IN PARTNERSHIP WITH:
CNRS

INRA

Université des sciences et techniques du Languedoc (Montpellier 2)

Activity Report 2011

Project-Team GRAPHIK

GRAPHs for Inferences and Knowledge representation

IN COLLABORATION WITH: Laboratoire d'informatique, de robotique et de microélectronique de Montpellier (LIRMM)

RESEARCH CENTER
Sophia Antipolis - Méditerranée

THEME
Knowledge and Data Representation and Management

Table of contents

Project-Team GRAPHIK

Keywords: Knowledge, Reasoning, Graphs, Ontologies, Complexity

1. Members

Research Scientists

Jean-François Baget [Junior Researcher, INRIA]

Rallou Thomopoulos [Junior Researcher, INRA, on leave since Sept. 2011]

Faculty Members

Michel Chein [Professor, Université Montpellier 2]

Madalina Croitoru [Associate Professor, Université Montpellier 2]

Jérôme Fortin [Associate Professor, Université Montpellier 2]

Souhila Kaci [Professor, Université Montpellier 2 (since Sept. 20011), HdR]

Michel Leclère [Associate Professor, Université Montpellier 2]

Marie-Laure Mugnier [Team leader, Professor, Université Montpellier 2, on leave at INRIA until Aug. 2011, HdR]

External Collaborators

Patrice Buche [Research Engineer, INRA, HdR]

Sébastien Destercke [Junior Researcher, CIRAD (until June 2011)]

Éric Salvat [Associate Professor, IMERIR (Perpignan) (until June 2011)]

Technical Staff

Alain Gutierrez [Engineer, CNRS]

Luc Menut [Engineer, INRA, 50% member of GraphIK]

Cécile Ochman [Engineer, Université Montpellier II (until Apr. 2011)]

PhD Students

Léa Guizol [2011 – co-funded with ABES]

Mélanie König [2011 – Ministry Grant]

Bruno Paiva Lima Da Silva [2010 – Ministry Grant]

Tjitze Rienstra [2010 – co-funded with University of Luxembourg (since sept. 2011)]

Michaël Thomazo [2010 – Grant from École Normale Superieure de Cachan]

Post-Doctoral Fellow

Khalil Ben Mohamed [ATER, Université Montpellier 2, until Aug. 2011]

Administrative Assistant

Annie Aliaga [INRIA, shared with other teams]

2. Overall Objectives

2.1. Logic and Graph-based KRR

The main research domain of GraphIK is Knowledge Representation and Reasoning (KRR), which studies paradigms and formalisms for representing knowledge and reasoning on these representations. We follow a logic-oriented approach of this domain: the different kinds of knowledge have a logical semantics and reasoning mechanisms correspond to inferences in this logic. However, in the field of logic-based KRR, we distinguish ourselves by using graphs and hypergraphs (in the graph-theoretic sense) as basic objects. Indeed, we view labelled graphs as an *abstract representation* of knowledge that can be expressed in many KRR languages (different kinds of conceptual graphs —historically our main focus—, the Semantic Web language RDFS, expressive rules equivalent to the so-called tuple-generating-dependencies in databases, some description logics dedicated to query answering, etc.). For these languages, reasoning can be based on the structure of objects (thus on graph-theoretic notions), with homomorphism as a core notion, while being sound and complete with respect to entailment in the associated logical fragments. An important issue is to study *trade-offs* between the expressivity of languages and the computational tractability of (sound and complete) reasoning in these languages.

2.2. From Theory to Applications, and Vice-versa

We study logic- and graph-based KRR formalisms from three perspectives:

- theoretical (structural properties, expressiveness, translations between languages, problem complexity, algorithm design),
- software (developing tools to implement theoretical results),
- applications (which also feed back into theoretical work).

2.3. Main Challenges

GraphIK focuses on some of the main challenges in KRR:

- ontological query answering, i.e., query answering taking an ontology into account, and able to process large datasets;
- reasoning with rule-based languages;
- dealing with heterogeneous and with hybrid knowledge bases (*i.e.* composed of several modules that have their own formalism and reasoning mechanisms);
- reasoning with “imperfect knowledge” (*i.e.* vague, uncertain, partially inconsistent, multi-viewpoints and/or with multi-granularity).

2.4. Scientific Axes

GraphIK has three main scientific directions:

1. **decidability, complexity and algorithms** for problems in languages corresponding to first-order logic fragments;
2. the addition of expressive and **non-classical features** (to the first-order logic languages studied in the first axis) with a good expressivity/efficiency trade-off;
3. the integration of theoretical tools to **real knowledge-based systems**.

From an applicative viewpoint, two themes are privileged for the next years:

- knowledge representation for agronomy, the final objective being a knowledge-based system to aid decision-making for the quality control in food processing.
- data integration and quality improvement, specifically for document metadata bases.

2.5. Highlights

The book "Working with Preferences — Less Is More" [11] by Souhila Kaci was released in September 2011 (by Springer, Cognitive Technologies Series). This book is devoted to the representation of preferences and the associated reasoning, as well as the application of preferences to argumentation systems, database queries and multi-criteria decision making.

Marie-Laure Mugnier was keynote speaker at the International Conference RR 2011 (The Fifth International Conference on Web Reasoning and Rule Systems). This conference is becoming a major forum for discussion and dissemination of new results on all topics concerning Web Reasoning and Rule Systems.

3. Scientific Foundations

3.1. Logic-based Knowledge Representation and Reasoning

We follow the mainstream *logical* approach to the KRR domain. First-order logic (FOL) is the reference logic in KRR and most formalisms in this area can be translated into fragments (i.e., particular subsets) of FOL. A large part of research in this domain can be seen as studying *trade-off* between the expressivity of languages and the complexity of (sound and complete) reasoning in these languages. The fundamental problem in KRR languages is entailment checking: is a given piece of knowledge entailed by other pieces of knowledge (for instance from the KB)? Another important problem is *consistency* checking: is a set of knowledge pieces (for instance the knowledge base, KB, itself) consistent, i.e., is it sure that nothing absurd can be entailed from it? The *query answering* problem is a topical problem (see 3.3). It asks for the set of answers to the query in the KB. In the special case of boolean queries (i.e., queries with a yes/no answer), it can be recast as entailment checking.

3.2. Graph-based Knowledge Representation and Reasoning

Besides logical foundations, we are interested in KRR formalisms that comply, or aim at complying with the following requirements: to have good *computational* properties and to allow users of knowledge-based systems to have a maximal *understanding and control* over each step of the knowledge base building process and use.

These two requirements are the core motivations for our specific approach to KRR, which is based on labelled *graphs*. Indeed, we view labelled graphs as an *abstract representation* of knowledge that can be expressed in many KRR languages (different kinds of conceptual graphs —historically our main focus—, the Semantic Web language RDFS, expressive rules equivalent to the so-called tuple-generating-dependencies in databases, some description logics dedicated to query answering, etc.). For these languages, reasoning can be based on the structure of objects, thus on based on graph-theoretic notions, while staying logically founded.

More precisely, our basic objects are labelled graphs (or hypergraphs) representing entities and relationships between these entities. These graphs have a natural translation in first-order logic. Our basic reasoning tool is graph homomorphism. The fundamental property is that graph homomorphism is sound and complete with respect to logical entailment i.e. given two (labelled) graphs G and H, there is a homomorphism from G to H *if and only if* the formula assigned to G is entailed by the formula assigned to H. In other words, logical reasonings on these graphs can be performed by graph mechanisms. These knowledge constructs and the associated reasoning mechanisms can be extended (to represent rules for instance) while keeping this fundamental correspondence between graphs and logics.

