networked ontologies, we introduced last year a new kind of distributed logics, namely Integrated Distributed Description Logics (IDDL), where ontologies are represented as description logic knowledge bases and alignments assert cross-ontology concept/role subsumptions or disjunctions, or cross-ontology instance membership. In particular, this formalism is adapted for reasoning with OWL ontologies aligned by automatic ontology matching tools. The semantics of the logic is given in the framework we introduced last year for systems of networked ontologies [6].

The difference between IDDL and the existing formalisms is that (i) IDDL focuses on alignments by considering them as independent pieces of knowledge among those of ontologies, (ii) IDDL does not make any expressiveness assumption on formalisms used in ontologies except for decidability, (iii) IDDL supports distributed reasoning, i.e., all local computing for ontologies can be independently performed by local reasoners.

We have developed an algorithm for consistecy checking in IDDL [31] [20]. The procedure is correct and complete when the correspondences which appear in the alignments only assert cross-ontology subsumption of concepts or roles, or cross-ontology disjointness of concepts. The complexity class of our consistency checking is at least NP but depends on the complexity of local reasoners.

This algorithm has beed implemented and a preliminary version of the IDDL reasoner is available from http://gforge.inria.fr/scm/?group_id=1480. First experiments with our prototype show that it answers quickly on several real life cases.

6.3. Semantic adaptation of multimedia documents

Participants: Sébastien Laborie [Contact], Faisal Alkhateeb, Jérôme Euzenat, Nabil Layaïda [WAM team].

When a multimedia document is played on platforms with limited resources, e.g., a mobile phone that can only display one image at a time or an interactive display without keyboard, it is necessary to adapt the document to the target device. In order to assess the meaning of adaptation, we have defined a semantic approach [3], which considers a model of a multimedia document as one of its potential executions (an execution satisfying its specification). In a first approximation, adaptation reduces the set of models of a specification by selecting those satisfying the adaptation constraints. Adapting amounts to finding this subset of models or, when it is empty, finding a compatible execution as close as possible to the initial execution. For that purpose, we proposed to express the set of possible interpretations by a resolved relation graph. Each relation of this graph could be a temporal, spatial, or spatio-temporal relation. This approach has been applied to the temporal and spatial dimensions based on Allen and RCC algebras respectively [25].

This year, we have followed on our work using semantic web technologies in the context of multimedia document adaptation.

On one hand, we have proposed an extension to SPARQL that allows to generate any kind of XML documents from multiple RDF data and a given XML template [12]. Thanks to this extension, an XML template can itself contain SPARQL queries that can import template instances. Such an approach allows to reuse templates, divide related information into various templates and avoid templates containing mixed languages. Moreover, reasoning capabilities can be exploited using RDFS, and document adaptation could be achieved using the SPARQL FILTER clause in order to restrict the answers to the set that satisfies the given profile.

On the other hand, we have considered the use of the author discourse in the context of semantic adaptation [5]. We have shown that specifying some rhetorical relations between multimedia objects, such as "examplified", may in turn identify implicit spatio-temporal relations between these objects. Hence, using the author discourse structure guides the adaptation process by providing adapting documents which are as close as possible from either the explicit document composition and the author discourse structure. Moreover, for SMIL documents, we have shown that this discourse may be specified with RDF triples in the SMIL Metadata Module.

Finally, we demonstrate the usefullness of our SMIL adaptation prototype during several events [23]. A prototype screencast is also available at http://www.inrialpes.fr/exmo/people/laborie/Research.html.

7. Other Grants and Activities

7.1. National grants and collaborations

7.1.1. WebContent RNTL platform

Participant: Jérôme Euzenat [Contact].

Exmo is involved in the development of the *WebContent* platform supported by the Agence Nationale de la Recherche (ANR). Its goal is to build a national platform for knowledge retrieval involving natural language and semantic web technologies. *Exmo* is co-responsible with Gémo (Chantal Reynaud) of work-package 3.2 : Ontology matching. It aims at integrating ontology matching solutions from several partners on the platform. We have integrated the Alignment server within the platform and integrated other matchers from partners in the Alignment server.

More information on *WebContent* can be found at http://www.webcontent.fr.

7.1.2. Réseau régional Web intelligence

Participants: Jérôme Euzenat [Contact], Jérôme David, Sébastien Laborie.

Exmo is involved in the *Web intelligence* project supported by the Rhône-Alpes region. *Exmo* is more specifically involved in ontology matching in peer-to-peer systems with Marie-Christine Rousset (LIG) and Jean-Marc Petit (LIRIS).

More information on *Web intelligence* can be found at http://www.web-intelligence-rhone-alpes.org/.

7.2. European initiatives

7.2.1. NeOn integrated project: Networked ontologies

Participants: Jérôme Euzenat [Contact], Chan Le Duc, Antoine Zimmermann.

Exmo contributes to the *NeOn* integrated project considering all the aspects of "networked ontologies", i.e., the ontologies considered with their links to other ontologies. We work on the aspects of providing semantics to these networked ontologies (through alignments and ontology modules) and using ontology matching to recontextualise ontologies.

More information on *NeOn* can be found at http://www.neon-project.org.

