INSTITUT NATIONAL DE RECHERCHE EN INFORMATIQUE ET EN AUTOMATIQUE

Project-Team EXMO

Computer-mediated communication of structured knowledge

Rhône-Alpes

THEME 3A

Activity Report

2003

Table of contents

1. Team

Head of project-team
Jérôme Euzenat [Research scientist (CR INRIA)]

Administrative assistant
Marion Ponsot

Research scientist
Jean-François Baget [CR INRIA]

Ph. D. students
Raphaël Troncy [CIFRE (Institut National de l'Audiovisuel)]

Technical staff
Fabien Triolet [Software development staff, until July 1st, 2003]

2. Overall Objectives

Key words: *knowledge representation, semantics of knowledge representation, transformations, ontologies, property preservation, semantic web, content representation, semiotics, Transmorpher, WWW, DLML, XML, XSLT.*

We consider that, in future information systems, formalized knowledge will be massively exchanged. In this communication process, the computer can complement its medium and memory roles by formatting, filtering, classifying, consistency checking or generalizing knowledge. These manipulations can be thought of as transformations. This approach is developing with the generalized use of standardized exchange languages (XML) in network communication. Consequently, the users must ask for more guarantees from the performed transformations. EXMO's goal is the development of theoretical and software tools for enabling interoperability in formalized knowledge exchange.

Our main approach is the investigation of the properties that transformations must satisfy. Among these properties are content or structure preservation, traceability, or, conversely, confidentiality. We want to contribute a "general theory of transformations" grounded on transformation properties rather than on transformations themselves.

On the one hand, we aim at showing that this approach can be applied to various contexts depending on languages, properties and transformations. We study information preservation modelled by lattices or scenario preservation in adapted multimedia documents. On the other hand, we investigate more precisely semantic properties when transforming from one knowledge representation language to another. The main question is: are the consequences of the initial representation still consequences of the transformed one? For helping answering it, we establish relationships between several kinds of semantic properties, known or new. We also investigate more restricted cases (family of languages, patterns) that can use these relationships for establishing properties more quickly.

On a longer term, we want to explore properties that we call semiotic, i.e., 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.

Our medium term objectives are (1) the opportunity to analyse transformations in terms of a set of composition operators, (2) the isolation of useful properties and the study of their behavior with regard to these operators and (3) the capability to prove these properties on this kind of transformations.

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

3. Scientific Foundations

3.1. Knowledge representation semantics

After years of empirical development, the domain of "knowledge representation" has been rationalized. In the past 15 years, the semantics of knowledge representation languages (description logics [19], conceptual graphs and object-based languages) has been investigated. It is usually defined within model theory initially developed for logics.

We consider a language L as a set of syntactically defined expressions (often inductively defined by applying constructors over other expressions). A representation (r) is a set of such expressions. An interpretation function (I) is inductively defined over the structure of the language to a set 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 interpretations. An expression (δ) is then a consequence of a set of expressions (r) if it is satisfied by all of its models (noted $r \models \delta$).

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). To that extent, 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 more classical programming. These programs are able to deduce theorems (noted $r \vdash \delta$). 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. And even for decidable languages, the algorithmic complexity of provers can 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 family of languages with associated modular prover algorithms - like description logics.

EXMO mainly considers languages with well-defined semantics, 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. Transformations and properties

A transformation (τ) is an algorithmic manner to generate a representation ($\tau(r)$) from another one (r), not necessarily in the same language. We will focus on transformations made of composition of more elementary transformations for which we only know the input, output and assumed properties.

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. More precisely, our work concerns syntactic transformations of XML ("eXtensible Markup Language") structures encoding knowledge representation languages. We take advantage of the XSLT transformation language ("XML Style Language Transformations" [21]) recommended by W3C, for which we put forward a compound transformation language (see §5.1).

The design of information systems as 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 - and is satisfied if there exists an algorithmic means to recover r from $\tau(r)$).

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. To that extent, one can identify:

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

Our goal is to study transformations based on transformation properties rather than on representations or transformations. It 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?). Hereafter we presente some applications of this to particular properties. We try to characterize, 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 first motivating context is transformation system engineering (§4.1). It has been reinforced recently by the "semantic web" framework in which our work can find a natural place (§4.2)

4.1. Transformation system engineering

Computerisation and networking lead organisations to exchange information in machine-readable form. E-commerce generates a continuous flow of such documents. Because the transmitted information is neither addressed nor adapted to all the members of the 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. Additionaly, the Object Management Group Model-Driven Architecture (MDA) consider software development future as a composition of transformations from (platform independent) domain models in function 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 behavior of the flow of transformations. This calls for real "transformation system engineering" which should address the following:

- the lack of global consideration of transformations: they are processed in relation with other transformations;
- the need to consider the 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 §3.2). EXMO is concerned about tools and formal methods and aims at combining them in proposing solutions for transformation flow design environments (see §5.1).