3.3. Ontological Query Answering

Querying knowledge bases is a central problem in knowledge representation and in database theory. A knowledge base (KB) is classically composed of a terminological part (metadata, ontology) and an assertional part (facts, data). Queries are supposed to be at least as expressive as the basic queries in databases, i.e., conjunctive queries, which can be seen as existentially closed conjunctions of atoms or as labelled graphs. The challenge is to define good trade-off between the expressivity of the ontological language and the complexity of querying data in presence of ontological knowledge. Classical ontogical languages, typically description logics, were not designed for efficient querying. On the other hand, database languages were able to process complex queries on huge databases, but without taking the ontology into account. There is thus a need for new languages and mechanisms, able to cope with the ever growing size of knowledge bases in the Semantic Web or in scientific domains.

This problem is related to two other problems identified as fundamental in KRR:

- *Query-answering with incomplete information.* Incomplete information means that it might be unknown whether a given assertion is true or false. Databases classically make the so-called closed-world assumption: every fact that cannot be retrieved or inferred from the base is assumed to be false. Knowledge-bases classically make the open-world assumption: if something cannot be inferred from the base, and neither can its negation, then its truth status is unknown. The need of coping with incomplete information is a distinctive feature of querying knowledge bases with respect to querying classical databases (however, as explained above, this distinction tends to disappear). The presence of incomplete information makes the query answering task much more difficult.
- *Reasoning with rules.* Researching types of rules and adequate manners to process them is a mainstream topic in the Semantic Web, and, more generally a crucial issue for knowledge-based systems. For several years, we have been studying some rules, both in their logical and their graph form, which are syntactically very simple but also very expressive. These rules can be seen as an abstraction of ontological knowledge expressed in main languages used in the context of KB querying. See point 6.2 for details on the results obtained.

A problem generalising the above described problems, and particularly relevant in the context of multiple data/metadata sources, is *querying hybrid knowledge bases*. In an hybrid knowledge base, each component may have its own formalism and its own reasoning mechanisms. There may be a common ontology shared by all components, or each component may have its own ontology, with mappings being defined among the ontologies. The question is what kind of interactions between these components and/or what limitations on the languages preserve the decidability of basic problems and if so, a “reasonable”complexity. Note that there are strong connections with data integration in databases.

3.4. Representation and Reasoning with Imperfect Knowledge

While classical FOL is the kernel of many KRR languages, to solve real-world problems we often need to consider features that cannot be expressed purely (or not naturally) in classical logic. The logic- and graph-based formalisms used for previous points have thus to be extended with such features. The following requirements have been identified from scenarios in decision making in the agronomy domain (see 4.2):

1. to cope with vague and uncertain information and preferences in queries;
2. to cope with multi-granularity knowledge;
3. to take into account different and potentially conflicting viewpoints ;
4. to integrate decision notions (priorities, gravity, risk, benefit);
5. to integrate argumentation-based reasoning.

Although the extensions we will develop need to be validated on the applications that motivated them, we also want them to be sufficiently generic to be applied in other contexts. Our approach consists in increasing the expressivity of our core languages, while trying to preserve their essential combinatorial properties, so that algorithmic optimizations can be transferred to these extensions.

4. Application Domains

4.1. Introduction

We currently focus on two application domains: knowledge representation in agronomy, more precisely applied to the quality in agri-food chains, and metadata management, in particular for bibliographic metadata.

The application to agronomy has been initiated recently in our group. The choice of this application domain is motivated both by the local context of GraphIK (UMR IATE) and by its adequation to our research themes. Indeed, the agri-food domain seems to be particularly well-adapted to artificial intelligence techniques: there are no mathematical models available to solve the problems related to the quality of agrifood chains, which need to be stated at a more conceptual level; solving these problems requires an integrated approach taking into account expert knowledge, which is typically symbolic, as well as numeric data, vague or uncertain information, multi-granularity knowledge, multiple and potentially conflicting viewpoints and actors.

The second area, metadata management, is not strictly speaking an application domain, but rather a cross-cutting axis. Indeed, metadata can be used to describe data in various areas (including for instance scientific publications in agronomy). We have a long experience in this domain, and we currently focus on biliographic metadata.

4.2. Agronomy

Quality control within agri-food chains, but also non-food chains relies on numerous criteria (environmental, economical, functional, sanitary quality, etc.). The objectives of quality are based on several actors. The current structure of chains is questioned as for system perenniality, protection of the environment, cost and energy. In all cases, the following questions have to be taken into account:

1. the actors' viewpoints are divergent, hence it is necessary to define reasoning mechanisms able to model and take into account the balance between viewpoints, and the risks and benefits they imply;
2. the successive steps involved in a chain, impacting the quality of end products, have limiting factors. Their improvement is a complex objective that has no simple solution;
3. data from literature are dispersed and scattered, which makes their use difficult.

These questions highlight the need for an integrated approach of agri-food chains, respectively with symbolic reasoning mechanisms, reverse engineering methods, and knowledge organization and modelling.

Our general objective is the conception of a decision support tool for the actors of an agri-food chain, in presence of contradictory viewpoints and priorities, including the concepts of gravity and certainty of a risk or a benefit. The first step is to build a knowledge-based system able to represent the different kinds of knowledge needed, and provided with consistency checking, querying and symbolic simulation mechanisms, which will allow to refine and validate the modelling.

Our results in 6.2, 6.3 and 6.4 can be seen as theoretical requirements towards this objective.

4.3. Bibliographic Metadata

Semantic metadata, in particular semantic annotations for multimedia documents, are at the core of the applications we are working on since several years. In the applications we developed in the previous years, mainly with INA (National Institute of Audiovisual) and FMSH (Fondation Maison des Sciences de l'Homme), we have built tools aimed at helping the manual construction of semantic annotations. In these projects, manual construction was unavoidable because semantically rich annotations, not obtainable by automatic processes, had to be built. In our current project with ABES (National Bibliographic Agency for Universities), the semantic metadata considered consists of information present in bibliographic databases and authority notices (which respectively describe documents and so-called authorities, such as authors typically). The challenge is not to build these metadata, which have been built by human specialists and already exist, but, for instance, to check their validity, to link or to merge different metadata bases.

Although not dedicated to metadata management, our formal graph-based framework allows to represent modular ontologies and rules, as well as semantic metadata and to reason with them (cf. for instance ontological query answering in 6.2). This framework is implemented in our software Cogui. Cogui provides several constructs (patterns, controlled interfaces, ...) to help the annotation process. One of our basic aim is now to develop and implement tools for managing and controlling semantic metadata bases (see 6.5 and 7.1).

5. Software

5.1. Cogui

Participants: Alain Gutierrez, Michel Chein, Michel Leclère, Marie-Laure Mugnier, Madalina Croitoru.

Cogui (http://www.lirmm.fr/cogui) is a tool for building and verifying knowledge bases. It is a freeware written in Java (version 1.2, 2005–2010 GPL Licence). Currently, it supports Conceptual Graphs and import/export in RDFS. It relies on CoGITaNT for reasoning tasks.

Here are the major evolutions of the version delivered this year:

- XML Datatypes are now supported.
- The use of URIrefs as identifiers and the notion of namespaces have been introduced to facilitate interoperability with RDF/XML.
- A pure java solver has been implemented to preserve reasoning capabilities on all platforms.
- A scripting language has been introduced on top of Cogui to satisfy specific applications requirements and facilitate the writing of prototypes. Scripts can be serialized in Cogui projects and give end-users the ability to manipulate objects of the knowledge base and use reasoning features through the Cogui core API.