7.3. International Initiatives

7.3.1. Collaboration with Universidade Federal de Pernambuco

Participants: Jérôme Euzenat [Contact], Antoine Zimmermann.

We have started collaborating with Frederico Freitas of the Universidade Federal de Pernambuco (Recife) on ontology modules and composition (see §6.1.4).

Sébastien Laborie visited UFPE in September 2008.

8. Dissemination

8.1. Leadership within scientific community

- Jérôme Euzenat is founding member of the "Semantic Web Science Association" (steering committee for the ISWC conference series), member of the "Scientific advisory board" of the "European Academy for Semantic web Education" (EASE) and foundig member of EASE and member of the steering committee of the LMO conference series.
- Jérôme Euzenat has been co-chairman (with Aldo Gangemi as chairman) of the 16th International Conference on Knowledge Engineering and Knowledge Management (EKAW) held in Acitrezza, Italy [27].

8.2. Editorial boards, conference and workshop committees

- Editorial board of the journal "Journal of Web Semantics" and "Journal on Data Semantics" (Jérôme Euzenat).
- Programme committee member for the 2008 issues of the conferences International Semantic Web Conference (ISWC), European Semantic Web Conference (ESWC), European Conference on Artificial Intelligence (ECAI), (US) National conference on AI (AAAI), International Conference on Conceptual Modeling (ER), Formal Ontologies for Information Systems (FOIS), International Conference on Artificial Intelligence: Methodology, Systems, Applications (AIMSA), Reconnaissance des Formes et Intelligence Artificielle (RFIA), and Langages et Modèles à Objets (LMO).

8.3. Conferences, meetings and tutorial organisation

- Jérôme Euzenat has organised (with Paolo Bouquet, Chiara Ghidini, Deborah McGuinness, Valeria de Paiva, Gulin Qi, Luciano Serafini, Pavel Shvaiko, Holger Wache and Alain Léger) the 4th "Context and ontologies" workshop of the 18th ECAI, Patras (GR), 2008 [26].
- Jérôme Euzenat has organised (with Pavel Shvaiko, Fausto Giunchiglia and Heiner Stuckenschmidt) the 3rd "Ontology matching" workshop of the 7th ISWC, Karlsruhe (DE), 2008 [28].
- Jérôme Euzenat has organised (with many other colleagues) the Ontology Alignment Evaluation Initiative 2008 at the "Ontology matching" workshop of the 7th ISWC, Karlsruhe (DE), 2008 [13].

8.4. Invited conferences and other talks

- Alignement d'ontologies: problèmes et solutions sémantiques et dynamiques, journée projet ANR "FORUM", Paris (FR), 15 May 2008 (Jérôme Euzenat)
- (an overview of) Interoperability in semantic distributed systems, seminar DERI, Galway (IE), 4 July 2008 (Jérôme Euzenat)
- Knowledge interchange with no limits: the ontology matching challenge: invited conference 20th birthday of the EPFL database laboratory, Lausanne (CH), 8 September 2008 (Jérôme Euzenat)
- Semantic interoperability... through ontology matching: 1st INTEROP-Vlab.It workshop on "enterprise interoperability", Cagliari (IT), 12 September 2008 (Jérôme Euzenat)
- Semantic adaptation of multimedia documents: Seminar UFPE, Recife (BR), 15 September 2008 (Sébastien Laborie)
- Dynamique et sémantique: l'alignement d'ontologies dans le web sémantique est bien plus difficile que vous n'osiez même le penser: Invited conference 24e journées "Bases de données avancées (BDA)", Valence (FR), 22 October 2008 (Jérôme Euzenat)
- Ten challenges for ontology matching: Invited conference (with Pavel Shvaiko) ODBase, Monterey (MX), 13 November 2008 (Jérôme Euzenat)
- Technologies du web sémantique pour la gestion documentaire: Technological watch seminar IN'Tech, Montbonnot (FR), 4 December 2008 (Jérôme Euzenat)

8.5. Teaching

- Co-ordination of the Web intelligence profile of the second year of mathematics and informatics master, Intelligence, Interaction, Information track, Joseph Fourier university and INPG, Grenoble, resp. Yves Demazeau.
- Ontology matching lecture and hands-on session (Jérôme Euzenat, 3h): European Summer School on Ontology Engineering and the Semantic Web, Cercedilla (ES), resp. John Domingue.
- Ontology matching lectures (Jérôme Euzenat, 10h): Universidad Politecnica de Madrid, Madrid (ES), resp. Asunción Gómez-Pérez.

- Semantic interoperability tutorial (Jérôme Euzenat with Natasha Noy, 1h): ISWC invited tutorial, Karlsruhe (DE), resp. John Domingue.

8.6. Miscellaneous

- Jérôme Euzenat has been consulting visitor for the EDGAR project, ISEP, Porto (PT).
- Jérôme Euzenat has been member of the AERES visiting committee for LORIA and INRIA Lorraine.
- Jérôme Euzenat has been expert on OSEO (FR) and WWTF (AT) funding demand.
- Jérôme Euzenat has participated in the European Commission Knowledge and content research unit FP7 brainstorming meeting (Luxembourg, LU).

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