4.2. Semantic web technologies

Internet technologies support access and sharing of knowledge, often difficult to access in a documentary form, in the organisations. However, the 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 the computer to manipulate knowledge on a more formal ground and to carry out similarity or generality search... Knowledge representation formalisms are good candidates for expressing the content.

The vision of a "semantic web" [20] 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 the annotations according to their semantics and their use. Taking advantage of this semantic web will require the manipulation of various knowledge representation formats. EXMO's problematic is thus central to the semantic web implementation.

Our work aims at enhancing content understanding. This concerns 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 there exists one day a standard knowledge representation language, it will be necessary to import and exchange ontologies in such a way that the semantics of their representation language is taken care of. Bringing solutions to this problem is part of the ambition of EXMO (see §6.3).

5. Software

EXMO's work can be used in software. We have designed and developed a system for expressing and processing relatively complex transformation flows.

5.1. Transmorpher : expression and processing of XML transformation flows

Participants: Jérôme Euzenat [Correspondent], Fabien Triolet.

In order to prove or check the properties of transformations, it is necessary to have a representation of these transformations. The XSLT language enables the expression of a transformation in XML but is relatively difficult to analyse. In order to overcome this problem, we have designed and developed in collaboration with the FLUXMEDIA company, the TRANSMORPHER environment. TRANSMORPHER is a layer on top of XSLT allowing the expression of complex transformation flows.

TRANSMORPHER enables the definition and processing of generic transformations of XML documents. It aims at providing XSLT extensions in order to:

- Describe straightforwardly simple transformations (e.g., removing elements, replacing attribute names, merging documents, applying regular expression substitution);
- Composing transformations by connecting their (multiple) input and output;
- Applying transformations until closure;
- Calling external transformation engines.

TRANSMORPHER describes the transformation flows in XML. Input/output channels carry the information, mainly XML, from one transformation to another. Transformations can be other transformation flows or elementary transformations. TRANSMORPHER provides a set of abstract elementary transformations (including their execution model) and one default instantiation. Such elementary transformations include external call (e.g. XSLT), dispatcher, serializer, query engine, iterator, merger, generator and rule sets.

Rule sets describe transformations in a language simpler than XSLT. It is currently processed by transformation to XSLT (extended by regular expression substitution).

TRANSMORPHER provides a set of documented JAVA classes (which can be refined or integrated into another software) and a transformation flow processing engine. A transformation flow can be described by programming in JAVA or providing an XML description. TRANSMORPHER has been registered by the "Agence de Protection des Programmes" (APP) under the IDDN.FR.001.430009.000.R.P.2003.000.30620. It is freely available, under the GPL licence, since June 2001 at http://transmorpher.inrialpes.fr. It works correctly but is still subject to improvements.

An extension of TRANSMORPHER towards safer transformations consists in attaching assertions to the transformations in a transformation flow in order to tell if a property is assumed, proved or to be checked. This will allow experimentats on proving properties of compound transformations.

6. New Results

The results obtained in 2003 are especially related to the transformation specification approach (we always consider them in relation with a semantic definition but do not characterize properties). The language designed for composing content and structure description of audio-visual documents makes use of transformation for avoiding redondancy (§6.1). Transformation is also used for adapting multimedia documents (§6.2) and for reasning in graph-based knowledge representation languages (§6.3). More recent results concern the research of ontology alignments, which, in turn, will provide transformations (§6.4).

6.1. Structure and content representation of audiovisual documents

Participant: Raphaël Troncy [Correspondent], Jérôme Euzenat.

There exist various formats for describing audio-visual documents. Among them MPEG-7 is the de facto standard for describing the structure and low-level content of documents. It promotes the use of XML-Schema for describing the higher-level content. However, XML-Schema is not the best suited language for knowledge representation: it is able to describe the structure of documents but has no model theoretic semantics on which to ground inference. There is a need for integrating the structural representation of documents to their conceptual representation so that it is possible to query both the content and the structure in an integrated way.

