IN PARTNERSHIP WITH:
CNRS

INRA

Université de Montpellier

Activity Report 2017

Project-Team GRAPHIK

GRAPHs for Inference 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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1. Personnel

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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, we also use 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) 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 and reasoning for agronomy, oriented towards knowledge-based systems to aid decision-making for the quality control in food processing.
- knowledge representation and reasoning for data journalism, oriented towards efficient ontology-mediated query answering of heterogeneous information sources.

3. Research Program

3.1. Logic-based Knowledge Representation and Reasoning

We follow the mainstream *logic-based* approach to knowledge representation (KR). 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 7.1 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. Application Domains

4.1. Agronomy

Agronomy is a strong expertise domain in the area of Montpellier. Some INRA researchers (computer scientists) are members of GraphIK, and more generally we closely collaborate with the Montpellier research laboratory IATE, a join unit of INRA and other organisms. A major issue for INRA is modeling agrifood chains (i.e., the chain of all processes leading from the plants to the final products, including waste treatment). This modeling has several objectives. It provides better understanding of the processes from begin to end, which aids in decision making, with the aim of improving the quality of the products and decreasing the environmental impact. It also facilitates knowledge sharing between researchers, as well as the capitalization of expert knowledge and "know how". This last point is particularly important in areas strongly related to a "terroir" (like in cheese or wine making), where knowledge and "know how" are transmitted by experience, with the risk of non-sustainability of the specific skills. For all these reasons, INRA became very interested in developing knowledge engineering methods. An agrifood chain analysis is a highly complex procedure since it relies on numerous criteria of various types: environmental, economical, functional, sanitary, etc. Quality objectives imply different stakeholders, technicians, managers, professional organizations, end-users, public organizations, etc. Since the goals of the implied stakeholders may be divergent, decision making raises arbitration issues. In this context, our first investigations led to identify decision support based on argumentation frameworks as a promising topic, as well as the representation and processing of preferences.

4.2. Data Journalism

One of today's major issues in data science is to design techniques and algorithms that allow analysts to efficiently infer useful information and knowledge by inspecting heterogeneous information sources, from structured data to unstructured content. We take data journalism as an emblematic use-case, which stands at the crossroad of multiple research fields: content analysis, data management, knowledge representation and reasoning, visualization and human-machine interaction. We are particularly interested in issues raised by the design of data and knowledge management systems that will support data journalism. These systems include an ontology that typically expresses domain knowledge, heterogeneous data sources, and mappings that relate these data sources expressed with their own vocabulary and querying capabilities, to a (possibly virtual) factbase expressed using the ontological vocabulary. Ontologies play a central role as they act both as a mediation layer that glue together pieces of knowledge extracted from heterogeneous data sources, and as an inference layer that allow to draw new knowledge. In the context of data journalism, those ontologies require challenging features that we need to take into account:

- the wide range of topics addressed in journalism requires a rich top-level ontology, though very specific ontologies might be required to handle specific knowledge (e.g. detailed knowledge on finance to handle the panama papers).
- in data journalism, each piece of knowledge requires different timestamps (temporal information represented within the data, for instance when an event effectively takes place, and temporal information about the data itself, for instance when this event is recorded / validated in the system). Temporal relations (such as Allen's) can be used to express constraints between timestamps and ensure the consistency of the (virtual) knowledge base.
- in data journalism, each piece of knowledge has an identified source. The analysis of conflicting knowledge in the (virtual) knowledge base has to take the source fiability into account.

Besides pure knowledge representation and reasoning issues, querying such systems raise issues at the crossroad of data and knowledge management. In particular, the notion of mappings has to be revisited in the light of the reasoning capabilities enabled by the ontology. More generally, the consistency and the efficiency of the system cannot be ensured by considering the components of the system in isolation (i.e., the ontology, data sources and mappings), but require to study the interactions between these components and to consider the system as a whole.

5. Highlights of the Year

5.1. Highlights of the Year

Organization of the 30th Workshop on Description Logics (Montpellier, July 2017), which is the major annual event of the Description Logics research community.

