INSTITUT NATIONAL DE RECHERCHE EN INFORMATIQUE ET EN AUTOMATIQUE

Project-Team GraphIK

Graphs for Inferences on Knowledge

Sophia Antipolis - Méditerranée

Theme : Knowledge and Data Representation and Management

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GraphIK is a new INRIA EPI created in 2010. It has been carried out by members of the former RCR team (LIRMM, University of Montpellier II & CNRS) and jointly built with computer scientists of the research laboratory IATE (Cirad, University of Montpellier II, INRA & SupAgro). Our research focus is graph-based knowledge representation and reasoning.

1. Team

Research Scientists

Jean-François Baget [Junior Researcher, INRIA]
Rallou Thomopoulos [Junior Researcher, INRA, on leave until August 2010]

Faculty Members

Marie-Laure Mugnier [Team leader, Professor, INRIA on leave from Université Montpellier II, HdR]
Madalina Croitoru [Associate Professor, Université Montpellier II]
Jérôme Fortin [Associate Professor, Université Montpellier II]
Michel Leclère [Associate Professor, Université Montpellier II]

External Collaborators

Patrice Buche [Research Engineer, INRA, HdR]
Michel Chein [Professor, Université Montpellier II]
Sébastien Destercke [Junior Researcher, CIRAD]
Éric Salvat [Associate Professor, IMERIR (Perpignan)]

Technical Staff

Alain Gutierrez [Engineer, CNRS]
Luc Menut [Engineer, INRA, 50% member of GraphIK]
Cécile Ochman [Engineer, Université Montpellier II, 6 months since Nov. 2010]

PhD Students

Khalil Ben Mohamed [Université Montpellier II, Ministry Grant, PhD defence in Dec. 2010]
Jean-Rémi Bourguet [INRA & Region Grant, PhD defence in Dec. 2010]
Bruno Paiva Lima Da Silva [2010 – Ministry Grant]
Michaël Thomazo [2010 – Grant from École Normale Superieure de Cachan]

Administrative Assistant

Annie Aliaga [INRIA, shared with other teams]

Others

Nicolas Dalssas [Internship from École Centrale Paris – 6 months from Sept 2010]
Imane Haffane [Master's thesis – 5 months, Spring 2010]

2. Overall Objectives

2.1. GraphIK Research Directions

The main research domain of GraphIK is Knowledge Representation and Reasoning (KRR). We have a computational and logic-oriented approach of this domain: the different kinds of knowledge have a logical semantics and reasonings correspond to inferences in this logic. However, in the field of logic-based KRR, we distinguish ourselves by using labelled graphs (in the graph-theoretic sense) as basic objects.

We study KRR formalisms from three perspectives:

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

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 rules;
- dealing with hybrid knowledge bases (*i.e.* composed of several modules which have their own formalism and reasoning mechanisms);
- reasoning with imperfect knowledge (*i.e.* vague, uncertain, partially inconsistent and/or with multi-granularity).

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 axes are privileged:

- knowledge representation for agronomy, the final objective being a knowledge-based system to aid decision-making for the quality control in food processing.
- the construction and management of semantic annotations of documents and their use in document retrieval and publication assistance.

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 for 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 6.1 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 ontogoly, 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 axes: knowledge representation in agronomy, more precisely applied to the quality in agri-food chains, and semantic annotations of resources.

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 axes. 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, semantic annotations, is not strictly speaking an application domain, but rather a cross-cutting axis. Indeed, semantic annotations can be used in various areas (including for instance scientific publications in agronomy). We have a long experience in this domain.

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 6.1, 6.2, 6.3 and 6.4 can be seen as theoretical requirements towards this objective.

4.3. Semantic Annotations

Metadata management, in particular semantic annotations, is the other privileged application axis. In the applications we consider, annotations are manually built, which is specially time-consuming even if some tools can help automatizing some tasks (e.g. speech recognition or natural language processing tools); nevertheless, this manual construction is unavoidable when semantically rich annotations have to be built. This was for instance the case in our projects with INA (National Institute of Audiovisual) and FMSH (Fondation Maison des Sciences de l'Homme)[1]. In our current project with ABES (National Bibliographic Agency for Universities), the construction of bibliographic notices also requires a high level of human expertise.