Raphaël Troncy proposed a solution by allowing the expression of content in the OWL language and by transforming the structural description within the framework of an OWL ontology for audio-visual documents [12][13]. This system has been implemented and experimented on a corpus of documents on which it was able to answer queries that cannot be answered in one of the other formalisms alone.

6.2. Scenario-preservation in multimedia documents adaptation

Participants: Jérôme Euzenat [Correspondent], Nabil Layaïda [WAM team-project].

When a multimedia document is executed on platforms with limited resources (e.g., a mobile phone that can only display one image at once or an interactive display without keyboard), it is necessary to adapt the document to the target device. We want to describe properties that must be preserved by that adaptation. To that purpose, we use the semantic approach, which considers a model of a multimedia document as one of its potential execution (an execution satisfying its specification). We define classes of models (e.g., considering that all models with the same scheduling are the same). In a first approximation, adaptation will reduce the set of models of a specification by selecting those satisfying the adaptation constraints [8].

When there is no model satisfying adaptation constraints, it is necessary that the transformation provides specifications whose models satisfy the constraints and are close to a model of the initial specification. A distance between models must thus be defined. We have experimented on the temporal structure of multimedia documents taking adavantage of the conceptual neighborhood structure of the set of qualitative relations.

While we have developed a framework in general and shown how to use it with Allen temporal algebra, we are further considering the direct translations from currently used languages for specifying multimedia documents. We are developing a SMIL 2.0 to Allen translation that allows the round-trip and will provide adaptation within this loop. By so doing, we ensure that the adaptation is not dependent on the translation.

This translation will take into account other dimensions of multimedia documents (space and structure) in SMIL 2.0. The extension of this work towards rhetorical representation is still one of our main goals. Although not specifically addressed this year, it is not totally unrelated to the work of Raphaël Troncy on combining structural and conceptual representation in audio-visual documents [12][13][14].

6.3. Algorithms for graph-based knowledge representation languages

Participant: Jean-Fraçois Baget [Correspondent].

We are interested in various knowledge representation languages provided with model-theoretic semantics and whose objects can be represented by graphs. Though the graphical representation of these objects is often considered as an interesting feature for knowledge representation (natural representation, intuitive understanding), we are most interested in graphs as a mathematical structure, and in their use for reasoning. Expressing reasoning as graph-theoretic operations achieves two different goals: for an optimization purpose, we can benefit from various algorithms studied in graph theory; moreover, we believe that visualizing reasoning on graphs adds much to the intuitive understanding of data.

Coming from a Conceptual Graphs background, we have adapted the reasoning operation used in this model (basically a graph homomorphism) to obtain sound and complete inferences in the Semantic Web languages RDF [7] and RDFS. These inferences can thus benefit from the efficient graph homomorphism algorithms developed for Conceptual Graphs [15].

This work has to be generalized by characterizing, in terms of semantics, languages for which inferences can be expressed via some kind of graph homomorphism. Then it will have to be extended: more expressivity is gained using description logics (yielding the language OWL [15]), or rules (adapting to RDF/RDFS work previously done on Conceptual Graphs).

6.4. Similarity for ontology alignment

Participant: Jérôme Euzenat [Correspondent].

Integrating heterogeneous resources of the web will require finding agreement between the underlying ontologies. A variety of methods from the literature may be used for this task, basically they perform pair-wise comparison of entities from each of the ontologies and select the most similar pairs.

Semantic interoperability can be grounded in ontology reconciliation. The underlying problem, which we call the "ontology alignment" problem, 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) that hold between these entities.

In order to be able to align ontologies written in OWL-Lite, we adapted a method developed for measuring object-based similarity [10]. This method has the benefit of considering many of the features of ontology descriptions in computing the alignment: it deals successfully with external data types, internal structure of classes as given by their properties and constraints, external structure of classes as given by their relationships to other classes and the availability of individuals. This is an improvement towards other methods that take advantage of only a subpart of the language features.

The proposed method does not only compose linearly individual methods for assessing the similarity between entities, it uses an integrated similarity definition that makes them interact during computation. So doing, it copes with the unavoidable circularities that occur within ontologies.

This work is complemented by a reflexion on the common features and results of alignment algorithms that will be used for designing format allowing to compose and to evaluate these algorithms [11]. This will be further considered in the framework of the "Knowledge web" network of excellence.

This work is developed in collaboration with the University of Montréal (see §8.3.2).

7. Contracts and Grants with Industry

7.1. INA

Participants: Raphaël Troncy, Jérôme Euzenat.