5.2. Towards Large Knowledge Bases

Participants: Jean-François Baget, Madalina Croitoru, Bruno Paiva Lima Da Silva.

We have began to study different storage solutions for large databases, first as part of a Master's thesis, and now with the PhD of Bruno Paiva Lima da Silva [29]. The goal of this work is to evaluate different storage paradigms and systems (e.g., relational databases *MySQL* and *Sqlite*; triple stores *Sesame* and graph databases *Neo4J*, *DEX*, *HyperGraphDB* and *OrientDB*) with respect to our particular requirements (mainly ontological conjunctive query answering with large knowledge bases), and to integrate them in a unified way in a software tool (answering our genericity requirement and paving the way for hybrid KBs). We believe this work to be a necessary step for our next generation of software tools.

6. New Results

6.1. Note

Note that we do not include here the results from Souhila Kaci and Tjitze Rienstra since they joined the team in September 2011.

6.2. Ontological Query Answering with Rules

Participants: Jean-François Baget, Marie-Laure Mugnier, Michaël Thomazo, Michel Leclère, Eric Salvat, Mélanie König.

In collaboration with: Sebastian Rudolph (Karlsruhe Institute of Technology)

We have developed a framework based on rules that have the ability of generating unknown individuals, an ability sometimes called value invention in databases. These rules are of the form *body* $\rightarrow$ *head*, where the body and the head are conjunctions of atoms (without function symbols except constants) and variables that occur only in the head are *existentially* quantified, hence their name existential rules hereafter. E.g., $\forall x(Human(x) \rightarrow \exists y(isParent(y, x) \wedge Human(y)))$. These rules can be seen as the logical translation of conceptual graph rules, historically a main focus of the team [70] [55]. Existential rules have the same logical form as the well-known Tuple-Generating Dependencies (TGDs) in databases [45]. TGDs have been extensively used as a high-level generalization of different kinds of constraints, e.g., for data exchange [57]. Recently, there has been renewed interest for TGDs seen as rules in the context of ontological query answering. Indeed, the *value invention* feature has been recognized as crucial in an open-world perspective, where it cannot be assumed that all individuals are known in advance. The deductive database language Datalog allows to express some ontological knowledge but it does not allow for value invention. This motivated the recent extension of Datalog to TGDs (i.e., existential rules), which gave rise to the Datalog +/- family [52], [53], [54]. In KRR and in the Semantic Web, ontological knowledge is often represented with formalisms based on description logics (DLs). However, DLs traditionally focused on reasoning tasks about the ontology itself (the so-called TBox), for instance classifying concepts; querying tasks were restricted to ground atom entailment. Conjunctive query answering with classical DLs has appeared to be extremely complex, hence less expressive DLs more adapted to conjunctive query answering on large amounts of data have been designed recently, namely DL-Lite [51], $\mathcal{EL}$ [41], [63], and more generally Horn DLs (see e.g., [60]), cf. also the tractable profiles of the Semantic Web language OWL2. Existential rules cover the core of lightweight DLs dedicated to query answering, while being more powerful and flexible [53], [44],[21]. In particular, they have unrestricted predicate arity (while DLs consider unary and binary predicates only), which allows for a natural coupling with database schemas, in which relations may have any arity; moreover, adding pieces of information, for instance to take contextual knowledge into account, is made easy by the unrestricted predicate arity, since these pieces can be added as new predicate arguments.

Building on our previous work on conceptual graphs, while meeting this new trend, we have developed a knowledge representation framework centered on existential rules, which can be seen both as logic-based and graph-based.

Entailment, hence query answering, with existential rules is not decidable, thus finding decidable classes of rules as expressive as possible is a crucial issue. We have pursued our previous work on better understanding the border between decidability and undecidability. We have also extended rule dependency to k-dependency, which takes into account sequences of rule applications.

▷ *Results published in Artificial Intelligence Journal [13] (extending the work in [3], [44]); keynote talk synthesizing this work at RR'2011 [20]; extension to k-dependency at RR'2011 [22]*

.

For newly exhibited decidable classes (namely, "frontier-one", "frontier-guarded" and "weakly-frontier-guarded" rules), the problem complexity was unknown, moreover there was no algorithm for computing entailment. First, we have classified these classes with respect to combined complexity (i.e., usual complexity) with both unbounded and bounded predicate arity, and data complexity (i.e., restricting the input of the decision problem to the facts). An interesting result is that some of the new classes (namely frontier-one and frontier-guarded rules) have a polynomial time data complexity. Secondly, we have provided a generic algorithm for query entailment with a large class of rules including these classes, which is worst-case optimal for combined complexity (with or without bounded predicate arity) as well as for data complexity.

▷ *Results partially published at IJCAI'2011 [21]. Long paper in preparation with extended complexity results and all proofs, for submission to a major artificial intelligence journal.*

6.3. Processing Conjunctive Queries with Negation

Participants: Marie-Laure Mugnier, Michel Leclère, Khalil Ben Mohamed, Michaël Thomazo.

Conjunctive queries have long been recognized as the basic queries in database and knowledge-based systems. The fundamental decision problems on these queries, namely query inclusion checking (given two queries q_1 and q_2, is q_1 included in q_2, i.e., is the set of answers to q_1 included in the set of answers to q_2 for all databases) and query entailment (is a given query entailed by the database) are NP-complete. When atomic negation is added to queries and databases, these problems become Π_2^P-complete (with the open world assumption for the query entailment problem). Note that these problems can be recast as entailment in the FOL fragment of existentially closed conjunction of literals (without function symbols except constants). On the one hand, we have led a theoretical complexity study: we have investigated the role of pairs of literals called "exchangeable" (which generalizes the notion of unifiable literals) in the complexity increase. The main results are that when the number of exchangeable pairs is bounded, say by k, then the complexity falls from Π_2^P-complete to $P_{||}^{NP}$-complete for any $k \geq 3$, and is NP-complete for $k \leq 1$ (the case $k = 2$ being open).

In collaboration with: Geneviève Simonet (LIRMM Algeco team)

▷ *Research Report [65]. Long version accepted at* Information and Computation.

On the other hand, we have proposed, refined and compared experimentally several algorithms. This study follows first results of us in [61] and is the core of Khalil Ben Mohamed's PhD thesis defended in December 2010 [64].

▷ *Results published DEXA 2011 [24] (extending our work in RFIA 2010 [48], DEXA 2010 [46], AIMSA 2010 [47]).*

Let us point out that both theoretical and practical results still hold when the predicates are preordered, which allows to take very light ontologies into account, i.e., where concepts and relations are organized in a specialization preorder.

6.4. Argumentation Systems for Decision Making

Participants: Rallou Thomopoulos, Madalina Croitoru, Jérôme Fortin, Marie-Laure Mugnier.

In collaboration with: Joël Abecassis (IATE/INRA), Jean-Rémi Bourguet (UM3), Patrice Buche (IATE/INRA), Sébastien Destercke (IATE/CIRAD) Nir Oren (Univ. of Aberdeen, Scotland)

Scientific investigations in this axis are guided by applications of our partners in agronomy (IATE laboratory). Substantial part of the work has consisted of analyzing the proposed applications and the techniques they require in order to select appropriate applications with respect to our team project.

Argumentation is a reasoning model based on the construction and the evaluation of arguments. In his seminal paper, Dung has proposed an abstract argumentation framework [56]. In that framework, arguments are assumed to have the same strength. This assumption is unfortunately strong and often unsatisfied. Consequently, several generalizations of the framework have been proposed in the literature. In [49] and [50], we have led a comparative study of these generalizations. It clearly shows under which conditions two proposals are equivalent. We have also integrated those generalizations into a common more expressive framework.