Although not dedicated to metadata management, our formal graph-based framework allows to represent modular ontologies and rules, as well as semantic annotations and to reason with them (cf. for instance ontological query answering in 6.1). This framework is implemented in our software Cogui and Cogitant. Cogui provides several constructs (patterns, controlled interfaces, ...) to help the annotation process. One of our basic aim is to develop and implement tools for helping the annotating process and for managing and controlling annotation bases.

Another objective is related to the valorization of resources in the form of new publications (for instance, the valorization of audiovisual archives by hypermedia publications on web sites or on other numerical supports: DVD, PDA or mobiles). This is a strategic issue for INA and FMSH, with which we collaborated on projects centered on this publication issue. We have developed indexing and retrieval techniques that are used not only in the annotation process but also inside the authoring process itself: the idea is that during the publication process, the author can retrieve and select resources (videos segments for instance), but he/she can also enrich the annotation base, i.e., enrich the annotations themselves or put rhetoric relationships between annotations, which can be used to enhance the publication authoring studio.

Other issues are related to the integration of several annotation bases: linkage problems, entity resolution, reference reconciliation, see 6.7 and 7.1 (SudocAd).

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.

The major evolution of the version delivered this year has been:

- RDF and RDFS support has been made available, and precise relationships between the CG model and these Semantic Web languages have been studied in [22] (see 6.5);
- new wizards (assistants) have been added.

An half-day tutorial on Cogui has been given at ICCS'10 (the International Conference on Conceptual Structures).

5.2. CoGITaNT

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

In collaboration with: David Genest (LERIA)

[1] The former RCR team has been collaborating on semantic annotation management with INA since 2000, via several national and international projects (PRIAM–OPALES 2000-2002, ANR SAPHIR 2006-2009, European LOGOS 2006-2008)

CoGITaNT (http://cogitant.sourceforge.net) is a tool for managing and reasoning with conceptual graphs. It is a freeware written in C++ (version 5.2, 1997–2010 GPL Licence). It was mainly developed at LIRMM from 1997 to 2001, and is currently extended and maintained jointly with David Genest (LERIA).

The main evolutions this year are the extension of the Java API exporting access to the C++ methods to Java programs; and the optimization of basic reasoning operations.

5.3. KB-Food Chain

Participants: Luc Menut, Rallou Thomopoulos.

In collaboration with: Brigitte Charnomordic (UMR MISTEA), Bernard Cuq and Joël Abécassis (UMR IATE).

KB-Food Chain is a PHP software tool for the modelling and simulation of an agri-food chain,registered by an APP (Agence de Protection des Programmes) deposit. It is based upon both relational (MySQL) and graph data (CGs). Prediction is currently based upon decision trees. It has been enhanced this year with case-based prediction using reference reconciliation methods (see 6.7).

5.4. Towards Large Knowledge Bases

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

Our applications must overcome many challenges (see 2.1), among them the ability to query large hybrid knowledge base. A previous work in collaboration with the Edelweiss EPI (the COLOR Griwes, http://www-sop.inria.fr/acacia/project/griwes/wakka.php?wiki=ColorGriwes, 2007–2008) has led to the first specifications of the architecture of such a reasoning platform. A project allowing for the development of such an architecture has been submitted to the ANR call Contint (Contenus et Interactions) in 2010. Though this proposal has been positively evaluated, it has not been funded (acceptance rate 15%), but we have been encouraged to resubmit it.

Meanwhile, we have began to study different storage solutions for such large databases, first during a Master's thesis [39], and now with the beginning PhD of Bruno Paiva Lima da Silva. With Nicolas Dalssas internship from École Centrale, we begin to study probabilistic methods for large-scale reasonings.

6. New Results

6.1. Ontological Query Answering with Rules

Participants: Jean-François Baget, Marie-Laure Mugnier, Michel Leclère, Michaël Thomazo.