The work of Raphaël Troncy (see §6.1) is developed in close cooperation with the research and experiementation department of the National Institute for Audiovisual (Institut National de l'Audiovisuel, INA). Raphaël Troncy's thesis is jointly supervised by Bruno Bachimont and Jérôme Euzenat in the framework of a CIFRE contract.

8. Other Grants and Activities

8.1. National initiatives

8.1.1. *Action spécifique Web sémantique (CNRS)*

Participants: Jérôme Euzenat [correspondant], Jean-François Baget, Raphaël Troncy.

The STIC department within CNRS has funded some specific actions (« actions spécifiques ») in order to study research opportunities in particular areas. EXMO has been involved in the one devoted to the "semantic web" headed by Jean Charlet, Philippe Laublet and Chantal Reynaud. Other INRIA teams such as ACACIA and ORPAILLEUR have been participating as well.

The goal of our prospective work was to identify strong points in French research and their contribution to the semantic web and its development at the international level. We have more particularly considered the aspect of languages [15] in which we are otherwise involved (see §8.3.1).

8.2. European initiatives

8.2.1. *OntoWeb thematic network: ontology-based information exchange for knowledge management and electronic commerce*

Participants: Jérôme Euzenat [correspondant], Jean-François Baget, Raphaël Troncy, Philippe Dubreuil.

EXMO is involved in the European thematic network ONTOWEB (« Ontology-based information exchange for knowledge management and electronic commerce »). The INRIA node comprises the ACACIA, AXIS, EXMO and ORPAILLEUR teams. It is in charge of the "promotting international collaboration" workpackage. EXMO represents INRIA within the project board.

More information on ONTOWEB can be found at http://www.ontoweb.org.

8.3. International Initiatives

8.3.1. *W3C WebOnt Working group*

Participants: Jérôme Euzenat [correspondant], Jean-François Baget.

The Web Ontology working group (for short WebOnt) is one of the two working groups (along with RDF Core) that form the "Semantic Web Activity" of the World Wide Web Consortium (W3C). Jean-François Baget and Jérôme Euzenat are the INRIA representatives among 53 other members of WebOnt.

WebOnt's goal is to design an ontology language designed for the World Wide Web. The language proposed (named OWL - a somewhat disordered acronym of Web Ontology Language) is a description logics based language (in the continuity of DAML+OIL), built on top of the other language designed in W3C semantic web activity: RDF.

OWL is a proposed recommendation of W3C since december 2003. We have more specifically worked on the OWL/XML presentation language and its translation to the OWL/RDF interchange format [16].

More information on WebOnt can be found at http://www.w3.org/2001/sw/WebOnt/.

8.3.2. *Collaboration with University of Montréal*

Participants: Jérôme Euzenat [correspondant].

EXMO collaborates with the team of Petko Valtchev at the university of Montréal (DIRO) on the topic of "Ontology alignment" (see §6.4). This work has been supported by travel grants from the "Centre Jacques Cartier" and the "Consulat de France" in Montréal.

9. Dissemination

9.1. Leadership within scientific community

- Jérôme Euzenat is elected member of the board of the French artificial intelligence society (AFIA).
- Jérôme Euzenat is founding member of the "Semantic web science association" (steering committee for the ISWC conference series) and member of the steering committee for the RFIA 2004 conference.
- Jérôme Euzenat is board member and coordinator of "Promoting world-wide collaboration" work package of the OntoWeb thematic network (see §8.2) involving 70 teams (2001-2004).

9.2. Editorial boards, conference and workshop committees

- Editorial board of the journal « L'objet », « Journal électronique d'intelligence artificielle (JEDAI) » and "Journal of Data Semantics" (Jérôme Euzenat).
- Programme committee for the 2003 issues of the conferences "World-wide web conference (WWW)", "International Conference on Web Information Systems Engineering (WISE)", "Langages et modèles à objets (LMO)", "ODBase", "Ingénierie des connaissances (IC)", "national meeting on reasoning models (Journées nationales sur les modèles de raisonnement)", "French web conference (journées française de la toile)", and "Formal models of interaction (modèles formels de l'interaction)".
- Programme committee for the workshop on "Ontologies and distributed systems" at IJCAI 2003.

9.3. Conferences, meetings and tutorial organization

- Organizing committee (finance chair) of the "2nd international semantic web conference (ISWC-2003)", Sanibel Island (FL US), october 2003. 400 people.
- Organization of a "Semantic web industrial day" with Alain Léger and Eunika Mercier-Laurent on the AFIA joint event (Laval, July 2003).

