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Activity Report 2016

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
**Data and Knowledge Representation
and Processing**

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Project-Team GRAPHIK

Creation of the Project-Team: 2010 January 01

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- 3.1.1. - Modeling, representation
- 3.2.1. - Knowledge bases
- 3.2.3. - Inference
- 3.2.5. - Ontologies
- 7.4. - Logic in Computer Science
- 8.1. - Knowledge
- 8.6. - Decision support
- 8.7. - AI algorithmics

Other Research Topics and Application Domains:

- 3.1. - Sustainable development
- 9.4.5. - Data science
- 9.5.10. - Digital humanities
- 9.7.2. - Open data

1. Members

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- Marie-Laure Mugnier [Team leader, Univ. Montpellier, Professor, HDR]
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- Madalina Croitoru [Univ. Montpellier, Associate Professor, INRA delegation until Sept. 2016, HDR]
- Jérôme Fortin [Univ. Montpellier, Associate Professor]
- Michel Leclère [Univ. Montpellier, Associate Professor]
- Federico Ulliana [Univ. Montpellier, Associate Professor]

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- Brett Choquet [Inria, Jun.-Jul. 2016]
- Alain Gutierrez [CNRS, 30%]
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- Swan Rocher [Inria, until Dec. 2016]
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Others

Patrice Buche [INRA, Research Engineer, Associate member, HDR]

Odile Papini [Univ. Aix-Marseille, Professor, in delegation until Jul. 2016, HDR]

Adrien Pavao [Inria, Student, from Jun.-Jul. 2016]

2. Overall Objectives

2.1. Logic and Graph-based KR

The main research domain of GraphIK is Knowledge Representation and Reasoning (KR), which studies paradigms and formalisms for representing knowledge and reasoning on these representations. We follow a logic-oriented approach: 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 KR, we distinguish ourselves by also 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 KR 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 and 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 KR 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 KR:

- ontological query answering, *i.e.*, query answering taking an ontology into account, and able to process large datasets;
- reasoning with rule-based languages;
- reasoning with “imperfect knowledge” (*i.e.*, vague, uncertain, partially inconsistent, multi-viewpoints and/or with multi-granularity).

2.4. Scientific Directions

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 direction) 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 currently privileged:

- 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.

3. Research Program

3.1. Logic-based Knowledge Representation and Reasoning

We follow the mainstream *logic-based* approach to the KR domain. First-order logic (FOL) is the reference logic in KR and most formalisms in this area can be translated into fragments (i.e., particular subsets) of FOL. This is in particular the case for description logics and existential rules, two well-known KR formalisms studied in the team.

A large part of research in this domain can be seen as studying the *trade-off* between the expressivity of languages and the complexity of (sound and complete) reasoning in these languages. The fundamental problem in KR languages is entailment checking: is a given piece of knowledge entailed by other pieces of knowledge, for instance from a knowledge base (KB)? Another important problem is *consistency* checking: is a set of knowledge pieces (for instance the knowledge base itself) consistent, i.e., is it sure that nothing absurd can be entailed from it? The *ontology-mediated query answering* problem is a topical problem (see Section 3.3). It asks for the set of answers to a query in the KB. In the 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 KR 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 graph-based approach to KR. We view labelled graphs as an *abstract representation* of knowledge that can be expressed in many KR languages (different kinds of conceptual graphs —historically our main focus—, the Semantic Web language RDF (Resource Description Framework), its extension RDFS (RDF Schema), 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 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 reasoning 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. Ontology-Mediated Query Answering

Querying knowledge bases has become a central problem in knowledge representation and in databases. 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-offs between the expressivity of the ontological language and the

complexity of querying data in presence of ontological knowledge. Description logics have been so far the prominent family of formalisms for representing and reasoning with ontological knowledge. However, classical description logics were not designed for efficient data querying. On the other hand, database languages are 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 KR:

- *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, known as existential rules or Datalog+, can be seen as an abstraction of ontological knowledge expressed in the main languages used in the context of KB querying. See Section 6.1 for details on the results obtained.

A problem generalizing the above described problems, and particularly relevant in the context of multiple data/metadata sources, is *querying hybrid knowledge bases*. In a 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 the issue of data integration in databases.

3.4. Imperfect Information and Priorities

While classical FOL is the kernel of many KR 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.

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 solutions we 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. One angle of attack (but not the only possible one) 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. Highlights of the Year

4.1. Highlights of the Year

- M. Bienvenu was awarded the Bronze CNRS medal 2016 <http://www.cnrs.fr/ins2i/spip.php?article2197>. She was an invited speaker at IJCAI 2016 (International Joint Conference in Artificial Intelligence), Early Career Spotlight track http://ijcai-16.org/index.php/welcome/view/early_career_spotlight
- Theoretical and algorithmic results on ontology-mediated query answering recognized at the best international level (10 articles in the major conferences in Artificial Intelligence and Knowledge Representation and Reasoning: IJCAI, AAAI, ECAI and KR)
- Sudoqual prototype for the evaluation of link quality in document bases considered to be used in production conditions by ABES (French Agency for Academic Libraries).
- CoGui-Capex prototype linking food descriptors to actions considered to be used in production conditions by Régilait in its milk powder factory in Macon.

4.1.1. Best papers

BEST PAPER AWARD:

[29]

M. BIENVENU, M. THOMAZO. *On the Complexity of Evaluating Regular Path Queries over Linear Existential Rules*, in "10th International Conference on Web Reasoning and Rule Systems", Aberdeen, United Kingdom, 10th International Conference on Web Reasoning and Rule Systems, September 2016, <https://hal.inria.fr/hal-01341787>

5. New Software and Platforms

5.1. SudoQual

Participants: Michel Leclère, Michel Chein, Alain Gutierrez, Clément Sipieter, Brett Choquet.

Contact: Michel Leclère

SudoQual is a software suite that allows discovering and evaluating coreference links between individual entities references. It has been developed during the ANR project Qualinca. This software suite comprises:

- a generic API allowing to implement (thanks to a graphical interface) applications computing “same-as” and “different-from” links in knowledge bases;
- a generic application (whose specific parameters are defined in a configuration file) evaluating the quality of a knowledge base; it is available either as a standalone client or as a web service;
- a library dedicated to the comparison of individual entities’ attributes;
- the specific configuration file dedicated to evaluating the quality of links in ABES’ Sudoc catalogue.

Main developments this year are:

- adapting the API’s architecture to the NetBeans IDE in order to benefit from its better edition functionalities;
- finalizing, testing and optimizing the linkage application;
- specifying and implementing the quality evaluation application;
- implementing this latter application as a web service.

5.2. GRAAL

Participants: Clément Sipieter, Jean-François Baget, Michel Leclère, Marie-Laure Mugnier, Swan Rocher.

Contact: Marie-Laure Mugnier (scientific contact), Clément Sipieter (technical contact)

Keywords: Data management - Ontologies - Query Answering

Web site: <https://graphik-team.github.io/graal/>

Scientific Description Graal is a generic platform for ontological query answering with existential rules. It implements various paradigms that fall into that framework. It is an open source software written in Java.