We study the decidability of reasoning in a very expressive subset of first-order logic. Knowledge in this subset of FOL is expressed by *positive rules* of form $\forall \overrightarrow{x} \forall \overrightarrow{y} H(\overrightarrow{x}, \overrightarrow{y}) \rightarrow (\exists \overrightarrow{z} C(\overrightarrow{y}, \overrightarrow{z}))$, where H and C (respectively the hypothesis and the conclusion) are conjunctions of atoms. These rules are able to create new unknown individuals when they are applied, which is the source of the undecidability of reasoning. The logical form of these rules corresponds to *Tuple Generating Dependencies* (TGDs) in databases (where they form the core of the recently defined DATALOG+ language), or to Conceptual Graph Rules. This work on rules can be seen as a good illustration of our approach, both based on graphs and on logic. These rules generalize several KR languages adapted to query answering, such as the basic Semantic Web language RDFS, constraints in F-logic-Lite (in object oriented deductive databases), or the new families of description logics tailored for conjunctive query answering [47].

Pursuing our work in [50],[5], [2], [44] and [4] we have achieved this year a better understanding of the frontier between decidability and undecidability for specific subsets of rules. In particular, in [24], we have studied compatibility of decidable subsets of rules (a generic problems with many applications, e.g. "are reasonings still decidable when merging two decidable ontologies ?"). Our results have been detailed in a long paper, submitted to the *Artificial Intelligence Journal*.

This ongoing work is an essential part of GraphIK first research axis. This year, Michaël Thoamazo [40] has begun a PhD Thesis on decidability, complexity and algorithms for these rules. We have started a collaboration with Sebastian Rudolph, from the Knowledge Management group at AIFB, Karlsruhe Institute of Technology, http://www.aifb.kit.edu/web/Wissensmanagement/en, on the relationships between rules and description logics (that we had began to study in [43]). We are currently building a collaboration with other European leader teams on this aspect.

6.2. Processing Conjunctive Queries with Negation

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

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, these problems become Π_2^P-complete (with the open world assumption for the query entailment problem). We have proposed, refined and compared experimentally several algorithms [34], [25], [26]. This study follows first results of us in [10] and is the core of Khalil Ben Mohamed's PhD thesis defended in December 2010 [14]. The latest experimental results have not been published yet.

6.3. Multi-criteria Argumentation

Participants: Rallou Thomopoulos, Marie-Laure Mugnier, Jean-Rémi Bourguet.

In collaboration with: Leila Amgoud (IRIT/RPDMP team).

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 [49]. In that framework, arguments are assumed to have the same strength. This assumption is unfortunately strong and often unsatisfied. Consequently, several extensions of the framework have been proposed in the literature. In [46] and [27], we have led a comparative study of these extensions. It clearly shows under which conditions two proposals are equivalent. We have also integrated those extensions into a common more expressive framework. First results concerning graph-based representation and computation, using default conceptual graph rules (see 6.4) have been obtained.

This approach has been applied to agri-food chain analysis [45]. It 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 collectivities, 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 analysed 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 & health program, millers, bakers, consumers.

The proposed approach is novel both for theoretical and application aspects, since argumentation-based decision is little studied in the international literature, with a first formal paper in 2009 [41], and appears as an extremely relevant approach to support decision in food chains in a sustainability perspective.

These results are presented in Jean-Rémi Bourguet's PhD thesis, defended in December 2020 [13].

6.4. Default Rules for Non-monotonic Reasoning

Participants: Jean-François Baget, Jérôme Fortin, Jean-Rémi Bourguet.

The study of non-monotonic reasonings (part of GraphIK's research axis 2) is a major requirement for the agronomy application presented in 4.2. In [42], we had proposed an extension of the rules presented in Sect 6.1 to Reiter's defaults. In [23], we have proposed a more intuitive algorithm computing credulous and skeptical deduction using these default rules, as well as an implementation of atomic negation (6.2). Following this approach, we intend to extend the decidable subclasses of rules studied in 6.1 to default rules, with or without atomic negation.

We have also used these rules in an argumentation framework. In [13], we have proposed a formalism allowing for the representation of arguments and the computation of attack relations between these arguments. Default rules are then used to generate maximal subsets of acceptable arguments.