9.4. Miscellaneous

- Development and maintainance of the web site (http://jedai.afia-france.org) for the Journal électronique d'intelligence artificielle (JEDAI).

9.5. Invited conferences and other talks

- Semantic web opportunities for ILOG: an outsider* technical view: ILOG technical advisory board, Boston (MA US), January 17th 2003 (Jérôme Euzenat)
- Le web sémantique : presentation at Groupement des Éditeurs de services en ligne (GESTE), Paris (FR), January 21th 2003 (Jérôme Euzenat)
- Semantic web and formalized knowledge exchange : 4th Sino-Franco workshop on web technologies, Tamkang University, Taipei (TW), March 18th 2003 (Jérôme Euzenat)
- Le web sémantique : presentation to AEPI ambassadors (local players), Montbonnot, April 16th 2003 (Jérôme Euzenat)
- De la sémantique formelle à une approche computationnelle de l'interprétation : workshop of CNRS/STIC "Web sémantique" specific action on "Semantic web and social sciences", Ivry-sur-Seine (FR), May 7th 2003, 2p. (Jérôme Euzenat)
- Knowledge web : hearings of the 6th PCRD first call, Luxembourg (LU), June 10th 2003, 5p. (Jérôme Euzenat)
- Le web sémantique : industrial day on the "semantic web" at AFIA joint event, Laval (FR), July 4th 2003 (Jérôme Euzenat)
- Knowledge technologies and the 6th Framework programme, KTWeb workshop, Luxembourg (LU), December 3rd 2003 (Jérôme Euzenat)

10. Bibliography

Major publications by the team in recent years

[1] ROLAND DUCOURNAU, JÉRÔME EUZENAT, GÉRALD MASINI, AMEDEO NAPOLI, editors, *Langages et modèles à objets : état et perspectives de la recherche.* series collection « Didactique », volume 19, INRIA, INRIA Rocquencourt (FR), 1998, http://www.inria.fr/rrrt/d-019.html.

[2] JÉRÔME EUZENAT. *Représentations de connaissance : de l'approximation à la confrontation.* Habilitation à diriger des recherches, Université Joseph Fourier, Grenoble (FR), janvier, 1999.

Books and Monographs

[3] JÉRÔME EUZENAT, AMEDEO NAPOLI, editors, *Special issue: XML et les objets. La voie vers le web sémantique?.* in « RSTI - L'objet », Hermès, Paris (FR), volume 9, number 3, 2003.

Articles in referred journals and book chapters

[4] JÉRÔME EUZENAT, HEINER STUCKENSCHMIDT. *The 'family of languages' approach to semantic interoperability.* in « Knowledge transformation for the semantic web », BORYS OMELAYENKO, MICHEL KLEIN, editors, IOS press, Amsterdam (NL), pages 49-63, 2003.

[5] JÉRÔME EUZENAT, AMEDEO NAPOLI, JEAN-FRANÇOIS BAGET. *XML et les objets (Objectif XML).* in « RSTI - L'objet », Hermès, Paris (FR), volume 9, number 3, pages 11-37, 2003.

Publications in Conferences and Workshops

[6] JEAN-FRANÇOIS BAGET. *Simple conceptual graphs revisited: hypergraphs and honjunctive types for efficient projection algorithms.* in « Proc. 11th international conference on conceptual sructures (ICCS), Dresden (DE) », in « Lecture notes in computer science », Springer Verlag, Heidelberg (DE), volume 2870, 2003, ALDO DE MOOR, WILFRIED LEX, BERNHARD GANTHER, editors, pages 195-208.

[7] JEAN-FRANÇOIS BAGET. *Homomorphismes d'hypergraphes pour la subsomption en RDF.* in « Actes 3e journées nationales sur modèles de raisonnement (JNMR), Paris (FR) », 2003.

[8] JÉRÔME EUZENAT, NABIL LAYAÏDA, VICTOR DIAS. *A semantic framework for multimedia document adaptation.* in « Proc. 18th International Joint Conference on Artificial Intelligence (IJCAI), Acapulco (MX) », 2003, pages 31-36, Morgan Kauffman, San-Mateo (CA US).

[9] JÉRÔME EUZENAT. *De la sémantique formelle à une approche computationelle de l'interprétation.* in « Actes journées AS 'Web sémantique' CNRS sur Web sémantique et sciences de l'homme et de la société, Ivry-sur-Seine (FR) », 2003, http://www.inrialpes.fr/exmo/cooperation/asws/wsshs.html.