5.1.1. Awards

BEST PAPER AWARD:

[36]
H. VILMART, J.-C. LÉON, F. ULLIANA. *Extraction et Inférence de Connaissances à partir d'Assemblages Mécaniques Définis par une Représentation CAO 3D*, in "EGC 2017 - Conférence Extraction et Gestion des Connaissances", Grenoble, France, January 2017, https://hal-lirmm.ccsd.cnrs.fr/lirmm-01662810

6. New Software and Platforms

6.1. GRAAL

KEYWORDS: Knowledge database - Ontologies - Querying - Data management
SCIENTIFIC DESCRIPTION: Graal is a Java toolkit dedicated to querying knowledge bases within the framework of existential rules, aka Datalog+/-.
FUNCTIONAL DESCRIPTION: Graal has been designed in a modular way, in order to facilitate software reuse and extension. It should make it easy to test new scenarios and techniques, in particular by combining algorithms. The main features of Graal are currently the following: (1) a data layer that provides generic interfaces to store various kinds of data and query them with (union of) conjunctive queries, currently: MySQL, PostgreSQL, Sqlite, in memory graph and linked list structures, (2) an ontological layer, where an ontology is a set of existential rules, (3) a knowledge base layer, where a knowledge base is composed of a fact base (abstraction of the data via generic interfaces) and an ontology, (4) algorithms to process ontology-mediated queries, based on query rewriting and/or forward chaining (or chase), (5) a rule analyzer, which performs a syntactic and structural analysis of an existential rule set, (6) several IO formats, including imports from OWL 2.

RELEASE FUNCTIONAL DESCRIPTION: The new version (1.3.0) apports some bug fixes, makes the dlgp parser more flexible (dlgp being our serialization format for existential rules) and improves the efficiency of the forward chaining (chase) algorithms.
NEWS OF THE YEAR: A new stable version (1.3.0) has been delivered. Moreover, the Graal website has been deeply restructured and enriched with new tools, available online or for download, and documentation including tutorials, examples of use, and technical documentation about all Graal modules.

- Participants: Marie-Laure Mugnier, Clément Sipieter, Jean-François Baget, Mélanie König, Michel Leclère and Swan Rocher
- Contact: Marie-Laure Mugnier
- Publications: Graal: A Toolkit for Query Answering with Existential Rules - Datalog+, RuleML and OWL 2: Formats and Translations for Existential Rules
- URL: https://github.com/graphik-team

6.2. Cogui

KEYWORDS: Knowledge database - Ontologies - GUI (Graphical User Interface)

SCIENTIFIC DESCRIPTION: Cogui is a visual tool for building and verifying graphical knowledge bases (KB). Knowledge bases are represented under graphical form (close to conceptual graphs). There is a complete correspondence with the logical existential rule (or Datalog+) framework.
FUNCTIONAL DESCRIPTION: Cogui is a freeware written in Java. It allows to graphically create a KB, to handle its structure and content, and to control it. Currently, it supports Conceptual Graphs and import/export in RDFS and Datalog+. Wizards allow to analyze and check facts with respect to some constraints, as well as to query them while taking into account inferences enabled by the ontology.
NEWS OF THE YEAR: Cogui is currently under heavy refactoring to benefit from NetBeans graphical libraries, as well as the plugin-based architecture and Java 9 Jigsaw.

- Participants: Alain Gutierrez, Michel Chein, Marie-Laure Mugnier, Michel Leclère and Madalina Croitoru
- Partner: LIRMM
- Contact: Michel Chein
- URL: http://www.lirmm.fr/cogui/

6.3. CoGui-Capex

KEYWORD: Ontologies
SCIENTIFIC DESCRIPTION: CoGui-Capex is a decision support tool dedicated to food industry based on the CoGui editor. 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. Since 2016, the version of CoGui-Capex for Neatbeans environnement is coupled with the so-called “Knowledge book” developed by INRA I2M team in Bordeaux.
FUNCTIONAL DESCRIPTION: CoGui-Capex is a decision support tool dedicated to food industry.

RELEASE FUNCTIONAL DESCRIPTION: The new version of Cogui-Capex has been coupled with the tool "MakeBook".
NEWS OF THE YEAR: CoGui-Capex has been been delivered to the industral partner Régilait, a powder milk producer.

- Participants: Jérôme Fortin, Patrice Buche, Alain Gutierrez and Clément Sipieter
- Partners: INRA - LIRMM
- Contact: Jérôme Fortin

6.4. NoAWVote

KEYWORD: Social choice
SCIENTIFIC DESCRIPTION: NoAWVote is a decision-making system which relies on the fair aggregation of individual preferences, i.e. the preference profile. It allows to: - Compute collective preferences according to different voting methods such as, among others, k-approval, Borda, Kemeny-Young, - Filter the individual preferences according to the voters characteristics (categories such as age, location, etc.), - Cluster individual preferences into group preferences according to some given categories, these groups’ preferences being then aggregated themselves, - Format the aggregation result (single winner, k-top alternatives, full ranking)
FUNCTIONAL DESCRIPTION: NoAWVote is a software providing a decision-making mechanism which relies on the fair aggregation of individual preferences which is developed within the context of the H2020 Projects NoAW project.

RELEASE FUNCTIONAL DESCRIPTION: The first release of the tool contains the described functionalities.

NEWS OF THE YEAR: The development of the tool started this year.