6.5. Translations between RDFS and CGs

Participants: Jean-François Baget, Madalina Croitoru, Michel Leclère, Marie-Laure Mugnier, Alain Gutierrez.

The fundamental Semantic Web language RDF (Resource Description Framework), as its extension RDFS, which adds a lightweight ontological level on top of RDF, are very close to basic conceptual graphs (BG, the simplest conceptual graphs, which are equivalent to the existential positive conjunctive fragment of classical first-order logic). However, since RDFS does not obey standard logics, there is no obvious semantic-preserving correspondence between both languages. We propose two sound and complete transformations between RDFS and BG [22]. The first one relies on [3] and allows to translate any RDFS document into BG (and more generally first-order logic). W.r.t. the first translation, the second one has the advantage of intuitiveness because it respects the distinction between categories of knowledge (concepts, relations, instances); however, to obtain this property, one has to restrict the translation to a well-formed fragment of RDFS. Both translations have been implemented in Cogui, which allows on one hand communication between conceptual graphs and Semantic Web languages, on the other hand use of visualisation and verification tools provided by Cogui for RDFS files.

6.6. Coalitions and Norms

Participants: Madalina Croitoru, Jérôme Fortin.

In collaboration with: T. Rahwan, T. Micholock and N. Jennings (University of Southampton); and with N. Oven, S. Miles and M. Luck (King's College, UK).

We are interested in graph-based representations for analyzing and designing forms of interaction amongst rational agents (argumentation, coalition formation, norm monitoring). This work is exploiting unique graph based representation for the above mentioned problems that improve expressiveness and problem solving efficiency.

We addressed two such interaction paradigms, namely coalition formation [33] and norm monitoring [29], [30]. Coalition formation can be seen as a special case of multi agent resource allocation where all resources need to be allocated. Representing compactly the characteristic function of such coalition games can be thus exploited in efficient algorithms for problem solving. In the work on norm monitoring, we address the problem of aiding a system's designer in understanding the effects of norms on the system. We propose a graphical representation of norms within a system which allows for visual explanation of the state of norms (for instance why they have been activated or violated).

6.7. Data Reconciliation

Participants: Rallou Thomopoulos, Sébastien Destercke.

In collaboration with: Fatiha Saïs (LRI / INRIA Leo)

It often happens that different references (i.e. data descriptions), possibly coming from different heterogeneous data sources, concern the same real world entity. In such cases, it is necessary: (i) to detect whether different data descriptions refer to the same real world entity and (ii) to fuse them into a unique representation. Data reconciliation consists in deciding whether different data descriptions, also called references, concern the same real-world entity (e.g. the same person, the same experiment, the same paper). Once the reconciliation problem is solved , data fusion then consists in merging the reconciled references into a single one. In [48], [32], we proposed a fusion method based on possibility theory, able to cope with uncertainty and with ontological knowledge. An implementation using W3C standards was provided. Rising from the fusion process, an ontology enrichment procedure was proposed to complete the global ontology.

This work on data reconciliation is close to issues arising in the SudocAd project (7.1), and a common working group has been recently initiated on these issues.

7. Contracts and Grants with Industry

7.1. Contracts with Industry

7.1.1. SAPHIR

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

SAPHIR was an ANR-RIAM project that ended in Feb. 2010. It was led by INA (Institut National de l'Audiovisuel) and involved the MSH (Maison des Sciences de l'Homme), LERIA (University of Angers), the IHM team of LIRMM, and NETIA.

SAPHIR aimed at the development of a working environment for indexing and republishing multimedia resources online. GraphIK focused more specifically on the framework for managing semantic annotations and the associated reasoning mechanisms (see 4.3).

7.1.2. MIMOS

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

2009-10 (2 years): Collaboration with MIMOS, the national research and development institute of Malaysia. Objectives: (1) development of knowledge-based applications and technologies based on our software, Cogitant (http://cogitant.sourceforge.net) and Cogui (http://www.lirmm.fr/cogui/); (2) high-level training for MIMOS R&D team, with a long-term perspective of master and phD codirection.

7.1.3. SudocAd

Participants: Michel Leclère, Michel Chein, Alain Gutierrez, Cécile Ochman.