An instantiation of Dung's abstract framework with the conceptual graph framework has been proposed. This representation uses default conceptual graph rules, an extension of classical conceptual graph rules (equivalent to existential rules, see Axis 1) with Reiter's defaults [67] allowing for non-monotonic reasoning, that we developed independently of the argumentation framework [42], [43]. In the conceptual graph representation, arguments are represented as nested graphs, attacks between arguments can be computed from the structure of arguments and default rules allow to compute several kinds of extensions (i.e., maximal sets of arguments jointly acceptable according to a given semantics).

This approach has been applied to agrifood chain analysis, which is a highly complex procedure since it relies on numerous criteria of various types: environmental, economical, functional, sanitary, etc. Quality objectives imply different stakeholders, technicians, managers, professional organizations, end-users, public organizations, etc. Since the goals of the implied stakeholders may be divergent, decision-making raises arbitration issues. Arbitration can be done through a compromise—a solution that satisfies, at least partially, all the actors— or favor some of the actors, depending on the decision-maker's priorities. We have analyzed a case study concerning risks/benefits within the wheat-to-bread chain. It concerns the controversy about the possible change in the ash content of the flour used for commonly used French bread. Several stakeholders of the chain are concerned, in particular the Ministry of Health through its recommendations in a national nutrition and health program, millers, bakers and consumers.

As already pointed out, the proposed approach is novel both for theoretical and application aspects.

▷ *Results presented in [30], [28].*

Let us mention additional results related to the applications in agronomy on decision making combining machine learning based on decision trees and ontologies [58],[30], as well as results obtained by our collaborators on semi-automatic data extraction from web data (tables), data reliability, and the representation and flexible querying of imprecise data with fuzzy sets [16], [14], [17], [26], [31], [25], [27], [33], [34]. These investigations are complementary to the above mentioned results on argumentation and generally relate to other aspects in the same applicative projects.

6.5. Semantic Data Integration

Participants: Michel Leclère, Michel Chein, Madalina Croitoru, Rallou Thomopoulos, Léa Guizol.

It often happens that different references (i.e. data descriptions), possibly coming from heterogeneous data sources, concern the same real world entity. In such cases, it is necessary: (i) to detect whether different data descriptions really refer to the same real world entity and (ii) to fuse them into a unique representation. Since the seminal paper [66], this issue has been been studied under various names:"record linking", "entity resolution","reference resolution", "de-duplication", "object identification", "data reconciliation", etc., mostly in databases (cf. the bibliography by William E. Winckler [1]). It has become one of the major challenges in the Web of Data, where the objective is to link data published on the web and to process them as a single distributed database. Most entity resolution methods are based on classification techniques; Fatiha Saïs, Nathalie Pernelle and Marie-Christine Rousset proposed the first logical approach [68]. Many experiments on public data are underway, in France (cf. DataLift[2] and ISIDORE[3] projects) or internationally (e.g., VIAF project[4] led by OCLC[5], whose aim is to interconnect authority files coming from 18 national organizations).

Two years ago, we began a collaboration with ABES (National Bibliographic Agency for Universities, which takes part in the VIAF project). The aim of this collaboration is to enable the publication of ABES metadata bases on the Web of Data and to provide an identification service dedicated to bibliographic notices. ABES bibliographic bases, and more generally document metadata bases, appear to be a privileged application domain for the representation and reasoning formalisms developed by the team. This work has an interdisciplinary dimension, as it also requires experts in the Library and Information Science domain. We think that a logical approach is able to provide a generic solution for entity resolution in document metedata bases, even though it is generally admitted in Library and Information Science that "there is no single paradigmatic author name disambiguation task—each bibliographic database, each digital library, and each collection of publications, has its own unique set of problems and issues" [69].

6.5.1. SUDOC Metadata Formalization

The first step of collaboration with ABES was to formalize the SUDOC catalogue, which contains all French academic libraries bibliographic notices, into a knowledge base using a suitable knowledge representation and reasoning language. This required to first analyze SUDOC content, as well as document description standards (CRM-CIDOC, FRBR, Dublin Core). We then designed an ontology expressed in the Semantic Web languages

[1] http://www.hcp.med.harvard.edu/statistics/survey-soft/docs/WinklerReclinkRef.pdf
[2] DataLift, http://datalift.org/
[3] ISIDORE, http://www.rechercheisidore.fr/
[4] The Virtual International Authority File, http://www.oclc.org/research/activities/viaf/
[5] Online Computer Library Center, http://www.oclc.org

RDFS + OWL, compatible with document description standards, as well as translations from any SUDOC set of notices into a set of RDF facts according to this ontology. These translations have been implemented, which allows to export SUDOC bases into Semantic Web formats. Moreover, using the RDFS to CG second translation mentioned above, we are now able to import SUDOC bases into our tools CoGUI + CoGITaNT.

▷ *Technical report [40].*

6.5.2. Implementation of an Entity Identification Service

In order to perform entity resolution (for entities restricted to "authors" for now), we have defined a set of rules allowing to enrich Sudoc descriptions; then, using enriched descriptions, authors can be classified according to a proximity criterion. A prototype providing this service has been implemented on top of Cogui. Experiments are currently led in the context of the SudocAd project jointly conducted by ABES and GraphIK. SudocAd aims at enriching the author field of a bibliographic record describing a document with links to Sudoc authorities referring to the authors of the target document. A general description of the implemented approach, an analysis of this approach on a representative sample of bibliographic records and first results on 13400 bibliographic records extracted from a corpus independent from Sudoc catalog are presented in the final report of SudocAd.

▷ *Link to SudocAd Final Report: http://www.abes.fr/Media/Fichiers/Sudoc-Fichiers/SudocAD_rapportFinal*

Finally, we have defined an extension of our own logical framework (existential rules, constraints, homomorphism-based mechanisms) based on Hector J. Levesque and Gerhard Lakemeyer's Standard Names [62], and the notion of knowledge base faithfulness with respect to the entity resolution problem (intuitively, the fact that the knowledge base is non-ambiguous). This is still ongoing work.

▷ *Research Report [38].*

7. Contracts and Grants with Industry

7.1. ABES

Collaboration with ABES. Funding of a 6-month engineer (Cécile Ochman) and half a PhD grant (Léa Guizol, started in October 2011). See Section 6.5.

7.2. CFTC

We have initiated a national collaboration with the technical center of Comptois' cheese (CTFC : Centre Technique des Fromages Comtois). The objective of this collaboration is to design and test a platform for expert knowledge management. This will allow us to validate the integration of our theoretical tools on a new real-world application and strengthen GraphIK's involvement in agronomy applications. A master degree internship in collaboration with CTFC will be proposed on this project in 2012.

8. Partnerships and Cooperations

8.1. Regional Initiatives

We are taking part in the Laboratory of Excellence ("labex") NUMEV (Digital and Hardware Solutions, Modelling for the Environment and Life Sciences), led by University of Montpellier 2 in partnership with CNRS, University of Montpellier 1 and INRIA. This project aims at developping information and communication technologies for environmental and life sciences. We are participating to one of the four axis, namely "Scientific Data: processing, integration and security".

8.2. European Initiatives

8.2.1. EcoBioCap

FP7-KBEE, March 2011–March2015. Led by INRA (and scientifically managed by Montpellier IATE laboratory). Sixteen partners among which Cork University (Ireland), CSIC (Spain), Roma University La Sapienza (Italy), SIK (Sweden). The objective of EcoBioCAP is to "provide the EU food industry with customizable, ecoefficient, biodegradable packaging solutions with direct benefits both for the environment and EU consumers in terms of food quality and safety". GraphIK is involved in this project via its common members with IATE-KRR team. The budget is managed by IATE team. This project will feed Axis 2.