Functional Description See last year's report for a description of GRAAL's features <http://raweb.inria.fr/rapporactivite/RA2015/graphik/uid49.html>.

New Features The main features developed in 2016 are:

- improvement of the semi-saturation algorithm with compilable rules;
- implementation of mappings allowing to query an existing database as it is, without prior loading it in GRAAL;
- design and implementation of classes that manage a knowledge base (i.e., the rules and the data). In particular, the results of the rule analyser Kiabora (that has been integrated within GRAAL) are used to automatically select the most appropriate algorithms for querying the knowledge base.

5.3. Cogui

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

Contact: Marie-Laure Mugnier (scientific contact), Alain Gutierrez (technical contact)

Keywords: Graphical knowledge bases - Ontology Editor - Conceptual Graphs

Web site: <http://www.lirmm.fr/cogui/>

Scientific Description Cogui is a tool for building and verifying graphical knowledge bases. It is a freeware written in Java.

Functional Description See last year's report for a description of CoGui's features <http://raweb.inria.fr/rapporactivite/RA2015/graphik/uid41.html>.

New features Cogui is currently under heavy refactoring to benefit from NetBeans graphical libraries.

5.4. CoGui-Capex

CoGui-Capex is a decision support tool dedicated to food industry. Its knowledge base represents the causal links between food descriptors and actions which can be undertaken by operators to control food quality on the line. The new version of CoGui-Capex developed in 2016 in a Neatbeans environnement is coupled with the so-called "Knowledge book" developed by INRA I2M team in Bordeaux [49]. This collaboration will be extended in the CASDAR Docamex national project (funded by the French Ministry of Agriculture), which will begin in January 2017 for 4 years with several cheese makers.

5.5. @Web

An extension of the 5 stars/FAIRS scientific data annotation platform called @Web (<http://www6.inra.fr/cati-icat-atweb>), managed by INRA, has been developed by Leandro Lovisolo (UBA master student) co-supervised by Federico Ulliana and Patrice Buche using semantic web languages (OWL, SPARQL, RDF). This extension permits to represent negative constraints expressed on annotated data and will be used in data curation phase.

6. New Results

6.1. Logics and Graph-Based Languages for Ontology-Mediated Query

Answering

Participants: Jean-François Baget, Meghyn Bienvenu, Efstathios Delivouras, Michel Leclère, Marie-Laure Mugnier, Swan Rocher, Federico Ulliana.

Ontology-mediated query answering (and more generally *Ontology-Based Data Access, OBDA*) is a recent paradigm in data management, which takes into account inferences enabled by an ontology when querying data. In other words, the notion of a database is replaced by that of a knowledge base, composed of data (also called facts) and of an ontology. Two families of formalisms for representing and reasoning with the ontological component are considered in this context: *description logics* and the more recent *existential rule* framework. Until last year, the team has mainly investigated existential rules. This expressive formalism generalizes most lightweight description logics used in OBDA (such as \mathcal{EL} and DL-Lite, on which OWL 2 tractable profiles are based) on the one hand, and Datalog, the language of deductive databases, on the other hand. With the arrival of Meghyn Bienvenu, description logics have joined the core formalisms studied by the team. Compared to existential rules, the description logics considered for OBDA lead to lower complexity classes and specific algorithmic techniques. Studying both formalisms is scientifically highly relevant, specially in the context of OBDA.

We have also broadened this research line by starting investigating ontological languages for non-relational data, an issue that has barely been considered yet.

Before presenting this year' results, we recall the two classical ways of processing rules, namely forward chaining and backward chaining. In forward chaining (also known as the *chase* in databases), the rules are applied to enrich the initial facts and query answering can then be solved by evaluating the query against the "saturated" factbase (as in a classical database system *i.e.*, with forgetting the rules). The backward chaining process can be divided into two steps: first, the initial query is rewritten using the rules into a first-order query (typically a union of conjunctive queries, UCQ); then the rewritten query is evaluated against the initial factbase (again, as in a classical database system). Note that forward and backward processes do not halt for all kinds of existential rules nor all lightweight description logics.

6.1.1. New Results in the Description Logics Framework

When using Description Logics (DL) ontologies to access relational data, mappings are used to link the relational schema to the vocabulary of the ontology (which uses only unary and binary predicates). In order to debug and optimize DL-based OBDA systems, it is important to be able to analyze and compare ontology-mapping pairs, called OBDA specifications. Prior work in this direction compared specifications using classical notions of equivalence and entailment.

- We have explored an alternative approach in which two specifications are deemed equivalent if they give the same answers to the considered query or class of queries for all possible data sources. After formally defining such query-based notions of entailment and equivalence of OBDA specifications, we investigated the complexity of the resulting analysis tasks when the ontology is formulated in (fragments of) DL-Lite_R, which forms the basis for the Semantic Web ontological language OWL 2 QL.

– KR'16 [28]

- We consider a range of Horn DLs for which query answering has polynomial data complexity, but which do not guarantee the existence of First-Order(FO)-rewritings of all queries. In order to extend the applicability of the FO-rewriting technique, a key task is to be able to identify specific ontology-query pairs that admit an FO-rewriting. This led us to study FO-rewritability of conjunctive queries in the presence of ontologies formulated in DLs ranging between \mathcal{EL} and Horn- \mathcal{SHF} , along with related query containment problems. Apart from providing characterizations, we established complexity results ranging from EXPTIME via NEXPTIME to 2EXPTIME, pointing out several interesting effects. In particular, FO-rewriting is more complex for conjunctive queries than for atomic queries when inverse roles are present, but not otherwise.

– IJCAI'16 [27]

6.1.2. New Results in the Existential Rule Framework

Several new theoretical results have been obtained on ontology-mediated query answering with existential rules:

- While most work in the area of ontology-mediated query answering focuses on conjunctive queries, navigational queries are gaining increasing attention. In collaboration with Michael Thomazo (Inria CEDAR), we took a step towards a better understanding of the combination of navigational query languages and existential rules by pinpointing the (data and combined) complexities of evaluating path queries (more precisely, two-way regular path queries) over knowledge bases whose ontology is composed of linear existential rules (a class of rules that can be seen as a natural generalisation of the description logic DL-Lite_R). We extended an algorithm tailored for DL-Lite_R and showed that, despite an exponential blow-up with respect to the maximum predicate arity, our algorithm was worst-case optimal.
 - *RR'16 (Best paper award) [29]*
- Boundedness is an important notion for optimizing the processing of rule languages, as it ensures that materialisation can be performed in a predefined number of steps, independently from the size of any factbase. We are currently studying several boundedness notions for existential rules that extend the well-known boundedness notion of Datalog, and investigate their relationships with properties ensuring the finiteness of the chase or query rewriting. One of our first results is that, for a natural notion of boundedness, bounded existential rules are exactly those at the intersection of finite expansion sets (which ensure that any factbase has a finite sound and complete saturation) and finite unification sets (which ensure that any conjunctive query can be finitely rewritten into a sound and complete union of conjunctive queries).
 - *DL'16 [36]*
- Finally, Swan Rocher's PhD thesis deepened the study of the decidability and complexity of conjunctive query answering for classes of existential rules added with transitivity rules (previous results were presented at IJCAI 2015 [48])