Funded by TGE Adonis and ABES (National Bibliographic Agency for Universities) 2009-2010.

Main components of a bibliographic systems are a base of bibliographic notices (metadata about documents) and a base of authority notices (metadata about authors, collectivities, subjects,). Our short-term goal is to build an authority linkage service, e.g. to link an author in a bibliographic notice to an authority notice concerning this author (if such a notice exists). The predominant used automatic technique is classification by similarity scores. The set of metadata bases can be seen as a structured graph. We are developing a logic-based method using our graph techniques (rules, constraints, exact and approximate retrieval procedures) for solving this linkage problem and we plan to study other problems concerning bibliographic databases (e.g., consistency checking & redundancy detection). This project is interesting for several reasons: the record linkage problem, and its cousins entity resolution, reference reconciliation, de-duplication, merge/purge, object identification , are important problems for many kinds of databases (especially data warehouses) and also on (part of) the web; it gives us the opportunity to assess our methods on large graphs (several dozen of millions of nodes) and to compare them to classification methods.

8. Other Grants and Activities

8.1. National Initiatives

8.1.1. Collaborations

- French computer science research laboratories:
  - IRIT (Toulouse) 6.3,
  - LRI (Orsay)/INRIA Saclay 6.7 (data reconciliation),
  - LERIA (Angers) 5.2;
- IATE laboratory (CIRAD-INRA-SupAgro, Montpellier), Met@risk (INRA laboratory, Paris) 4.2;
- ABES (Bibliographical French Agency for Universities, Montpellier) 4.3;
- INA (National Institute for Audiovisual, Bry-sur-Marne) 4.3.

8.1.2. Invited Talks

- Michel Leclère (May 2010, with Yann Nicolas): Invited talk at the Journées ABES 2010, Montpellier. *Des autorités aux autorités enrichies : vers une liaison automatique sémantiquement contrôlée aux autorités Sudoc*;
- Madalina Croitoru (June 2010): Invited Talk at the MARA Workshop, Paris. *Generalised network flows for combinatorial auctions*;
- Jérôme Fortin (November 2010): Invited Talk at "Journées Aliments–Procédés", Montpellier. *Default Conceptual Graphs Rules for an Agronomy Application*;
- Rallou Thomopoulos (November 2010): Invited talk at "Journées Aliments–Procédés", Montpellier. *Argumentation to support decision in Agri-Food Chains*.

8.2. European Initiatives

8.2.1. Biodegradable Packaging for Food Products

Participants: Sébastien Destercke, Patrice Buche, Rallou Thomopoulos.

In collaboration with: Valérie Guillard, Université Montpellier II, IATE

The team participated in the project "Outil de modélisation et d'aide à la décision pour la conception d'emballages alimentaires biodégradables" (UM II call), which will be followed by the European project "EcoBioCap" starting in 2011 (responsible: Nathalie Gontard, UM II/IATE). This work aims at developing a decision support system that will allow safe packaging of food products with biodegradable materials considering stakeholders preferences, acceptances and needs. Both qualitative and quantitative approaches are considered.

8.2.2. CAFE

Participant: Rallou Thomopoulos.

Participation in the European project CAFE: Computer-Aided Food processes for control Engineering (Large Scale Collaborative European Project 2008–2012, coordinator: Denis Dochain, U. Louvain, Belgium).

http://www.inra.fr/les_partenariats/collaborations_et_partenaires/entreprises/en_direct_des_labos/cafe

Contribution: definition of generic models for the acquisition of symbolic knowledge (conceptual organisation of information such as expertise, ...), their validation and their use within alimentary food processes, jointly with numerical data.

8.3. International Initiatives

8.3.1. Collaborations

King's College (UK), University of Southampton (UK), University of Karlsruhe (Germany), KMI Open University (UK), IIT-BAS (Bulgaria), Community Sense (Netherlands), MIMOS (Malaysia).

8.3.2. Invitations and Seminars

- Sebastian Rudolph (March 2010), from University of Karlsruhe, "Knowledge Management Group", has been visiting our team during 3 weeks;
- Jean-François Baget and Marie-Laure Mugnier (March 2010): Seminar at Oxford University, invitation by Georg Gottlob, *Walking the Decidability Line for Rules with Existential Variables*;
- Madalina Croitoru (November 2010): Invitation to the University of Karlsruhe, "Knowledge Management Group" (2 weeks) and invited seminar at the KIT Institute, Germany, *CF-NETS for Coalition Formation*.