8.3. International Initiatives

Invited research visit in Japan (June-August 2011): Michaël Thomazo has been invited to Ken Kaneiwa laboratory at Iwate University (Japan), thanks to a grant from the Japan Society for the Promotion of Science (JSPS). A comparison between the existential rule framework studied in GraphIK and the predicate/meta-predicate hierarchies framework as studied by Ken Kaneiwa in [59] has been conducted. They have been shown mutually reducible to each other, allowing to enrich existential rules with meta-predicates and to discover new decidable classes for query answering with (meta-)predicate hierarchies. Article in preparation.

8.3.1. Visits of International Scientists

- Meghyn Bienvenu, CNRS INRIA LEO (1 week in May 2011) - Collaboration on query answering on knowledge bases;
- Nir Oren, Univ. of Aberdeen (1 week in May 2011) - Collaboration on argumentation for multi-agent systems;
- Sebastian Rudolph, Univ. of Karlsruhe, "Knowledge Management Group" (5 weeks in March / April 2011) - Collaboration on existential rules;
- Leon van Torre, Univ. of Luxembourg (1 week in October 2011) - Collaboration on dynamic argumentation systems;
- Serena Villata, Univ. of Torino, January 2011 - Contact on argumentation systems.

9. Dissemination

9.1. Animation of the scientific community

9.1.1. Organization of Conferences/Workshops

ECAI 2012 (European Conference in Artificial Intelligence): Local Organization Committee (members of GraphIK are specially in charge of the budget and the publicity)
Organization of the workshop GKR@IJCAI 2011, associated with IJCAI 2011, Madalina Croitoru

9.1.2. Editorial Boards

ICCS (International Conference on Conceptual Structures)
RIA (Revue Francophone d'Intelligence Artificielle)

9.1.3. Program Committees

International: KR 2012 (Principles of Knowledge Representation and Reasoning), RR 2011-2012 (Reasoning the Web), ECAI 2012 (European Conference on Artificial Intelligence), ICCS 2011-2012 (International Conference on Conceptual Structures), SGAI AI-2010-2011 (Specialist Group on Artificial Intelligence), Datalog 2.0 (2012), GKR@IJCAI'11 workshop

National: JIAF 2010-2011 (Journées d'Intelligence Artificielle Fondamentale), IC 2010-2011 (Ingénierie des Connaissances), RFIA 2010-2012 (Reconnaissance des Formes et Intelligence Artificielle)

9.1.4. Invited Talks

Keynote Talks at International Conferences
- RR 2011: Ontological Query Answering with Existential Rules, Marie-Laure Mugnier, August 2011
Invited Talks at Workshops
- GKR@IJCAI 2011: Graph-based Reasonings for Ontological Conjunctive Query Answering, Jean-François Baget, July 2011
- IAF 2011 (Journées d'Intelligence Artificielle Fondamentale): Raisonner en présence d'ontologies, Jean-François Baget, in collaboration with Meghyn Bienvenu (INRIA project-team LEO)
Invited Seminars
- LIMOS (Univ. of Clermont-Ferrand): Interrogation de données basée sur une ontologie décrite avec des règles existentielles (Data Access based on an Ontology Described with Existential Rules), Marie-Laure Mugnier, June 2011

9.1.5. Scientific Advisory Boards

- ABES (National Bibliographic Agency for Universities) Scientific Advisory Board, Michel Chein (since its creation in 2010)
- Advisory Board of the Center of Excellence in Semantic Technologies (MIMOS, Malaysia), Marie-Laure Mugnier (since its creation in 2008)
- Scientific board of INRA-CEPIA department (Caractérisation et Elaboration des Produits Issus de l'Agriculture – Agricultural Products Engineering), Marie-Laure Mugnier (since Septembre 2011)

9.1.6. Expertise Tasks:

Experts for ANR, INRA and INRIA (project proposal reviewing); reviewers for Artificial Intelligence Journal, IEEE Transactions on Fuzzy Systems, Journal of Visual Languages & Computing, European Journal of Operational Research, ...

9.1.7. Local Collective Tasks:

LIRMM Scientific Council (Jean-François Baget), Vice-chair of "Expert Pool" section 27–Computer Science (Michel Leclère), member of Expert Pool Section 27 (Marie-laure Mugnier), LIRMM Laboratory Concil (Marie-Laure Mugnier), "Chargé de mission pour l'INRIA auprès de Mme la présidente de l'Université de Montpellier II" (Michel Chein)

9.1.8. Participation to the W3C RDF Working Group

(Jean-François Baget) The mission of the RDF Working Group, part of the Semantic Web Activity, is to update the 2004 version of the Resource Description Framework (RDF) Recommendation. The scope of work is to extend RDF to include some of the features that the community has identified as both desirable and important for interoperability based on experience with the 2004 version of the standard, but without having a negative effect on existing deployment efforts. http://www.w3.org/2011/01/rdf-wg-charter

9.2. Teaching

The next table details the number of lecture hours as well as the number of module responsibilities for each team member. Note that Michel Chein being Emeritus Professor has no teaching duty and Marie-Laure Mugnier had an INRIA Delegation for two years (September 2009/August 2011). Given their arrival date, Souhila Kaci (Professor) and the new PhD students do not appear in this table.

Name	Position	2010/11	Cursus (*)	Module Resp. (per year)
J.-F. Baget	Research Scientist	15	M2 (UM2)	1
M. Croitoru	Assistant Prof.	200	L (IUT) and M	2
M. Chein	Emeritus Prof.	0		
M. Fortin	Assistant Prof	192	Polytech	2
M. Leclère	Assistant Prof.	210	L and M (UM2)	4
M. -L. Mugnier	Prof. (Delegation)	10	M2 (UM2)	1
R. Thomopoulos	Research Scientist	0		no
K. Ben Mohamed	ATER	192	L (UM2)	no
B. Paiva Lima	PhD	64	L (UM2)	no
M. Thomazo	PhD	64	L and M1 (UM2)	no

(*) L =Licence, M = Master (M1 = first year, M2 = second year), UM2 = Univ. Montpellier 2 (Sciences), IUT = Institute of Technology of UM2 (Licence Cursus), Polytech = Engineering School of UM2, UM3 = Univ. Montpellier 3 (Art and Humanities)

Globally, the team ensures the courses in logics (propositional logic and first-order logic in L, logics for Artificial Intelligence in M2) at the Montpellier 2 University, as well as the Master courses in Artificial Intelligence, Knowledge Representation and Knowledge Engineering. We are also responsible of modules in Web Technologies (Professional L at IUT) and Databases (L).

We have some specific responsibilities in the Computer Science Master:

- Michel Leclère was responsible of the first master year (about 100 students) from 2005 to 2011. He is now co-responsible of the new master speciality DECOL (about 20 students) started in September 2011.
- Marie-Laure Mugnier is co-responsible of the new Computer Science Master started in September 2011 (about 120 students).