6.1.3. Querying NoSQL databases (Key-value stores)

Over the last decade, research efforts to develop algorithms for OBDA have built on the assumption that data conforms to relational structures (including RDF) and that the paradigm can be deployed on top of relational databases with conjunctive queries at the core (e.g., in SQL or SPARQL). However, this is not the prominent way on which data is today stored and exchanged, especially in the Web. Whether OBDA can be developed for non-relational structures, like those shared by increasingly popular NOSQL languages sustaining Big-Data analytics, is still an open question. In collaboration with Marie-Christine Rousset (University of Grenoble, LIG), we proposed the first framework for studying the problem of answering ontology-mediated queries on top of NOSQL key-value stores. More precisely, we formalized the core data model and basic queries of these systems and introduced a rule language (NO-RL) to express lightweight ontologies on top of data. We defined a sound and complete query rewriting technique and studied the decidability and data complexity of answering ontology-mediated queries depending on considered the rule fragment.

- *AAAI'16 [39]; DL'16 [40]*

6.2. Representing and Processing Imperfect Information

Participants: Abdallah Arioua, Jean-François Baget, Meghyn Bienvenu, Pierre Bisquert, Patrice Buche, Madalina Croitoru, Jérôme Fortin, Fabien Garreau, Abdelraouf Hecham, Marie-Laure Mugnier, Odile Papini, Swan Rocher, Rallou Thomopoulos, Bruno Yun.

Inconsistency-Tolerant Query Answering is one of the challenging problems that received a lot of attention in recent years as inconsistency may arise in practical applications due to several reasons: merging, integration, revision. In the context of Ontology-Based Data Access (OBDA), where the ontological knowledge is assumed to be coherent and fully reliable, inconsistency comes from the data, i.e., occurs when some assertional facts contradict some constraints imposed by the ontological knowledge. Existing works in this area have studied different inconsistency-tolerant query answering techniques, called “semantics”: some examples include Brave, IAR, ICR, AR etc.. These proposals are closely related to works on querying inconsistent databases, or inference from inconsistent propositional logic knowledge bases.

The work of this year on inconsistency-tolerant query answering techniques for Ontology Based Data Access focused on (i) new results about different kinds of semantics or (ii) the user interaction with such semantics (we investigated the notion of repair based explanation or argumentation based explanation). We have investigated the interest of inconsistency-tolerant semantics in general and argumentation techniques for the agrifood chain in particular.

6.2.1. Inconsistency-Tolerant Semantics for Query Answering

In all approaches considered here, a knowledge base can have, in opposition to the logics studied in 6.1, several incompatible “minimal” models. Those models can correspond to possible repairs of an inconsistent knowledge base or can be the models generated by a non-monotonic logic. The questions we address here are linked to the semantics (how to define those models, how to define preferences on those models), while trying to preserve a satisfying trade-off between expressivity and computational complexity of the querying mechanism.

- We proposed a new inconsistency-tolerant inference relation, called non-objection inference, where a query is considered as valid if it is entailed by at least one repair and it is consistent with all the other repairs. The main salient points of the newly introduced semantics is its efficiency (query answering with non-objection inference is achieved in polynomial time) and the fact that the inferences are strictly more productive than universal inference while preserving the consistency of its set of conclusions. The intuition behind is that no repair has an objection veto to the acceptance of the query. If query entailment from repairs is seen as posing a vote for, against or abstaining to a query then, in this semantics, some repairs are “voting” for a query (i.e., the query is entailed) and the rest of the repairs are not against (i.e., the query body atoms together with the atoms in the repair are consistent with the terminology) then the query is accepted without any objection. In addition, two variants of non-objection inference based on a selection of repairs (that can be against a query) are also considered.
 - *IJCAI'16* [31]
- We provided a dialectical characterization of the Brave and IAR semantics. We proposed an argumentation dialogue system that considers a turn taking game between a proponent and an opponent. We defined the concept of participant’s profile and depending on these profiles we were able to give necessary and sufficient conditions for the Brave and IAR semantics. We further proposed a new TPI-like dialectical proof theory (a procedure where two players exchange arguments (moves) until one of them cannot play) for universal acceptance (i.e., AR semantics). We limit the scope of the work to finite and coherent logic-based argumentation frameworks that correspond to the OBDA instantiation we consider in practical applications.
 - *ECAI'16* [18]; *FLAIRS'16* [19]
- We proposed a unifying framework for inconsistency-tolerant query answering within existential rule setting. In this framework, an inconsistency-tolerant semantics is seen as a pair composed of a modifier, which produces consistent subsets of the data, and an inference strategy, which evaluates queries on the selected subsets. We systematically compared the productivity and the complexity of the obtained semantics.
 - *KR'16* [22]; *JELIA'16* [23]
- We studied the relationships between our unifying repair framework and stable model semantics. In particular, we provided a generic encoding for most semantics defined in that framework using Answer Set Programming.
 - *SUM'16* [24]

6.2.2. Practical Applicability of Inconsistency-Tolerant Semantics and Argumentation

- Several inconsistency-tolerant semantics have been introduced for querying inconsistent knowledge bases. In order for users to be able to understand the query results, it is crucial to be able to explain why a tuple is a (non-)answer to a query under such semantics. We defined explanations for positive

and negative answers under the brave, AR and IAR semantics. We then studied the computational properties of explanations in the lightweight description logic DL-Lite_R. For each type of explanation, we analyzed the data complexity of recognizing (preferred) explanations and deciding if a given assertion is relevant or necessary. We established tight connections between intractable explanation problems and variants of propositional satisfiability (SAT), enabling us to generate explanations by exploiting solvers for Boolean satisfaction and optimization problems. Finally, we empirically studied the efficiency of our explanation framework using the well-established LUBM benchmark.

– *AAAI'16* [25]

- We considered the problem of query-driven repairing of inconsistent DL-Lite knowledge bases: query answers are computed under inconsistency-tolerant semantics, and the user provides feedback about which answers are erroneous or missing. The aim is to find a set of data modifications (deletions and additions), called a repair plan, that addresses as many of the defects as possible. After formalizing this problem and introducing different notions of optimality, we investigated the computational complexity of reasoning about optimal repair plans and proposed interactive algorithms for computing such plans. For deletion-only repair plans, we also presented a prototype implementation of the core components of the algorithm.

– *IJCAI'16* [26]

- Based on the equivalent use of inconsistency-tolerant semantics for OBDA and logical instantiation of argumentation with existential rules, we highlighted some of the practical advantages that come from the interplay of the two techniques. More generally, we focussed on the generic problem of dealing with the uncertain knowledge (elicitation, representation and reasoning) involved at different levels of the food chain that model complex processes relying on numerous criteria, using various granularity of knowledge, most often inconsistent (due to the fact that complementary points of view can be expressed).