[10] JÉRÔME EUZENAT, PETKO VALTCHEV. *An integrative proximity measure for ontology alignment.* in « Proc. ISWC-2003 workshop on semantic information integration, Sanibel Island (FL US) », pages 33-38, 2003, ftp://ftp.inrialpes.fr/pub/exmo/publications/euzenat2003h.pdf.

[11] JÉRÔME EUZENAT. *Towards composing and benchmarking ontology alignments.* in « Proc. ISWC-2003 workshop on semantic information integration, Sanibel Island (FL US) », 2003, pages 165-166, ftp://ftp.inrialpes.fr/pub/exmo/publications/euzenat2003i.pdf.

[12] RAPHAËL TRONCY. *Le raisonnement dans les descriptions documentaires: l'apport de la représentation des connaissances.* in « Actes 14e journées francophones sur Ingénierie des Connaissances (IC), Laval (FR) », Presses Universitaires de Grenoble (PUG), Grenoble (FR), 2003, pages 161-176.

[13] RAPHAËL TRONCY. *Integrating structure and semantics into audio-visual documents.* in « Proc. 2nd conference on International semantic web conference (ISWC), Sanibel Island (FL US) », in « Lecture notes in computer science », Springer Verlag, Heidelberg (DE), volume 2870, DIETER FENSEL, KATIA SYCARA, JOHN MYLOPOULOS, editors, pages 566-581, 2003.

[14] RAPHAËL TRONCY, ANTOINE ISSAC, VÉRONIQUE MALAISÉ. *Using XSLT for interoperability: DOE and the travelling domain experiment.* in « Proc. 2nd workshop on evaluation of ontology-based tools (EON), Sanibel Island (FL US) », pages 92-102, 2003, http://ceur-ws.org/Vol-87/EON2003_Troncy.pdf.

Internal Reports

[15] JEAN-FRANÇOIS BAGET, ÉTIENNE CANAUD, JÉRÔME EUZENAT, MOHAND SAÏD-HACID. *Les langages du web sémantique.* in « Action spécifique « Web sémantique » », JEAN CHARLET, PHILIPPE LAUBLET, CHANTAL REYNAUD, editors, chapter 2, pages 9-24, 2003, ftp://ftp.inrialpes.fr/pub/exmo/publications/baget2003b.pdf.

[16] MASAHIRO HORI, JÉRÔME EUZENAT, PETER PATEL-SCHNEIDER. *OWL Web Ontology Language XML Presentation Syntax*. Note, W3C, 2003, http://www.w3.org/TR/owl-xmlsyntax.

Miscellaneous

[17] JÉRÔME EUZENAT. *Les avancées du web sémantique (Qu'est-ce que le web sémantique?)*. in « Archimag », number 165, pages 22-26, 2003, ftp://ftp.inrialpes.fr/pub/exmo/reports/euzenat2003d.pdf.

[18] JÉRÔME EUZENAT. *A theory of computer semiotics par Peter Borg Andersen*. in « Bulletin de l'AFIA », AFIA, volume 55, pages 55-58, 2003, ftp://ftp.inrialpes.fr/pub/exmo/publications/euzenat2003e.pdf.

[18] JÉRÔME EUZENAT, AMEDEO NAPOLI. *The semantic web: year one (Spinning the semantic web: bringing the world wide web to its full potential by Dieter Fensel, James Hendler, Henry Lieberman and Wolfgang Wahlster)*. in « IEEE Intelligent systems », volume 18, number 6, pages 76-78, 2003, ftp://ftp.inrialpes.fr/pub/exmo/publications/euzenat2003k.pdf.

Bibliography in notes

[19] FRANZ BAADER, DIEGO CALVANESE, DEBORAH MCGUINNESS, DANIELE NARDI, PETER PATEL-SCHNEIDER, editors, *The description logics handbook*. Cambridge university press, Cambridge (UK), 2003.

[20] TIM BERNERS-LEE, JAMES HENDLER, ORA LASSILA. *The semantic web*. in « Scientific american », number 5, volume 279, 2001, pages 35-43, http://www.scientificamerican.com/2001/0501issue/0501berners-lee.html.

[21] JAMES CLARK. *XSL Transformations (XSLT)*. Recommendation, W3C, 1999, http://www.w3.org/TR/xslt.