- Participants: Pierre Bisquert, Madalina Croitoru, Patrice Buche, Rallou Thomopoulos and Nikolaos Karanikolas
- Partner: INRA
- Contact: Pierre Bisquert
- Publication: Selection of agro-waste valorisation routes based on a computational social choice and argumentation decision support tool

6.5. Genetix

KEYWORDS: Biological sequences - Propositional logic
SCIENTIFIC DESCRIPTION: Genetix is a design assistant for biologists. The tool allows experts to precompute biological designs (corresponding to DNA sequences) implementing an intended boolean function. The software includes a parallel generator of sequences running on HPC clusters which is able to manage functions with up to 4 input variables. An open database allows biologists to explore and query available designs.
FUNCTIONAL DESCRIPTION: Genetix is a tool for generating biological sequences implementing boolean functions.

RELEASE FUNCTIONAL DESCRIPTION: The first version of the tool is able to generate biological implementations of boolean functions with up to 4-inputs.
NEWS OF THE YEAR: The development of Genetix started this year.

- Participants: Michel Leclère, Federico Ulliana and Guillaume Perution Kihli
- Contact: Michel Leclère
- Publication: Scalable composition frameworks for multicellular logic
- URL: http://genetix.lirmm.fr/

7. New Results

7.1. Logics and Graph-Based Languages for Ontology-Mediated Query Answering

Participants: Jean-François Baget, Meghyn Bienvenu, Efstathios Delivorias, Michel Leclère, Marie-Laure Mugnier, Federico Ulliana, Arthur Boixel, Marin Julien, Benjamin Boisson, Thibault Bondetti.

Ontolology-mediated query answering (OMQA) is the issue of querying data while taking into account inferences enabled by an ontology. 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 (DLs) and existential rules (aka Datalog+). Both frameworks correspond to fragments of first-order logics, which are incomparable in general, but closely related in the context of OMQA: indeed, the DLs considered for OMQA (so-called Horn-DLs) are naturally translated into specific classes of existential rules. Compared to existential rules, Horn-DLs feature lower complexity classes and allow for specific algorithmic techniques. A well-known Horn-DL is the lightweight description logic family DL-Lite. Importantly, the foundational work carried by the KR community led to the definition of several W3C standards for Semantic Web languages, namely the family of OWL languages. For example, DL-Lite corresponds to OWL 2 QL, a dialect of OWL 2 with polynomial conjunctive query answering (in terms of data complexity; conjunctive queries are the basic and most frequent relational database queries). Furthermore, the ontology-based paradigm for data access is also supported by commercial systems, such as Oracle 11g, which offers a module dedicated to Semantic Web technologies (https://docs.oracle.com/cd/B28359_01/appdev.111/b28397/toc.htm).

This year, we further investigated OMQA with both description logics and existential rules. We also broadened this research line, by investigating ontological languages for non-relational data, hereby continuing the work initiated last year on OMQA for key-value stores.

7.1.1. Ontology-Mediated Query Answering in the Description Logics Framework

The OWL 2 QL profile, based upon the DL-Lite family, is a popular ontology language for applications involving large amounts of data. OWL 2 QL possesses the first-order rewritability property, meaning that conjunctive query answering can be reduced to database query evaluation by means of query rewriting. However, query rewriting can be costly and/or produce rewritten queries that are hard to evaluate, so it is important to understand when and how one can construct small and efficient rewritings, and more generally, under which conditions can OWL 2 QL be queried effectively. Building upon our earlier work, we explored these questions together with colleagues from Birkbeck College and the Free University of Bozen-Bolzano.

First, we studied the overhead of answering ontology-mediated queries (OMQs) in ontology-based data access compared to evaluating their underlying tree-shaped and bounded treewidth conjunctive queries (CQs). We showed that OMQs with bounded-depth ontologies have nonrecursive datalog (NDL) rewritings that can be constructed and evaluated in LOGCFL (a strict subclass of PTIME) for combined complexity, even in NL if their CQs are tree-shaped with a bounded number of leaves, and so incur no overhead in complexity-theoretic terms. For OMQs with arbitrary ontologies and bounded-leaf CQs, NDL-rewritings are constructed and evaluated in LOGCFL. We conducted experiments that demonstrate feasibility and scalability of our rewritings compared to standard NDL-rewritings.