– *IPMU'16* [32]

Beside, regarding the various granularity of knowledge, inspired from a hierarchical graph-based definition, we introduced the possibility of representing hierarchical knowledge using existential rules.

– *ICCS'16* [33]

- Agent technology and notably argumentation can optimise food supply chain operation in presence of inconsistency by employing intelligent agent applications (as shown in supply chain management case) but also facilitate reasoning with incomplete, inconsistent and missing knowledge as shown in the results presented in the previous sections. We considered two main methods of handling inconsistency: repair-based techniques and argumentation techniques. We demonstrated how to benefit from structured argumentation frameworks in practice by means of their implementations. Such implementations provide reasoning capabilities under inconsistency-tolerant semantics by means of a workflow that will enable Datalog frameworks to handle inconsistencies in knowledge bases using existing structured argumentation implementations.

– *COMMA'16* [46]

- We provided a first implementation of the explanation based techniques using argumentation that can be used for inconsistent tolerant semantics. Such implementation served as a proof of concept of the usefulness of the interplay of the two techniques.

– *COMMA'16* [17]

Furthermore, we provided an existential rule benchmark inspired from a real practical setting in the DURDUR project.

– *MTSR'16* [16]

To refine this approach, we presented a generic framework of capturing reasoning errors by the interplay of strict logical rules and associative rules in knowledge bases (with the latter being elicited using a game with a purpose). We showed that such model can capture certain reasoning biases and could be eventually used as a predictive model for interacting with domain experts. We also showed empirically the difference of associations agronomy experts exhibit with respect to a random control population validated in the context of the DURDUR ANR project.

– ECAI'16 [18]; ICCS'16 [20]

6.2.3. Decision Support in Agronomy

- We addressed a crucial problem for decision-making tools that are using inconsistency-handling methods (either argumentation frameworks or inconsistency-tolerant semantics) and namely the existence of multiple extensions / repairs. We placed ourselves in an applicative scenario, in the Pack4Fresh project, that investigates the best packaging for strawberries. We showed that being given a set of preferences on the initial set of facts in the existential rule knowledge base we can output meaningful (i.e., agrifood chain expert validated) extensions / repairs that will assist the decision maker.

– MTSR'16 [45]

- We proposed a novel approach for decision-making that allows not only to handle symbolic data but also handle numerical RDF datasets. To deal with the numerical data, a preprocessing step is applied to convert numerical data into symbolic data. Based on the obtained symbolic classes we discover keys that are valid in this preprocessed data. We tested this approach on a dataset that describes wines with the set of numerical values representing different chemical components that give the flavour of wines. In this application setting, the discovered keys can be used to discover flavour complementarity, unknown from the experts, that allow to distinguish various wine sorts amongst themselves. We then validated the keys obtained with domain experts and discussed their interest with respect to the statistical analysis.

– ICCS'16 [43]

- We presented a decision support system (DSS) which permits to compare, in a multi-criteria approach, innovative biomass transformation processes for biorefinery. Considered criteria are process extraction rate and green indicators. This DSS implements a pipeline which permits to annotate in a RDF knowledge heterogeneous textual data sources using a OWL/SKOS termino-ontological resource, to assess data source reliability and to compute several green indicators taking into account data reliability.

– CEA [13]; FUSS-IEEE'16 [37]

6.3. Quality and interoperability of large document catalogues

Participants: Michel Chein, Madalina Croitoru, Alain Gutierrez, Michel Leclère, Clément Sipieter.

The work in this research line mainly takes place in the ANR project Qualinca (see Section 8.1), devoted to methods and tools to repair linkage errors in bibliographical databases. Within this project, we specially work with our applicative partner ABES (French Agency for Academic Libraries, <http://www.abes.fr/>). ABES manages several catalogues and authority bases, in particular the Sudoc, the collective catalogue of French academic libraries. ABES also provides services to libraries and end-users, as well as to other catalogue managers (e.g., OCLC for Worldcat and, in France, Adonis for the Isidore platform).

6.3.1. Evaluating the Quality of a Bibliographic Database

This year, we have focused on the specification, development and test of the application allowing to evaluate reference quality in a bibliographic database. The goal is to evaluate “same-as” links between contextual references (references to named entities provided in the context of a bibliographic notice) and authority references (references establishing an identifier for a given named entity). Our approach to solve this problem consists in two successive steps:

1. use the linkage API developed last years to compute automatically weighted links between contextual references and authority references;
2. compare those weighted links with those present in the bibliographic database in order to produce an evaluation of those links quality.

The evaluation output considers 12 different cases split in 5 major link categories: valid, almost valid, erroneous, missing, doubtful. For the 3 latter categories, we can often provide a correction or completion proposal.

We have initially implemented this application as a standalone client written in Java (see Section 5.1). We have tested it on a benchmark comprising 550 links, for which the evaluation has been done by experts. Our application has obtained very good results, since more than 70% of the links are evaluated correctly, less than 1% wrongly, and the rest consists of links for which data is insufficient to provide an evaluation.

To allow professionals from ABES to use this application, we have developed an interactive web service: the user first asks for the evaluation output on the set of links induced by a subset of contextual references; then he can validate or invalidate the proposed correction/completion. The tool can be restarted after each correction/completion to improve the evaluation with this new data. Our ABES partner is currently developing an enhanced graphical interface for Sudoc users, that will communicate with that web service, in order to use the software in production conditions.

Finally, an evaluation of the time required by our application led to numerous optimizations. We have for now concluded that the time is essentially spent by the library functions computing similarities between attributes. We consider now using map/reduce techniques to parallelize those computations.

6.3.2. Argumentation for Quality Evaluation

Beside, we studied the use of the `owl:sameAs` property (expressing that two URIs actually refer to the same thing) in practice. Many existing identity links do not reflect genuine real identity and therefore might lead to inconsistencies. We formalized explanation dialogues that use argument-based explanation based on inconsistency-tolerant semantics, and showed how to support a domain expert in discovering inconsistencies due to erroneous SameAs links. We implemented a prototype of the explanation dialogue that communicates with our tool Graal and provided an example of sameAs invalidation over real data explaining what has been obtained while running dialogues and how such results might benefit domain experts.

- *SUM'16 [21], ECAI'16 [18]*

7. Bilateral Contracts and Grants with Industry

7.1. Bilateral Contracts with Industry

7.1.1. UMR IATE / UMR STLO / Régilait

Participants: Patrice Buche, Jérôme Fortin, Alain Gutierrez.

In the framework of a contract between INRA IATE and STLO (Rennes) research units and Régilait, two master students have been recruited in 2016. Marine Damblon, food engineer from Polytech Montpellier, has created a knowledge base which represents the causal links between a food descriptor (mouillabilité des poudres de lait) and actions which can be undertaken by operators to control food quality on the line. Justine Flore Tchouanguem participated to the development of the new CoGui-Capex version presented in section 5.4. CoGui-Capex prototype has been successfully evaluated by Régilait and is considered to be used in production conditions in its milk powder factory in Macon. Marine Damblon has been recruited by Régilait for that. This collaboration will be extended in 2017 and a new master student should be recruited.