No PhD was defended in 2011. Five PhD students are members of the team:

PhD in progress : Bruno Paiva Lima Da Silva, Comparing Storage Systems for Large knowledge bases, Oct. 2010, directed by Jean-François Baget and Madalina Croitoru (supervisor HDR: Marie-Laure Mugnier)

PhD in progress : Tjitze Rienstra, Dynamic argumentation systems, Oct. 2010, directed by Souhila Kaci and Leon van der Torre (University of Luxembourg)

PhD in progress: Michaël Thomazo, Querying knowledge bases: decidability, complexity and algorithms, Sept. 2010, directed by Marie-Laure Mugnier and Jean-François Baget

PhD in progress: Léa Guizol, Entity identification in metadata bases, Oct. 2011, directed by Michel Leclère and Madalina Croitoru (supervisor HDR: Marie-Laure Mugnier)

PhD in progress: Mélanie König, Algorithms for querying large knowledge bases, Oct. 2011, directed by Michel Leclère and Marie-Laure Mugnier

10. Bibliography

Major publications by the team in recent years

[1] F. ALKHATEEB, J.-F. BAGET, J. EUZENAT. *Extending SPARQL with regular expression patterns (for querying RDF)*, in "J. Web Sem.", 2009, vol. 7, n^o 2, p. 57-73.

[2] J.-F. BAGET, J. FORTIN. *Default conceptual graph rules, atomic negation and Tic-Tac-Toe*, in "ICCS'10: 18th International Conference on Conceptual Structures - Conceptual Structures: From Information to Intelligence", Malaisie, M. CROITORU, S. FERRÉ, D. LUKOSE (editors), LNAI, Springer, July 2010, p. 42-55, ICCS'10 Best Paper Award, http://hal-lirmm.ccsd.cnrs.fr/lirmm-00537338/en/.

[3] J.-F. BAGET, M. LECLÈRE, M.-L. MUGNIER, E. SALVAT. *Extending Decidable Cases for Rules with Existential Variables*, in "Proceedings of the Twenty-First International Joint Conference on Artificial Intelligence (IJCAI 2009)", Pasadena, California, USA, 2009, p. 677-682.

[4] J.-F. BAGET, M. LECLÈRE, M.-L. MUGNIER, E. SALVAT. *On Rules with Existential Variables: Walking the Decidability Line*, in "Artificial Intelligence -Amsterdam- Elsevier-", March 2011, vol. 175, n^o 9-10, p. 1620-1654 [*DOI :* 10.1016/J.ARTINT.2011.03.002], http://hal.inria.fr/lirmm-00587012/en.

[5] J.-F. BAGET, M.-L. MUGNIER, S. RUDOLPH, M. THOMAZO. *Walking the Complexity Lines for Generalized Guarded Existential Rules*, in "IJCAI'11: International Joint Conference on Artificial Intelligence", Barcelona, Spain, T. WALSH (editor), AAAI Press, July 2011, p. 712-717, http://hal.inria.fr/lirmm-00618081/en.

[6] M. CHEIN, M.-L. MUGNIER. *Graph-based Knowledge Representation and Reasoning—Computational Foundations of Conceptual Graphs*, Advanced Information and Knowledge Processing, Springer, 2009.

[7] M. CROITORU, K. VAN DEEMTER. *A Conceptual Graph Approach for the Generation of Referring Expressions*, in "IJCAI 2007, Proceedings of the 20th International Joint Conference on Artificial Intelligence", 2007, p. 2456-2461.

[8] S. DESTERCKE, P. BUCHE, V. GUILLARD. *A Flexible Bipolar Querying Approach with Imprecise Data and Guaranteed Results*, in "Fuzzy Sets and Systems", April 2011, vol. 169, n^o 1, p. 51-54 [*DOI :* 10.1016/J.FSS.2010.12.014], http://hal-lirmm.ccsd.cnrs.fr/lirmm-00611940/en/.

[9] J. FORTIN, D. DUBOIS, H. FARGIER. *Gradual Numbers and Their Application to Fuzzy Interval Analysis*, in "IEEE T. Fuzzy Systems", 2008, vol. 16, n^o 2, p. 388-402.

[10] J. FORTIN, A. KASPERSKI, P. ZIELINSKI. *Some methods for evaluating the optimality of elements in matroids with ill-known weights*, in "Fuzzy Sets and Systems", 2009, vol. 160, n^o 10, p. 1341-1354.

[11] S. KACI. *Working with Preferences: Less Is More*, Cognitive Technologies, Springer, 2011.

[12] M. LECLÈRE, M.-L. MUGNIER. *Some Algorithmic Improvements for the Containment Problem of Conjunctive Queries with Negation*, in "ICDT", 2007, p. 404-418.

Publications of the year

Articles in International Peer-Reviewed Journal

[13] J.-F. BAGET, M. LECLÈRE, M.-L. MUGNIER, E. SALVAT. *On Rules with Existential Variables: Walking the Decidability Line*, in "Artificial Intelligence -Amsterdam- Elsevier-", March 2011, vol. 175, n^o 9-10, p. 1620-1654 [*DOI :* 10.1016/J.ARTINT.2011.03.002], http://hal.inria.fr/lirmm-00587012/en.

[14] P. BUCHE, O. COUVERT, J. DIBIE-BARTHÉLEMY, G. HIGNETTE, E. METTLER, L. SOLER. *Flexible Querying of Web data to Simulate Bacterial Growth in Food*, in "Food Microbiology", June 2011, vol. 28, n^o 4, p. 685-693, http://hal-lirmm.ccsd.cnrs.fr/lirmm-00538961/en/.

[15] D. DAVID, M. CROITORU, D. SRINANDAN, G. ALEX, G.-V. HORACIO, L. MIGUEL, H. BO, L. PAUL, P. ANDREW. *A Knowledge-Rich Distributed Decision Support Framework: A Case Study for Brain Tumour Diagnosis*, in "Knowledge Engineering Review", August 2011, vol. 26, p. 247-260, http://hal-lirmm.ccsd.cnrs.fr/lirmm-00618606/en/.

[16] S. DESTERCKE, P. BUCHE, B. CHARNOMORDIC. *Evaluating Data Reliability: an Evidential Answer with Application to a Web-Enabled data Warehouse*, in "IEEE Transactions on Knowledge and Data Engineering", December 2011, http://hal-lirmm.ccsd.cnrs.fr/lirmm-00611954/en/.

[17] S. DESTERCKE, P. BUCHE, V. GUILLARD. *A Flexible Bipolar Querying Approach with Imprecise Data and Guaranteed Results*, in "Fuzzy Sets and Systems", April 2011, vol. 169, n^o 1, p. 51-54 [*DOI :* 10.1016/J.FSS.2010.12.014], http://hal-lirmm.ccsd.cnrs.fr/lirmm-00611940/en/.

[18] X. LIANG, D. SRINANDAN, L. PAUL, H. BO, P. ANDREW, G. ALEX, D. DAVID, M. CROITORU, E. FRANCESC, M.-M. JUAN, G.-V. HORACIO, A. MAGI LLUCH I. *The Design and Implementation of a Novel Security Model for HealthAgents*, in "Knowledge Engineering Review", August 2011, vol. 26, p. 261-282, http://hal-lirmm.ccsd.cnrs.fr/lirmm-00618611/en/.

Invited Conferences

[19] J.-F. BAGET. *Graph-based Reasonings for Ontological Conjunctive Query Answering*, in "GKR'11: Graph Structures for Knowledge Representation and Reasoning", Barcelone, Spain, M. CROITORU (editor), July 2011, http://hal.inria.fr/lirmm-00618581/en.

[20] M.-L. MUGNIER. *Ontological Query Answering with Existential Rules*, in "RR'11: Web Reasoning and Rule Systems", Galway, Ireland, S. RUDOLPH, C. GUTIERREZ (editors), LNCS, Springer, August 2011, p. 002-023, http://hal.inria.fr/lirmm-00618296/en.

International Conferences with Proceedings

[21] J.-F. BAGET, M.-L. MUGNIER, S. RUDOLPH, M. THOMAZO. *Walking the Complexity Lines for Generalized Guarded Existential Rules*, in "IJCAI'11: International Joint Conference on Artificial Intelligence", Barcelona, Spain, T. WALSH (editor), AAAI Press, July 2011, p. 712-717, http://hal.inria.fr/lirmm-00618081/en.