- *These results were published at* ***PODS 2017*** *[22]*

We investigated the parameterised complexity of answering tree-shaped ontology-mediated queries in OWL 2 QL under various restrictions on their ontologies and CQs. We proved that answering OMQs with tree-shaped CQs is not fixed-parameter tractable if the ontology depth is regarded as the parameter, and that answering OMQs with a fixed ontology (of infinite depth) is NP-complete for tree-shaped and LOGCFL for bounded-leaf CQs. Moreover, we constructed an ontology T such that answering OMQs (T, q) with tree-shaped CQs q is W[1]-hard if the number of leaves in q is regarded as the parameter. The number of leaves had previously been identified as an important characteristic of CQs as bounding it leads to tractable OMQ answering. Our result shows that treating it as a parameter does not make the problem fixed-parameter tractable, even for a fixed ontology.

- *These results were published at* ***DL 2017*** *[23]*

7.1.2. Ontology-Mediated Query Answering in the Existential Rule Framework

The class of existential rules that naturally generalizes OWL 2 QL is called linear existential rules. Such rules have a body restricted to a single atom. Linear existential rules are in turn generalized by guarded existential rules, one of the main classes of existential rules.

Building upon our work on OWL 2 QL (reported Section 7.1.1), we developed optimal rewriting-based methods for answering ontology-mediated queries (O,q) where O is a set of linear existential rules and q is a CQ of bounded hypertree width. Assuming that the arity of predicates is bounded, we show that polynomial-size nonrecursive Datalog rewritings can be constructed and executed in (i) LOGCFL for OMQs with ontologies of bounded existential depth; (ii) NL for OMQs with ontologies of bounded depth and CQs whose hypertree decompositions have a bounded number of leaves; (iii) LOGCFL for OMQs with acyclic CQs whose join trees have a bounded number of leaves.

- *These results were published at* ***DL 2017*** *[24]*

While most work on ontology-mediated query answering considers conjunctive queries, navigational queries are gaining increasing attention. Last year, we conducted a first study of such queries in the setting of existential rules, focusing on linear rules and regular path queries. This year, in a continued collaboration with Michael Thomazo (Inria CEDAR), we have significantly extended these results by considering the problem of answering two-way conjunctive regular path queries (CRPQs) over knowledge bases whose ontology is given by a set of guarded existential rules. We first showed that for the subclass of linear existential rules, CRPQ

answering is EXPTIME-complete in combined complexity and NL-complete in data complexity, matching the recently established bounds for answering non-conjunctive RPQs. For guarded rules, we gave a non-trivial reduction to the linear case, which allowed us to show that the complexity of CRPQ answering is the same as for CQs, namely 2EXPTIME-complete in combined complexity and PTIME-complete in data complexity.

- *These results were published at* ***IJCAI 2017*** *[20]*

Besides, three internships (L3, Master 1 and Master 2) explored different aspects related to existential rules.

7.1.3. Ontology-Mediated Query Answering on top of Key-Value Stores

Ontology-mediated query answering has been mainly investigated so far based 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 OMQA can be developed for non-relational structures, like those shared by increasingly popular NOSQL languages sustaining Big-Data analytics, has just begun to be investigated. Last year, we carried out the first study of OMQA for key-values stores, which are systems providing fast and scalable access to JSON records [46]. We proposed a rule language to express domain knowledge, with rules being directly applicable to key-value stores, without any translation of JSON into another data model. However, some limitations of our proposal were (1) the absence of correspondence with logic, the semantics remaining operational, and (2) the need to drastically restrict the rules to ensure decidability.

Building on this previous work, we pursued the investigation of a rule language for JSON records, together with colleagues from Inria Lille. This yielded a novel rule language, with a natural translation into first-order logics, and more precisely into guarded existential rules. From known results on existential rules, we got the decidability of query answering in our framework but only rough complexity bounds. By establishing an interesting and non-trivial connection to word rewriting, we were able to pinpoint the exact combined complexity of query answering in our framework and obtain promising tractability results for data complexity. The upper bounds were proven using a query reformulation technique, which can be implemented on top of key-value stores, thereby exploiting their querying facilities.

- *These results were published at* ***IJCAI 2017*** *[21]*

A master student project led to an implementation of OMQA for MongoDB tree-pattern queries and a subset of the proposed rule language featuring key inclusions and mandatory keys. The system contains query rewriting procedures for data access as well as an optimization module for parallelizing the query reformulation process.

- *Demo paper at* ***BDA 2017*** *[31]*

7.1.4. Applications to Computer Aided Design

Participant: Federico Ulliana.