8.3.3. Keynote Talks

- Michel Chein (June 2010): Keynote Talk at the International Conference on Enterprise Information Systems, Portugal. *Graph-Based Knowledge Representation and Reasoning* [20];
- Michel Chein (July 2010): Keynote Talk at the International Conference on Conceptual Structures, Malaysia. *Entities and Surrogates in Knowledge Representation* [19].

8.3.4. Program Committees

Editorial Committee of ICCS 2010 (International Conference on Conceptual Structures), Marie-Laure Mugnier

Program Chair of ICCS'10, Madalina Croitoru

Program Committee of ECAI 2010, ICCS 2010, IAF 2010, IC 2010, RFIA 2010, ...

Reviewing activity for Artificial Intelligence Journal, IEEE Transactions on Fuzzy Systems, Journal of Visual Languages & Computing, ...

8.3.5. Prizes and Awards

- Jean-François Baget and Jérôme Fortin received the **ICCS best paper award** for *Default conceptual graph rules, atomic negation and Tic-Tac-Toe* [23];
- Khalil Ben Mohamed, Michel Leclère and Marie-Laure Mugnier received the **AFIA Prize** ("Prix AFIA de RFIA") for *Déduction dans le fragment existentiel conjonctif de la logique du premier ordre : algorithme et expérimentations* [34] http://www.afia-france.org/tiki-index.php?page=Galerie+des+prix+et+des+honneurs

9. Dissemination

9.1. Animation of the scientific community

The members of the team have presented papers in various conferences and workshops (see the bibliography). We list below particular responsabilities or activities.

International:

- M. Croitoru has been the program chair of ICCS 2010 (http://www.mimos.my/iccs2010/)
- We have given a half-day tutorial at ICCS'2010 (Cogui)
- Three of us are in the organizing committee of ECAI 2012 (treasurer and publicity chairs), which will be held in Montpellier

National:

- Organizing committee of Journées d'Intelligence Artificielle Fondamentale (Fundamental Artificial Intelligence French Workshop) 2010 (http://gdri3iaf.info.univ-angers.fr/spip.php?rubrique25)

9.2. Scientific Advisory Boards

Michel Chein is member of the ABES (National Bibliographic Agency for Universities) scientific advisory board since 2010.

Marie-Laure Mugnier is member of the Advisory Board of the Center of Excellence in Semantic Technologies (MIMOS, Malaysia) since 2008.

9.3. Teaching

Four GraphIK members out of six belong to the university of Montpellier II (2 at the faculty of Science, but one is in INRIA delegation; 1 at the Polytech Engineer school; 1 at the IUT). The INRIA researcher also participates in teaching activities (master 2nd year) as well as our PhD students.

We have several module responsabilities in the computer science cursus, in Licence and in Master:

- *Licence:* propositional Logic, first-order Logic (delegated this year) and Web technologies.
- *Master:*
  - Knowledge Representation and Reasoning (M1)
  - Graph-Based Knowledge Representation and Reasoning (M2 - Research)
  - Logics for Artificial Intelligence (M2 - Research)
  - Knowledge Engineering (M2 - Research and pro)

M. Leclère is also responsible of the first year of the Computer Science Master (105 students).

We have been actively involved in the preparation of the new Master Habilitation (starting Automn 2011): Michel Leclère and Madalina Croitoru are respectively co-initiators of the Master cursus "DECOL" (Data, Knowledge and Natural Language Processing); and "Web Science" (with the University of Southampton). We are also involved in the master cursus "MOCA" (Mathematics and Computer Science).

9.4. Collective Tasks

Jean-François Baget is member of LIRMM's "Conseil Scientifique"

Michel Chein is "Chargé de mission pour l'INRIA auprès de Mme la présidente de l'Université de Montpellier II".

Marie-Laure Mugnier is member of LIRMM's "Conseil de Laboratoire"

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