[22] J.-F. BAGET, M.-L. MUGNIER, M. THOMAZO. *Towards Farsighted Dependencies for Existential Rules*, in "RR'11: Web Reasoning and Rule Systems", Galway, Ireland, S. RUDOLPH, C. GUTIERREZ (editors), LNCS, Springer, August 2011, p. 002-023, http://hal.inria.fr/lirmm-00618329/en.

[23] C. BAUDRIT, P. BUCHE, G. DELLA VALLE, S. DESTERCKE, K. KANSOU, A. NDIAYE, N. PERROT, R. THOMOPOULOS, G. TRYSTRAM. *Knowledge Engineering, a Useful Tool for Integrating Food Chain*, in "6th International CIGR Technical Symposium - Section VI: "Towards a Sustainable Food Chain. Food

Process, Bioprocessing and Food Quality Management"", France, April 2011, http://hal-lirmm.ccsd.cnrs.fr/lirmm-00611959/en/.

[24] K. BEN MOHAMED, M. LECLÈRE, M.-L. MUGNIER. *A Theoretical and Experimental Comparison of Algorithms for Containment of Conjunctive Queries with Negation*, in "DEXA'11: 22nd International Conference on Database and Expert Systems Applications", Toulouse, France, Springer, July 2011, vol. 22, 15, http://hal.inria.fr/lirmm-00618779/en.

[25] P. BUCHE, J. DIBIE-BARTHÉLEMY, R. KHEFIFI, F. SAÏS. *An Ontology-Based Method for Duplicate Detection in Web Data Tables*, in "DEXA'11: 22nd DEXA Conference", France, A. HAMEURLAIN (editor), LNCS, Springer-Verlag, August 2011, p. 511-525, http://hal-lirmm.ccsd.cnrs.fr/lirmm-00611944/en/.

[26] S. DESTERCKE, P. BUCHE, B. CHARNOMORDIC. *Data Reliability Assessment in a Data Warehouse Opened on the Web*, in "FQAS'11: Flexible Query Answering Systems", Belgique, LNAI, Springer-Verlag, October 2011, http://hal-lirmm.ccsd.cnrs.fr/lirmm-00611951/en/.

[27] S. DESTERCKE, P. BUCHE, C. GUILLAUME, V. GUILLARD. *A Decision Support System to Optimize Fresh Food Packaging*, in "6th International CIGR Technical Symposium - Section VI: "Towards a Sustainable Food Chain. Food Process, Bioprocessing and Food Quality Management"", France, April 2011, http://hal-lirmm.ccsd.cnrs.fr/lirmm-00611956/en/.

[28] J. FORTIN, R. THOMOPOULOS, J.-R. BOURGUET, M.-L. MUGNIER. *Supporting Argumentation Systems by Graph Representation and Computation*, in "GKR'11: Graph Structures for Knowledge Representation and Reasoning", Spain, LNCS, Springer, 2011, 12, http://hal.inria.fr/lirmm-00618049/en.

[29] B. PAIVA LIMA DA SILVA, J.-F. BAGET, M. CROITORU. *Ontological Conjunctive Query Answering over Semi-Structured KBs*, in "GDM'11: The 2nd International Workshop on Graph Data Management: Techniques and Applications", France, April 2011, p. 118-123, http://hal.inria.fr/lirmm-00618151/en.

[30] R. THOMOPOULOS, J.-R. BOURGUET, J. ABÉCASSIS. *An Artificial Intelligence-Based Approach for Arbitration in Food Chains*, in "6th International CIGR Technical Symposium", Nantes, France, April 2011, 6, http://hal.inria.fr/lirmm-00618640/en.

[31] R. TOUHAMI, P. BUCHE, J. DIBIE-BARTHÉLEMY, L. IBĂNESCU. *An Ontological and Terminological Resource for n-ary Relation Annotation in Web Data Tables*, in "10th International Conference on Ontologies, DataBases, and Applications of Semantics (ODBASE 2011)", Grèce, October 2011, http://hal-lirmm.ccsd.cnrs.fr/lirmm-00616241/en/.

National Conferences with Proceeding

[32] J.-F. BAGET, M.-L. MUGNIER, M. THOMAZO. *Notions de dépendances pour les règles Existentielles*, in "IAF'11: Journées de l'Intelligence Artificielle Fondamentale (JIAF)", Lyon, France, June 2011, p. 12-21, http://hal.inria.fr/lirmm-00618090/en.

[33] P. BUCHE, J. DIBIE-BARTHÉLEMY, L. IBĂNESCU, A. SAÏD. *Modélisation d'une ressource termino-ontologique de domaine pour l'annotation sémantique de tableaux*, in "EGC'11: Extraction et Gestion des Connaissances", France, A. KHENCHAF, P. PONCELET (editors), Revue des Nouvelles Technologies de l'Information, Hermann-Editions, January 2011, p. 581-586, http://hal-lirmm.ccsd.cnrs.fr/lirmm-00611935/en/.

[34] R. KHEFIFI, P. BUCHE, J. DIBIE-BARTHÉLEMY, F. SAÏS. *Détection de redondances dans les tableaux guidée par une ontologie*, in "EGC'11: Extraction et Gestion des Connaissances", France, A. KHENCHAF, P. PONCELET (editors), Revue des Nouvelles Technologies de l'Information, Hermann-Editions, January 2011, p. 563-568, http://hal-lirmm.ccsd.cnrs.fr/lirmm-00611938/en/.

Scientific Books (or Scientific Book chapters)

[35] S. KACI. *Working with Preferences: Less Is More*, Cognitive Technologies, Springer, 2011, http://www.springer.com/computer/ai/book/978-3-642-17279-3.

Research Reports

[36] J.-F. BAGET, M.-L. MUGNIER, S. RUDOLPH, M. THOMAZO. *Complexity Boundaries for Generalized Guarded Existential Rules*, LIRMM, February 2011, http://hal.inria.fr/lirmm-00568935/en.

[37] J.-F. BAGET, M.-L. MUGNIER, M. THOMAZO. *Towards Farsighted Dependencies for Existential Rules*, LIRMM, May 2011, http://hal.inria.fr/lirmm-00595033/en.

[38] M. CHEIN, M. LECLÈRE. *Entities and Surrogates in Knowledge Representation*, LIRMM, January 2011, http://hal.inria.fr/lirmm-00618868/en.

[39] N. DALSASS. *Test de propriété pour l'homomorphisme de graphes et d'hypergraphes*, LIRMM, March 2011, http://hal.inria.fr/lirmm-00618588/en.

[40] C. OCHMAN. *Rapport technique : Création des ontologies CIDOC, FRBRoo et SUDOC*, ABES/LIRMM, 2011, http://www.lirmm.fr/~leclere/recherche/RapportsTechniques/RapportModelisationSudoc.pdf.

References in notes

[41] F. BAADER, S. BRANDT, C. LUTZ. *Pushing the EL Envelope*, in "IJCAI'05", 2005, p. 364-369.

[42] J.-F. BAGET, M. CROITORU, J. FORTIN, R. THOMOPOULOS. *Default Conceptual Graph Rules: Preliminary Results for an Agronomy Application*, in "Conceptual Structures: Leveraging Semantic Technologies, 17th International Conference on Conceptual Structures, ICCS 2009, Moscow, Russia, July 26-31, 2009. Proceedings", Lecture Notes in Computer Science, Springer, 2009, vol. 5662, p. 86-99.