Complementing the theoretical work on the OMQA issue, the team also participated in the building of OMQA-based systems applied to the field of CAD (Computer Aided Design). We developed a system for querying and exploring complex 3D CAD models corresponding to the assembly of manufactory products (for example, an airplane wing). Our system features a pipeline of two modules : a geometric analysis module which reasons on numeric features of the CAD model and a knowledge-based module which reasons on symbolic information which is extracted by the former module. The knowledge-based module exploits a geometry-ontology for manufactory assemblies, that we developed in collaboration with an expert. This allows for an automatic classification of the solids that appear in a 3D scene (for example, for labelling screws and bolts), but also for associating them their functional role (for example, planar supports, seals, rotating guides). By automatically annotating objects, we minimize the errors usually introduced by the manual processes of annotation. Complex CAD models can therefore be queried by selecting objects and components based on the types (e.g., select all bolts of an airplane wing) or functions (e.g., planar supports) and the results of queries visualized in a 3D browser. This work is performed in the context of our collaboration with the Inria Imagine Team. A website http://3dassblyanlysis.gforge.inria.fr/3d/ gives a public access to a knowledge-based assembly example.

- *These results were published in* ***EGC 2017*** *and received a prize for* Best Application Paper

7.2. Dealing with Imperfect Information

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

Reasoning in presence of inconsistencies is a challenging task both from a theoretical and an application point of view. From a theoretical point of view, it means finding methods that can tolerate the inconsistency. From an application point of view, it means providing meaningful results to the user. In the works carried out this year inconsistency arose while developing a decision support system assisting human experts with a given task. The main challenges we faced where first to provide the user with a comprehensive vision over the different possibilities and then to assist her while she makes a decision.

7.2.1. Argumentation in the Existential Rule Setting

Our first line of work focussed on the use of argumentation-based methods for reasoning in presence of inconsistencies within knowledge bases expressed in the formalism of existential rules. Such inconsistency can occur either in the facts or in the rules of the knowledge base.

Logical based argumentation instantiates abstract argumentation frameworks by $i)$ constructing arguments from inconsistent knowledge bases, $ii)$ computing attacks between them, and $iii)$ using so-called argumentation semantics in order to select acceptable arguments and their conclusions. The advantage of using argumentation for reasoning in an inconsistent setting lies in the explanatory power of argumentation frameworks. We considered the first case of inconsistency arising from the factual level and investigated the formal properties of the argumentation frameworks. We showed then that the argumentation is of practical use as it allows for a principled explanatory dialogue. Finally, we carried out an experiment that compared the explanatory power of argumentation in this setting and found out that positive results are only achieved if particular attention is given to the phrasing of such interaction.

- *These results were published at* ***ESA 2017*** *[12],* ***IJAR 2017*** *[13], and* ***DL 2017*** *[28]*

In logical based argumentation, arguments are sometimes based upon equivalent data. Cores are notions introduced in that delete such arguments. We investigated two different notions of core in such a logically instantiated argumentation framework (more details about the instantiation can be found in [12]) that will remove redundant arguments and attacks in a different manner. We do not follow the argumentation semantics "a la Dung" but study ranking semantics that return a total order over the set of arguments in the logical argumentation framework. We show that the manner of defining the core of a logically instantiated argumentation framework affects the ranking output of ranking semantics.

- *These results were published at* ***AAMAS 2017*** *[38] and IDA [37]*

Another setting we explored was when the inconsistency arises from the rules (also sometimes referred to as incoherence). In this setting we investigated defeasible logics and proposed a refined formalism for defeasible existential rules. We showed that in the case of defeasible reasoning one may be interested in generating all provenance paths of an atom, an issue which raises an interesting technical challenge. In order not to lose paths due to the skolemisation process we introduced a new combinatorial structure called the graph of atom dependency and showed how using this structure prevents provenance paths loss. We implemented our approach and showed that it has a very good performance with respect to the other argumentation based tools that could be used for defeasible reasoning in existential rules.

- *These results were published at* ***RuleML+RR 2017*** *[29] and* ***AAMAS 2017*** *[30]*

7.2.2. Human Interaction and Decision Making

Our second line of contributions focussed on how to bridge the gap between the human and the machine in a decision support setting. We thus investigated how human reason and how cognitive biases can influence decision making. Then, we approached the decision making process by developing methods based on voting theory and classical decision theories allowing us to achieve desirable properties.

We proposed a dual system for artificial agents combining deductive logical reasoning with intuitive reasoning for the sake of argumentation. Our contribution is the definition of a new formal model of flexible argument evaluation. We consider that, when it is not possible for an agent to make a logical inference (since it requires too much cognitive effort or she has insufficient knowledge), she might replace certain parts of the logical reasoning with mere associations. We applied our work on the Durum Wheat variety selection in the context of the French National Agency (ANR) Dur-Dur project.

- *These results were published at* ***MM 2017*** *[15]*

Collective decision making is classically done via social choice theory with each member of the group expressing preferences as a (total) order over a given set of alternatives, and the group's aggregated preference is computed using a voting rule. However, such methods do not take into account the rationale behind agents' preferences. Our research hypothesis is that a decision made by a group of participants understanding the qualitative rationale (i.e., arguments) behind each other's preferences has better chances to be accepted and used in practice. To this end we proposed a novel qualitative decision process which combines argumentation with computational social choice for modelling the decision-making problem. We show that a qualitative approach based on argumentation can overcome some of the social choice deficiencies. A first version of this approach was implemented and practically demonstrated in [25].