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR

8.1.1.1. ASPIQ

Participants: Jean-François Baget, Madalina Croitoru, Fabien Garreau, Marie-Laure Mugnier, Jérôme Fortin, Michel Leclère, Odile Papini, Swan Rocher.

ASPIQ (ASP technologies for Querying large scale multisource heterogeneous web information), is an ANR white project that started in January 2013 (duration: 4 years, extended to July 2017). It involves partners from CRIL, LERIA and LSIS. The project coordinator is Odile Papini (LSIS). <http://aspiq.lsis.org/>

The main objective of this project is to propose:

- extensions of standard ASP for representing OWL2 tractable sublanguages;
- new operations for merging conflicting information in this extended ASP;
- the identification of subclasses of this extended ASP allowing for efficient query answering mechanisms;
- an implementation of a prototype reasoning system.
- *See Section 6.1 and 6.2 for this year's results.*

8.1.1.2. Pagoda

Participants: Meghyn Bienvenu, Jean-François Baget, Marie-Laure Mugnier, Swan Rocher, Federico Ulliana.

Pagoda (Practical Algorithms for Ontology-based Data Access) is an ANR JCJC (young researchers) project that started in Jan. 2013 (duration: 4 years, extended to August 2017). The project coordinator is Meghyn Bienvenu (initially in LRI, now member of GraphIK). It involves partners from the EPI LEO, the LIG, and the Anatomy Laboratory of Grenoble. <http://pagoda.lri.fr/>

The primary aim of this project is to address challenges brought by scalability and the handling of data inconsistencies by developing novel OBDA (Ontology Based Data Access) query answering algorithms and practical methods for handling inconsistent data.

- *See Section 6.1 and 6.2 for this year's results.*

8.1.1.3. Qualinca

Participants: Michel Leclère, Michel Chein, Madalina Croitoru, Rallou Thomopoulos, Alain Gutierrez, Swan Rocher, Clément Sipieter, Marie-Laure Mugnier.

Qualinca is an ANR Contint project that started in Apr. 2012 (duration: 4 years, extended to September 2016). The project coordinator is Michel Leclère (GraphIK). It involves partners from LRI, LIG, ABES and INA. <http://www.lirmm.fr/qualinca/index8ece.html?q=en/en/home>

The main objective is to elaborate mechanisms allowing to:

- evaluate the quality of an existing document base;
- maintain a given level of quality by controlling updating operations;
- increase the quality of a given base;
- develop generic methods that take into account the quality of a given base (for instance for searching documents or interconnecting bases).
- *See Section 6.3 for this year's results.*

8.1.1.4. Dur-Dur

Participants: Abdallah Arioua, Pierre Bisquert, Patrice Buche, Madalina Croitoru, Jérôme Fortin, Abdelraouf Hecham, Rallou Thomopoulos.

Dur-Dur (Innovations agronomiques, techniques et organisationnelles pour accroître la DURabilité de la filière blé DUR) is an ANR project that started in March 2014 (duration: 3 years). It is led by IATE Laboratory. <http://umr-iate.cirad.fr/projets/dur-dur>

The Dur-Dur project develops a systematic approach to investigate the questions related to the management of the nitrogen, energy and contaminants, to guarantee a global quality of products throughout the production and the processing chain. The knowledge representation task of Dur-Dur proposes to map the stakeholders' objectives into a multicriteria cartography, as well as possible means to reach them, and computes the compatibility / incompatibility of these objectives on the basis of argumentation methods. The research methods used are qualitative and based both on argumentation theory and on Social Multi- Criteria Evaluation (SMCE) theory. They will be extended and adapted to the needs of the project to provide a formal framework of assessment of the various orientations considered for the durum wheat chain.

- See Section 6.2 for this year's results.

8.1.2. Other projects

8.1.2.1. Pack4Fresh

Participants: Patrice Buche, Pierre Bisquert, Madalina Croitoru, Bruno Yun.

Pack4Fresh (Sept. 2015 - Sept. 2017) is a project selected in the framework of the GloFood INRA-CIRAD metaprogramme. The multi-year metaprogramme GloFoodS (Transitions to global food security) is dedicated to the investigation of pathways to worldwide food security in a context of competition for land and natural resources, and is jointly conducted by INRA and Cirad, the two leading French research institutions for agriculture. Involving research on crop yield and livestock systems, land use changes, food processing and waste, nutrition and governance, GloFoodS aims at articulating global modeling of food supply and demand, with local issues of production and access to food.

In this context, Pack4Fresh focuses on the big fragility of fresh foods which generates enormous post-harvest wastes, short shelf-life, and constitutes a major lock to their consumption and health benefit. This project aims at initiating an eco-design approach of the post-harvest phase of fresh foods working on the interdependency relation between environmental impact (1) positive for waste reduction, et (2) negative for technologies, which aims at reducing the waste, in order to minimize the ratio between those two parameters.

- See Section 6.2 for this year's results.

8.1.2.2. OBDA-KeyVal: Ontology-Based Data Access for NoSQL Databases

Participants: Federico Ulliana, Marie-Laure Mugnier.

OBDA-KeyVal is a one-year PEPS project (JCJC INS2I 2016, funded by CNRS-INS2I) dedicated to Ontology Based Data Access for NoSQL Databases. Its goal is to study the problem of answering ontology-mediated queries on top of non-relational databases, and more precisely Key-Value stores. These are a family of NoSQL databases dealing with data represented as nested-structures (JSON records), processed on distributed systems but also increasingly exchanged on the Web, slowly replacing XML and RDF formats. Key-value stores have been designed with performance and scalability in mind, and this opens the possibility to implement OBDA in a novel and efficient distributed setting. The work carried out in this project builds on our first results published at AAAI 2016 [39], see also Sect. 6.1. We addressed both practical and theoretical aspects of OBDA for key-value stores. First, a prototype of the reasoning framework for key-value stores has been developed by master students (<https://github.com/OBDA-KEYVAL/graal-keyval>). Second, a novel first-order logic semantics for the setting (in contrast to the former operational semantics) has been defined and investigated from a decidability viewpoint. This still ongoing work is a necessary step towards bridging this setting with the relational OBDA.

8.2. European Initiatives

8.2.1. FP7 & H2020 Projects

8.2.1.1. NoAW (No Agricultural Waste)

Participants: Patrice Buche, Pierre Bisquert, Madalina Croitoru, Nikolaos Karanikolas, Rallou Thomopoulos.

Website: http://cordis.europa.eu/project/rcn/203384_en.html

NoAW (No Agricultural Waste) is an H2020 european project led by INRA-IATE, started in Oct. 2016. Driven by a “near zero-waste” society requirement, the goal of NoAW project is to generate innovative efficient approaches to convert growing agricultural waste issues into eco-efficient bio-based products opportunities with direct benefits for both environment, economy and EU consumer. To achieve this goal, the NoAW concept relies on developing holistic life cycle thinking able to support environmentally responsible R&D innovations on agro-waste conversion at different TRLs, in the light of regional and seasonal specificities, not forgetting risks emerging from circular management of agro-wastes (e.g. contaminants accumulation).