[43] J.-F. BAGET, J. FORTIN. *Default conceptual graph rules, atomic negation and Tic-Tac-Toe*, in "ICCS'10: 18th International Conference on Conceptual Structures - Conceptual Structures: From Information to Intelligence", Malaisie, M. CROITORU, S. FERRÉ, D. LUKOSE (editors), LNAI, Springer, July 2010, p. 42-55, http://hal-lirmm.ccsd.cnrs.fr/lirmm-00537338/en/.

[44] J.-F. BAGET, M. LECLÈRE, M.-L. MUGNIER. *Walking the Decidability Line for Rules with Existential Variables*, in "Twelfth International Conference on the Principles of Knowledge Representation and Reasoning (KR 2010)", Canada, AAAI Press, May 2010, 11, http://hal-lirmm.ccsd.cnrs.fr/lirmm-00535780/en/.

[45] C. BEERI, M. VARDI. *A proof procedure for data dependencies*, in "Journal of the ACM", 1984, vol. 31, n^o 4, p. 718–741.

[46] K. BEN MOHAMED, M. LECLÈRE, M.-L. MUGNIER. *Containment of Conjunctive Queries with Negation: Algorithms and Experiments*, in "DEXA'10: International Conference on Database and Expert Systems Applications", Espagne, Lecture Notes in Computer Science, Springer, 2010, vol. 6262, p. 330-345 [*DOI :* 10.1007/978-3-642-15251-1_27], http://hal-lirmm.ccsd.cnrs.fr/lirmm-00537832/en/.

[47] K. BEN MOHAMED, M. LECLÈRE, M.-L. MUGNIER. *Deduction in Existential Conjunctive First-Order Logic: an Algorithm and Experiments*, in "AIMSA'10: International Conference on Artificial Intelligence: Methodology, Systems, Applications", Bulgarie, Lecture Notes in Computer Science, Springer, 2010, vol. 6304, p. 1-10 [*DOI :* 10.1007/978-3-642-15431-7_1], http://hal-lirmm.ccsd.cnrs.fr/lirmm-00537836/en/.

[48] K. BEN MOHAMED, M. LECLÈRE, M.-L. MUGNIER. *Déduction dans le fragment existentiel conjonctif de la logique du premier ordre : algorithme et expérimentations*, in "RFIA'10: Reconnaissance des Formes et Intelligence Artificielle", France, 2010, 8, http://hal-lirmm.ccsd.cnrs.fr/lirmm-00537824/en/.

[49] J.-R. BOURGUET, L. AMGOUD, R. THOMOPOULOS. *Contribution aux comparaisons formelles des modèles de préférences en argumentation*, in "Journées Francophones des Modèles formels de l'Interaction", 2009, p. 81-92.

[50] J.-R. BOURGUET, L. AMGOUD, R. THOMOPOULOS. *Towards a Unified Model of Preference-Based Argumentation*, in "FolKS'10: Foundations of Information and Knowledge Systems", Bulgarie, Lecture Notes in Computer Science, Springer, February 2010, p. 326-344, http://hal-lirmm.ccsd.cnrs.fr/lirmm-00538789/en/.

[51] D. CALVANESE, G. DE GIACOMO, D. LEMBO, M. LENZERINI, R. ROSATI. *Tractable Reasoning and Efficient Query Answering in Description Logics: The DL-Lite Family*, in "J. Autom. Reasoning", 2007, vol. 39, n^{o} 3, p. 385-429.

[52] A. CALÌ, G. GOTTLOB, M. KIFER. *Taming the Infinite Chase: Query Answering under Expressive Relational Constraints*, in "KR'08", 2008, p. 70-80.

[53] A. CALÌ, G. GOTTLOB, T. LUKASIEWICZ. *A general datalog-based framework for tractable query answering over ontologies*, in "PODS'09", 2009, p. 77-86.

[54] A. CALÌ, G. GOTTLOB, T. LUKASIEWICZ, B. MARNETTE, A. PIERIS. *Datalog+/-: A Family of Logical Knowledge Representation and Query Languages for New Applications*, in "LICS", IEEE Computer Society, 2010, p. 228-242.

[55] M. CHEIN, M.-L. MUGNIER. *Graph-based Knowledge Representation and Reasoning—Computational Foundations of Conceptual Graphs*, Advanced Information and Knowledge Processing, Springer, 2009.

[56] P. M. DUNG. *On the Acceptability of Arguments and its Fundamental Role in Nonmonotonic Reasoning, Logic Programming and n-Person Games*, in "Artif. Intell.", 1995, vol. 77, n^{o} 2, p. 321-358.

[57] R. FAGIN, P. G. KOLAITIS, R. J. MILLER, L. POPA. *Data exchange: semantics and query answering*, in "Theor. Comput. Sci.", 2005, vol. 336, n^{o} 1, p. 89-124.

[58] I. JOHNSON, J. ABÉCASSIS, B. CHARNOMORDIC, S. DESTERCKE, R. THOMOPOULOS. *Making Ontology-Based Knowledge and Decision Trees interact: an Approach to Enrich Knowledge and Increase Expert Confidence in Data-Driven Models*, in "KSEM'10: International Conference on Knowledge Science, Engineering

and Management", Royaume-Uni, Lecture Notes in Artificial Intelligence, Springer, September 2010, p. 304-316, http://hal-lirmm.ccsd.cnrs.fr/lirmm-00538795/en/.

[59] K. KANEIWA, P. H. NGUYEN. *Decidable Order-Sorted Logic Programming for Ontologies and Rules with Argument Restructuring*, in "Proceedings of the 8th International Semantic Web Conference", Berlin, Heidelberg, ISWC '09, Springer-Verlag, 2009, p. 328–343.

[60] M. KRÖTZSCH, S. RUDOLPH, P. HITZLER. *Complexity Boundaries for Horn Description Logics*, in "AAAI'07", AAAI Press, 2007, p. 452–457.

[61] M. LECLÈRE, M.-L. MUGNIER. *Some Algorithmic Improvements for the Containment Problem of Conjunctive Queries with Negation*, in "ICDT", 2007, p. 404-418.

[62] H. J. LEVESQUE, G. LAKEMEYER. *The logic of knowledge bases*, MIT Press, 2000.

[63] C. LUTZ, D. TOMAN, F. WOLTER. *Conjunctive Query Answering in the Description Logic EL Using a Relational Database System*, in "IJCAI'09", 2009, p. 2070-2075.

[64] K. B. MOHAMED. *Traitement de requêtes conjonctives avec négation : Algorithmes et expérimentations*, Université Montpellier II, 2010.

[65] M.-L. MUGNIER, G. SIMONET, M. THOMAZO. *On the Complexity of Entailment in Existential Conjunctive First Order Logic with Atomic Negation*, LIRMM, March 2011, http://hal-lirmm.ccsd.cnrs.fr/lirmm-00413699/en/.

[66] H. NEWCOMBE, J. KENNEDY, S. AXFORD, A. JAMES. *Automatic Linkage of Vital Records*, in "Science", 1959, vol. 130, p. 954-959.

[67] R. REITER. *A logic for default reasoning*, in "Artificial Intelligence", 1980, vol. 13, p. 81-132.

[68] F. SAÏS, N. PERNELLE, M.-C. ROUSSET. *L2R: A Logical Method for Reference Reconciliation*, in "AAAI", AAAI Press, 2007, p. 329-334.

[69] N. R. SMALHEISER, V. I. TORVIK. *Author name disambiguation*, in "Annual Review of Information Science and Technology", 2009, vol. 43.

[70] J. F. SOWA. *Conceptual Structures: Information Processing in Mind and Machine*, Addison-Wesley, 1984.