- *These results were published at* ***ADT 2017*** *[41]*

A recent work in cooperation with Laval University (Canada) and AGIR joint research unit (Toulouse) deals with the combination of argumentation and system dynamics simulation for decision support in the agri-food sector. We propose a systematic method to assess possible options, based on the complementarity of argumentation modeling and system dynamics (SD) simulation, in conjunction with field experimentation. As a practical application, we assess various options available to agri-food chain stakeholders when considering the adoption of cereal-legume intercrops as an alternative to sole crops. Moreover, we carried out complementary studies to explore the possible added-value of argumentation for decision support in practical cases related to agri-food chains. We proposed the introduction of numerical indicators in argumentation systems in order to evaluate to what extent the system studied (a short food supply chain) is polemical, i.e. subject to divergent viewpoints, and which criteria are mainly involved in these divergences. As a study case, we considered a food policy about bread-making which illustrated that a given argument may be interpreted through different scenarios, among which unexpected worst-cases can occur.

- *These results were published at* ***IEA/AIE 2017*** *[33], [35] and* ***WCCA 2017*** *[34], [32]*

7.3. Miscellaneous

We describe here some complementary work carried out this year in knowledge representation and knowledge engineering. First, we started a new collaboration with the Center for Structural Biochemistry in Montpellier, on the translation of boolean functions in a biological language, so as to help the design of biological devices satisfying formal properties. Second, in collaboration with MAREL team at LIRMM, which designs algorithms for Formal Concept Analysis, we developed a new algorithm for generating text under constraints, implemented in a tool that relies on our tool Cogui. Third, we report some complementary work carried out in the IATE team on the construction of ontologies in the agronomy domain and their use to integrate heterogeneous data, the obtained knowledge base acting as an input to a decision support system.

7.3.1. Encoding Boolean Functions in Biological Systems

Participants: Michel Leclère, Federico Ulliana, Guillaume Perution Kihli.

This work has been done as part of a new collaboration started in 2017 with the "Centre de Biochimie Structurale (CBS) de Montpellier" with Sarah Guiziou and Jérôme Bonnet. CBS is interested in developing a framework dedicated to the automatic design of "recombinase" biological systems implementing a boolean function. Recombinases are genetic enzymes which allow to manipulate the structure of genomes, and to control gene expression, which is seen as the output of a boolean function. Different ways of designing such systems are possible. In this collaboration, we study the design of biological sequences of DNA that are

intended to implement a specific boolean function defined by the expert biologist. From our side, we study the logical expressivity of such systems. Concretely, our goal is to characterize the set of boolean functions that do admit a biological implementation under certain constraints. Then, whenever this is possible, devise a method for automatically constructing such sequence.

This first year, we have studied and highlighted some characteristic properties of biological sequences, namely equivalence, irreducibility, and simplifiability. We also develop an algorithm to exhaustively explore the set of irreducible and not simplifiable sequences with n inputs (which allows us to implement a boolean function with n variables). This algorithm has been implemented in a distributed way and run on a high performance cluster. From its outputs, we built a database allowing to associate the different possible sequences to each boolean function up to 4 variables (http://genetix.lirmm.fr).

- *Our first findings are contained in a preliminary report [42]*

7.3.2. Text Generation Under Constraints on top of Cogui

Participants: Michel Chein, Alain Gutierrez.

We built a tool that can be used for building, editing, and reusing, large corpuses for text generation under constraints. Text generation is made by dynamically instantiating templates with terms that are drawn from a collection of available textual corpuses. We developed a database indexing technique based on a sub-order of a Galois lattice (so-called AOC-poset) that we use to describe the structure of the input texts as well as the terms that they contain. Thanks to the index we can efficiently find terms for the text generations process. The final tool is developed on top of Cogui. Finally, we conducted an experimental evaluation that outlines the size and construction time of indexes (which are built off-line), as well as the performance of text-generation.

- *Our results have been published in* ***ISMIS 2017*** *[27]*

7.3.3. Complementary Work on Ontologies for Data Integration in Agronomy

Participant: Patrice Buche.