GraphIK will contribute on two aspects. On one hand we will participate in the annotation effort of knowledge bases (using the @Web tool). On the other hand we will further investigate the interplay of argumentation with logically instantiated frameworks and its relation with social choice in the context of decision making.

8.2.2. Collaborations in European Programs, Except FP7 & H2020

8.2.2.1. COST FoodMC.

Participants: Madalina Croitoru, Rallou Thomopoulos.

Website: <http://www6.inra.fr/foodmc>

Rallou Thomopoulos is involved as Co-coordinator (together with Alberto Tonda and Kamal Kansou) in the European COST Action "FoodMC" (Mathematical and Computer Science Methods for Food Science and Industry) started in 2016. Both Madalina Croitoru and Rallou Thomopoulos are Members of the Management Committee, representing France.

8.3. International Initiatives

8.3.1. Inria International Partners

8.3.1.1. Informal International Partners

- University of Buenos Aires, Ricardo Rodriguez, since 2013. Work in progress.
- University of Aberdeen, Nir Oren, since 2010. Work in progress.
- Technical University of Dresden, Sebastian Rudolph, since 2012. [34], co-organizer for GKR@IJCAI 2017.
- University of Liverpool, Frank Wolter, since 2009. [11], [27]
- Sapienza University (Rome), Riccardo Rosati, since 2012. [28]
- University of Bremen, Carsten Lutz, since 2009. [27], [11]
- Technical University of Vienna, Magdalena Ortiz and Mantas Simkus, since 2010. Work in progress.
- Laval University (Quebec), Irène Abi-Zeid, since 2015, and Bernard Moulin, since 2012. [44], [38]
- University of Amsterdam, Ulle Endriss, since 2015. Work in progress.

8.3.2. Participation in Other International Programs

Patrice Buche is involved in the RDA AgriSemantics working group (<https://www.rd-alliance.org/groups/agrisemantics-wg.html>). The goal of the Agrisemantics WG is to gather community-based requirements and use cases for an infrastructure that supports appropriate use of semantics for data interoperability, with special focus on agriculture.

8.4. International Research Visitors

8.4.1. Visits of International Scientists

- Nov. 2016 (1 week). Visit of Elena Botoeva (Univ. of Bolzano), Stanislav Kikot (London Univ.), Roman Kontchakov (London Univ.) Vladislav Rhyzhikov (Univ. of Bolzano), and Michael Zakharyashev (London Univ.) to work on the complexity on ontology-mediated query answering with description logics and linear existential rules. Seminars: “Query Inseparability of Description Logic Knowledge Bases and TBoxes” by Elena Botoeva and “The Complexity of Ontology-Based Data Access with OWL 2 QL and Bounded Treewidth Queries” by Stanislav Kikot.
- Nov. 2016 (2 days). Visit of Sebastian Rudolph (TU Dresden) in the context of Swan Rocher’s PhD defense. Seminar: “The Curse of Finiteness: Undecidability of Database-Inspired Reasoning Problems in Very Expressive Description Logics”.
- Sept. 2016 (1 week) Visit of Ricardo Rodriguez (Univ. of Buenos Aires) to work on belief revision for inconsistent tolerant semantics.

8.4.2. Visits to International Teams

8.4.2.1. Research Stays Abroad

Pierre Bisquert was an invited researcher at the University of Amsterdam from May 2015 to Apr. 2016.

- In collaboration with Ulle Endriss (Institute for Logic, Language and Computation), he worked on the link between argumentation theory and social choice. The aim of this work was to study and understand how Arrow’s Impossibility Theorem (stating that there is no democratic voting rule) could be avoided thanks to deliberation and argumentation. More precisely, the favored approach was to define a formal framework of the deliberation process predating a vote, and to establish conditions under which deliberation may help to output a democratic and collectively rational choice through the notion of preference structuration, i.e., the changes in preferences that the agents may undergo after discussion.

Rallou Thomopoulos was invited at Laval University (Québec, Canada) for one year until July 2016. She worked on two projects dealing with decision support:

- An academic project conducted with the Computer Science Division of Laval University. It aimed at conceiving a systematic approach to assess several scenarios in agriculture, by combining a qualitative model based on argumentation and a quantitative simulation technique based on system dynamics.
- The second project was conducted both with a private partner and with the Operation and Decision Division of Laval University. It aimed to provide explanations for automatically-computed instructions, to improve human understanding of the situation. These instructions were the results of a commercial software used for real-time decision support for the flow management of a combined and sanitary wastewater system.

9. Dissemination

9.1. Promoting Scientific Activities

9.1.1. Scientific Events Organisation

9.1.1.1. General Chair, Scientific Chair

9.1.1.1.1. 2016 Events

- We were local co-organizers (with the Coconut team at LIRMM) of the French workshop JIAF (Journées d’Intelligence Artificielle Fondamentale), held in Montpellier in June 2016, in conjunction with the JFPC, the Journées de Programmation par Contraintes (JFPC). https://www.supagro.fr/jfpc_jiaf_2016/index_jiaf.php

- Still with Coconut team at LIRMM, we also welcomed the opening days of the National CNRS Group on theoretical and algorithmic aspects of Artificial Intelligence (pre-GDR IA) in Jun. 2016.
- Marie-Laure Mugnier co-organized the workshop “Ontologies and logic programming for query answering” co-located with IJCAI 2016 <http://ontolp.lsis.org/>

9.1.1.1.2. 2017 Events

- We are organizing the 30th Workshop on Description Logics, to be held in July 2017 in Montpellier. The general chairs are Meghyn Bienvenu and Marie-Laure Mugnier. <https://project.inria.fr/dl2017/>
- Madalina Croitou will co-organise the 5th International Workshop of Graph Based Knowledge Representation and Reasoning collocated with IJCAI 2017 in Melbourne Australia. The organiser list is the same as GKR 2015. More information about past editions can be found at: <https://www.lirmm.fr/~croitoru/GKR/>
- Madalina Croitoru and Pierre Bisquert will organize a special session “Agronomy and AI” at IEA-AIE 2017 (30th International Conference on Industrial, Engineering and Other Applications of Applied Intelligent Systems) <http://www.cril.univ-artois.fr/ieaaie2017/main/specialtracks/>

9.1.2. Scientific Events Selection

9.1.2.1. Member of the Conference Program Committees

We are regularly members of the program committees of the main generalist conferences in AI (i.e., IJCAI, AAAI, ECAI) and more specialized conferences and workshops (KR, the main conference in knowledge representation and reasoning, RR — Web reasoning and Rule Systems, SUM — International Conference on Scalable Uncertainty Management, COMMA — International Conference on Computational Models of Argument, Metadata and Semantics Research Conference, etc.)

For 2016, we served in the following program committees:

- IJCAI 2016 (21st International Conference on Artificial Intelligence): 1 senior PC + 3 PC
- ECAI 2016 (22nd European Conference on Artificial Intelligence): 2 PC
- ISWC 2016 (15th International Semantic Web Conference): 1 PC
- AAAI 2016 (30th AAAI Conference on Artificial Intelligence): 2 PC
- DL 2016 (29th International Workshop on Description Logics): 2 PC
- RR 2016 (10th International Conference on Web Reasoning and Rule Systems): 2 PC
- FOIS 2016 (9th International Conference on Formal Ontology in Information Systems): 1 PC
- BDA 2016 (Gestion de Données — Principes, Technologies et Applications): 1 PC
- FoIKS 2016 (9th International Symposium on Foundations of Information and Knowledge Systems): 1 PC
- CARI 2016 (13ème Colloque Africain sur la Recherche en Informatique et Mathématiques Appliquées): 1 PC
- IC 2016 (27es journées francophones d’Ingénierie des Connaissances): 1 PC
- MTSR 2016, AgroSEM Special track (10th Metadata and Semantics Research Conference): 1 PC
- LFA 2016 (25ème Conférence sur la Logique Floue et ses Applications): 1 PC

For 2017, we will serve in the following program committees (list not exhaustive yet):

- IJCAI 2017 (22nd International Conference on Artificial Intelligence): 1 senior PC, 1 PC
- AAAI 2017 (31st AAAI Conference on Artificial Intelligence): 2 PC
- PODS 2017 (36th International Conference on the Principles of Database Systems): 1 PC
- ICDT 2017 (20th International Conference on Database Theory): 1 PC
- SIGMOD 2017 (ACM SIGMOD International Conference on Management of Data): 1 PC
- EGC 2017 (Extraction et Gestion des Connaissances): 1 PC
- IC 2017 (28èmes journées francophones d’Ingénierie des Connaissances): 1 PC

9.1.3. Journal

9.1.3.1. Member of the Editorial Boards

Patrice Buche Member of the ARIMA Editorial Board (<http://arima.inria.fr/docs/04redaction.html>)

Rallou Thomopoulos is chapter coordinator in 2016 special issue of the IFSET journal, and member of the proposal committee of the special issue 2011 of the RNTI journal (Revue des Nouvelles Technologies de l'Information) on the topic of the evaluation of methods in EKD (Extraction of Knowledge from Data).

9.1.3.2. Reviewer - Reviewing Activities

Reviews for *Artificial Intelligence* and *Journal of Artificial Intelligence Research* (JAIR).

9.1.4. Invited Talks

- Meghyn Bienvenu was invited speaker at IJCAI 2016 (International Joint Conference in Artificial Intelligence), Early Career Spotlight track: “Ontology-mediated query answering : Harnessing knowledge to get more from data”
- Meghyn Bienvenu was keynote speaker at RR 2016 (International Conference on Web Reasoning and Rule Systems): “Query rewriting : Limits and possibilities”
- Meghyn Bienvenu was invited speaker at Reasoning Web (RW) Summer School 2016: “Inconsistency-Tolerant Querying of Inconsistent Description Logic Knowledge Bases”
- Meghyn Bienvenu (with Magdalena Ortiz) was invited speaker at ESSLLI 2016 (European Summer School in Logic, Language and information): “Ontology- Mediated Query Answering with Horn Description Logics”

9.1.5. Invited Seminars

- Efstathios Delivourias gave a talk at the Computational Logic Group Seminar Dresden 2016.
- Meghyn Bienvenu gave a talk at the Séminaire Inria CEDAR 2016.
- Marie-Laure Mugnier, Rallou Thomopoulos, Bruno Yun and Patrice Buche gave talks at the INRA research school “intégration de connaissances et modèles”, Nantes, Nov. 2016

9.1.6. Leadership within the Scientific Community

- **Scientific animation at INRA:** Patrice Buche co-animates the national network INRA IN-OVIVE, devoted to methods and tools for big data management in life sciences, agronomy and food processing <http://www6.inra.fr/reseau-in-ovive>
In particular, he co-organized three editions of the IN-OVIVE workshop dedicated to heterogeneous data sources integration in life sciences during the French conference IC (ingénierie des connaissances) from 2013 to 2016 https://workshop.inra.fr/in_ovive_2016/Programme
Patrice Buche is also co-animator (2012-2017) at the national level of the INRA CATI ICAT “Ingénierie des connaissances et analyse textuelle” <http://www6.inra.fr/cati-icat/Presentation>. Moreover, he co-animates the regional seminar MIAD (Mathematical models for decision making in environment, agronomy and processing of agricultural resources).
- **Scientific animation at the national level:** Marie-Laure Mugnier is member of the animating committee of the pre-GDR “Aspects algorithmiques de l’Intelligence Artificielle” <http://www.gdria.fr> and of the organizing committee of the workshop “Journées d’Intelligence Artificielle Fondamentale” (JIAF, the annual meeting of the French community on the foundations of AI) http://icube-web.unistra.fr/gdri3/index.php/Thème_1_:_Intelligence_Artificielle_Fondamentale
Rallou Thomopoulos is co-leader (together with César Acéves, INSA Toulouse) of the trans-unit program “InCom” (Knowledge and Model Integration) of the CEPIA Division of INRA.

9.1.7. Scientific expertise

- Rallou Thomopoulos and Madalina Croitoru are members of the management committee of the European cooperation network (COST) "Mathematical and Computer Science Methods for Food Science and Industry", accepted in Nov. 2105. http://www.cost.eu/COST_Actions/ca/CA15118 http://www.cost.eu/COST_Actions/ca/CA15118?management
- Marie-Laure Mugnier is member of the scientific advisory board of the Food and Bioproducts department (CEPIA) at INRA (2011-2016).
- Michel Chein is member of the scientific advisory board of ABES (French Agency for Academic Libraries), (2010-2016)
- Patrice Buche participates to the Wheat Data initiative of Research Data Alliance, whose objective is to propose recommendations for wheat and other cereals data <http://ist.blogs.inra.fr/wdi/> (2015-2016)
- Marie-Laure Mugnier was member of the HCERES 2016 evaluation committee for IRISA.
- We also participate to punctual expertise tasks, as experts for ANR, INRA and Inria.

9.2. Teaching - Supervision - Juries

9.2.1. Teaching

The six faculty members teach at all university levels (IUT, Licence, Master). The main courses they are in charge of are: Logics (L), Web Technologies (IUT), Artificial Intelligence (M), Knowledge Representation and Reasoning (M), Social and Semantic Web (M). Some full-time researchers give Master courses (J.-F. Baget 40H; M. Bienvenu 15H).

In addition, Rallou Thomopoulos has been lecturer in the 2015-2016 "Multicriteria Decision Methods" training session, and instructor in the "Companion Modeling" and "Data, Knowledge and Model Integration" 2016 training programs of Laval University (Quebec).