We use here ontologies to integrate experimental data across complementary sub-domains in agronomy. Scientific literature in the agronomy field is growing fast and could be a valuable source of data for researchers willing to address extended research questions, for example, comparing the efficiency of the same biomass treatment applied in different contexts. However, scientific data is abundant, mostly in textual format, and heterogeneously structured, all factors that can hinder its systematic reuse. We put an effort on the implementation of decision support systems using ontologies and structured knowledge to integrate scientific data coming from different sources. This led to the definition of a new ontology network called Agri-Food Experiment Ontology (AFEO), which was developed based on two ontological resources AEO (Ontology for Agricultural Experiments) and OFPE (Ontology for Food Processing Experiments) and of a termino-ontological resource to compare ligno-cellulosic biomass and agro-waste valorisation routes. We studied methods for linking existing ontologies in life sciences and environment. To extract knowledge from data, we also devised an automatically discovery and extraction method for relevant data modeled as n-ary relations in plain text.

- *Results were published in* ***CEAR*** *[17],* ***WCCA 2017*** *[26],* ***ESA*** *[14], and* ***AKDM*** *[39]*

Heterogeneous data integrated thanks to ontology networks are reused in Decision support systems (DSS). Two prototypes have been implemented in the domain of food packaging selection for respiring and non respiring fresh foods. Additionnaly, our team contibutes to international initiatives to suggest ontological standards in sub-domains of Agriculture.

- *Results were published in* ***F1000Research*** *[18],* ***Innovations Agronomiques*** *[19], and* ***Packaging Research*** *[16]*

8. Bilateral Contracts and Grants with Industry

8.1. Bilateral Grants with Industry

- Régilait contract: In the framework of a contract between INRA IATE and STLO (Rennes) research units, a master student from Toulouse University has been recruited in 2017. He developed a new version of the CoGui-Capex software tool, based on Cogui, which permits to navigate and reason in decision-support trees that link food descriptors and the actions that can be undertaken by some operators. The final delivery (December 2017) will be evaluated by Régilait till mid-2018.

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR Projects

9.1.1.1. ASPIQ (ANR white, Jan. 2013-July 2017)

Participants: Jean-François Baget, Madalina Croitoru, Marie-Laure Mugnier.

ASPIQ (ASP technologIes for Querying large scale multisource heterogeneous web information), coordinated by Odile Papini (LSIS), involves other participants from CRIL, LERIA and LSIS. http://aspiq.lsis.org/

The aim 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 7.1 for this year's results. An international workshop (WASPIQ 2017) associated with the conference IEA/AIE 2017 was also organized (see Section 10.1.1)*

9.1.1.2. Pagoda (ANR JCJC, Jan. 2013-Dec. 2017)

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

Pagoda (Practical Algorithms for Ontology-based Data Access), coordinated by Meghyn Bienvenu, involves participants from IRISA, LIX, 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 7.1 for this year's results.*

9.1.1.3. Dur-Dur (ANR ALID, March 2014-Feb. 2017)

Participants: 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), coordinated by Bernard Cuq (IATE), involves participants from 6 agronomy research units (including IATE), and 4 technical / professional partners. 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 7.2 for this year's results.*

9.1.2. Other projects

9.1.2.1. ICODA (Inria Project Lab, 2017-2021)

Participants: Jean-François Baget, Michel Chein, Marie-Laure Mugnier.

The iCODA project (Knowledge-mediated Content and Data Interactive Analytics—The case of data journalism), coordinated by Guillaume Gravier and Laurent Amsaleg (LINKMEDIA), takes together four Inria teams: LINKMEDIA (with being the project leaders), CEDAR, ILDA and GraphIK, as well as three press partners: Ouest France, Le Monde (les décodeurs) and AFP.

Taking data journalism as an emblematic use-case, the goal of the project is to develop the scientific and technological foundations for knowledge-mediated user-in-the-loop big data analytics jointly exploiting data and content, and to demonstrate the effectiveness of the approach in realistic, high-visibility use-cases.

9.1.2.2. Docamex (CASDAR project, 2017-2020)

Participants: Patrice Buche, Madalina Croitoru, Jérôme Fortin, Clement Sipietier.

DOCaMEx (Développement de prOgiciels de Capitalisation et de Mobilisation du savoir-faire et de l'Expérience fromagers en filière valorisant leur terroir), let by CFTC (centre technique des fromages de Franche-Comté) involves 7 research units (including IATE and LIRMM), 8 technical centers and 3 dairy product schools. It represents five cheese-making chains (Comté, Reblochon, Emmental de Savoie, Salers, Cantal).

Traditional cheese making requires a lot of knowledge, expertise, and experience, which is usually acquired over a long time. This knowledge is today mainly transmitted by apprenticeship and a concrete risk of knowledge forgetting is raised by the evolutions of practices in the sector. Using new methods for expert capitalization and numeric representation, the main goal of the project is to develop a new approach for expert knowledge explicitation and representation and the development of a software dedicated to their manipulation. With this software, cheese makers will be able to easily access to these knowledge for decision making assistance, and more generally any learner in cheese making process will be able to use it to complete its knowledge. His sustainability will be assured by possibility of enrichment with new knowledge and experience feedback. The software will be delivered with a tool-box including a methodological guide and a software package to be informed to assured its usability. IATE, Heudyasic and Graphik will design the new version of CoGui-Capex software tool (based on Cogui) in this project. The original part of the reasoning tool will consist in representing and computing the efficiency and the reliability of actions undertaken to maintain a food quality descriptor. This new tool will be able to enrich information with new experiences.