Moreover, faculty members have some specific responsibilities in the Computer Science Licence and Master:

- Michel Leclère (Faculty): since 2011, he manages the program "Data, Knowledge and Natural Language Processing" (DECOL), part of the Master of Computer Science (about 30 students). This program is co-managed by Federico Ulliana (Faculty) since 2016.
- Marie-Laure Mugnier (Faculty): since 2011, she is (co)-director of the Master in Computer Science, which gathers 6 programs (about 250 students). She also led the Master project for the next four years (LMD4, from 2015/16 to 2018/2019).
- Madalina Croitoru (IUT): since Sept. 2014, she manages the "année spéciale" (about 25 students).

9.2.2. Involvement in University Structures

- Michel Leclère: since Sept. 2015, he is deputy manager of the Computer Science teaching Department from the Science Faculty, University of Montpellier.
- Marie-Laure Mugnier: since 2016, she is member of the "pôle de formation et de recherche" MIPS (Mathématiques, Informatique, Physique et Systèmes) of the University of Montpellier.

9.2.3. Supervision

9.2.3.1. Thesis defended in 2016

- Namarata Patel defended her PhD thesis "Mise en oeuvre de préférences dans les problèmes de décision" on Oct., 7 2016 in Montpellier. Advisor: Souhila Kaci (Univ. Montpellier), co-advisor: Roland Ducournau (Univ. Montpellier), reviewers: Jérôme Lang (CNRS, LAMASADE) and Nic Wilson (Univ. College Cork), jury members: Farid Nouioua (Univ. Aix-Marseille) and Nadjib Lazaar (Univ. Montpellier).

- Abdallah Arioua defended his PhD thesis “Formalizing and Studying Dialectical Explanations in Inconsistent Knowledge Bases” on Oct., 17 2016 in Montpellier. Advisors: Patrice Buche (UMR IATE) and Madalina Croitoru (Univ. Montpellier), reviewers: Anthony Hunter (Univ. College London) and Nicolas Maudet (Univ. Pierre et Marie Curie), jury members: Juliette Dibia (AgroParis-Tech), Leila Amgoud (IRIT), Bernard Cuq (Montpellier SupAgro) and Jérôme Fortin (Univ. Montpellier).
- Fabien Garreau defended his PhD thesis “Extension d’ASP pour couvrir des fragments DL traitables : étude théorique et implémentation” on Nov., 24 2016 in Angers. Advisor: Igor Stephan (Univ. Angers), co-advisors: Jean-François Baget (Inria) and Laurent Garcia (Univ. Angers), reviewers: Andreas Herzig (IRIT) and Philippe Lamarre (INSA Lyon), jury members: Odile Papini (Univ. Aix-Marseille), Claire Lefevre (Univ. Angers) and Marie-Laure Mugnier (Univ. Montpellier).
- Swan Rocher defended his PhD thesis “Querying Existential Rule Knowledge Bases: Decidability and Complexity” on Nov., 25 2016 in Montpellier. Advisor: Marie-Laure Mugnier (Univ. Montpellier), co-advisor: Jean-François Baget (Inria), reviewers: Marie-Christine Rousset (Univ. Grenoble) and Sebastian Rudolph (TU Dresden), jury members: Andreas Pieris (Univ. Edinburgh) and Christophe Paul (CNRS, LIRMM).

9.2.3.2. Ongoing thesis

PhD in progress are:

- Stathis Delivourias. Supervisors: Federico Ulliana, Michel Leclère and Marie-Laure Mugnier. “Boundedness and Module extraction in Existential Rules KBs”. Started Oct. 2015.
- Abdelraouf Hecham. Supervisors: Madalina Croitoru and Pierre Bisquert. “Logical argumentation with dual cognitive systems”. Algerian National Ministry Grant 2015-2018.
- Bruno Yun. Supervisors: Madalina Croitoru, Rallou Thomopolous, Srdjan Vesic. “Decision Making and Ranking Semantics in Logical Argumentation Frameworks”. French National Ministry Grant 2016-2019.

9.2.4. Juries

In the following list, we exclude our participation in the PhD juries of GraphIK PhD Students.

- Marie-Laure Mugnier was PhD jury president - Christopher Beatrix - University of Nantes /LERIA - November 2016
- Meghyn Bienvenu was PhD co-supervisor - Camille Bourgaux - University of Orsay / LRI - September 2016
- Marie-Laure Mugnier was PhD reviewer - Camille Bourgaux - University of Orsay / LRI - September 2016
- Marie-Laure Mugnier was HDR reviewer - Nathalie Pernelle - University of Orsay / LRI - June 2016
- Patrice Buche was PhD reviewer - Fatma Chamekh - University of Jean Moulin / Lyon 3- December 2016
- Patrice Buche was HDR examiner - Nathalie Pernelle - University of Orsay / LRI - June 2016
- Federico Ulliana was member of the selection committee for a “Maître de conférence” position in Paris Dauphine

10. Bibliography

Major publications by the team in recent years

- [1] J.-F. BAGET, M. BIENVENU, M.-L. MUGNIER, S. ROCHER. *Combining Existential Rules and Transitivity: Next Steps*, in “IJCAI: International Joint Conference on Artificial Intelligence”, Buenos Aires, Argentina, July 2015, <https://hal.archives-ouvertes.fr/hal-01171846>

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- [6] V. GUILLARD, P. BUCHE, S. DESTERCKE, N. TAMANI, M. CROITORU, L. MENUT, C. GUILLAUME, N. GONTARD. *A Decision Support System to design modified atmosphere packaging for fresh produce based on a bipolar flexible querying approach*, in "Computers and Electronics in Agriculture", February 2015, vol. 111, pp. 131-139 [DOI : 10.1016/J.COMPAG.2014.12.010], <https://hal.archives-ouvertes.fr/hal-01104835>
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Publications of the year

Articles in International Peer-Reviewed Journals

- [11] F. BAADER, M. BIENVENU, C. LUTZ, F. WOLTER. *Query and Predicate Emptiness in Ontology-Based Data Access*, in "Journal of Artificial Intelligence Research", 2016, vol. 56, pp. 1-59 [DOI : 10.1613/JAIR.4866], <https://hal-lirmm.ccsd.cnrs.fr/lirmm-01367867>
- [12] F. DUPIN DE SAINT-CYR, P. BISQUERT, C. CAYROL, M.-C. LAGASQUIE-SCHIEX. *Argumentation update in YALLA (Yet Another Logic Language for Argumentation)*, in "International Journal of Approximate Reasoning", August 2016, vol. 75, pp. 57-92 [DOI : 10.1016/J.IJAR.2016.04.003], <https://hal-lirmm.ccsd.cnrs.fr/lirmm-01372745>

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- [20] A. ARIOUA, M. CROITORU, L. PAPALEO, N. PERNELLE, S. ROCHER. *Explanation Dialogues on Erroneous SameAs Using Argumentation Theory*, in "ICCS: International Conference on Conceptual Structures", Annecy, France, July 2016, <https://hal-lirmm.ccsd.cnrs.fr/lirmm-01328668>
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