9.1.2.3. Convergence Institute #DigitAg (2017-2023)

Participants: Patrice Buche, Madalina Croitoru, Marie-Laure Mugnier, Rallou Thomopoulos, Federico Ulliana.

Located in Montpellier, #DigitAg (for Digital Agriculture) gathers 17 founding members: research institutes, including Inria, the University of Montpellier and higher-education institutes in agronomy, transfer structures and companies. Its objective is to support the development of digital agriculture. GraphIK is involved in this project on the issues of designing data and knowledge management systems adapted to agricultural information systems, and of developing methods for integrating different types of information and knowledge (generated from data, experts, models).

9.1.2.4. Pack4Fresh (GloFoodS INRA-Cirad metaprogram, sept. 2015-sept 2017)

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

Pack4Fresh is funded by the multi-year metaprogramme GloFoodS (Transitions to global food security), which 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. 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 7.2 for this year's results.*

9.1.3. Informal National Partners

- A new collaboration started this year with Pierre Bourhis (SPIRALS Inria team, UMR CRIStAL) and Sophie Tison (LINKS Inria team, UMR CRIStAL) on the OMQA issue for the case of Key-Value stores [21].
- The team continues the collaboration with Michael Thomazo (CEDAR Inria team) on Ontology-Mediated Query Answering. This year we worked on extensions of conjunctive queries that enable regular path expressions [20].
- We continued our collaboration with Florence Dupin de Saint-Cyr (Paul Sabatier University, Toulouse) [15], since 2014.
- We continued our collaboration with Srdjan Vesic, Researcher (CNRS - CRIL), Lens, France, since 2016 [13].
- This year we started a collaboration with the Center for Structural Biochemistry of Montpellier (CBS), with Jérôme Bonnet and Sarah Gouiziou, on the encoding of Boolean functions in biological systems [42].
- A new collaboration started with Reza Akbarinia (ZENITH Inria team) on parallel query rewriting for OMQA [31].
- We collaborated with Marianne Huchard (MAREL team, LIRMM) on the combined application of our techniques to generate text under constraints [27].
- We continued our collaboration with Jéan-Claude Léon (IMAGINE Inria team), since 2014 [36].

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

9.2.1.1. NoAW (H2020, Oct. 2016-Sept. 2020)

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

NoAW (No Agricultural Waste) is led by INRA-IATE. 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. http://cordis.europa.eu/project/rcn/203384_en.html

9.2.2. Collaborations in European Programs, Except FP7 & H2020

9.2.2.1. FoodMC (European COST action, 2016-2020)

Participants: Patrice Buche, Madalina Croitoru, Rallou Thomopoulos.

COST actions aim to develop European cooperation in science and technology. FoodMC (CA 15118) is a cost action on Mathematical and Computer Science Methods for Food Science and Industry. Rallou Thomopoulos is co-leader of this action for France, and member of the action Management Committee, and several members of GraphIK (Patrice Buche, Madalina Croitoru) are participants. The action is organised in four working groups, dealing respectively with the modelling of food products and food processes, modelling for eco-design of food processes, software tools for the food industry, and dissemination and knowledge transfer. http://www6.inra.fr/foodmc

9.3. International Initiatives

9.3.1. Informal International Partners

- Laval University (Quebec city, Canada): since 2012 we collaborate with Bernard Moulin on combined argumentation and simulation for decision support, and with Irène Abi-Zeid on Argumentation and multicriteria decision [33], [34].
- Birmingham University (UK), we continued our collaboration with Serafim Bakalis on decision support in agronomy [32].
- University of Toronto (Canada): this year a new collaboration started with Sheila McIlraith and her research group.
- Birkbeck College, University of London (UK): ongoing work with Michael Zacharyschev, Roman Kontchakov, and Stanislav Kikot on the OMQA issue.
- Sapienza University (Rome, Italy): collaboration with Riccardo Rosati, since 2012 [45].
- University of Bremen (Germany): collaboration with Carsten Lutz, since 2009 [44], [43].
- University of Liverpool (UK): collaboration with Frank Wolter, since 2009 [43], [44].
- Patras University (Greece): collaboration with Nikolaos Karanikolas, since 2017 (formerly postdoc in the team) [41], [25].

9.4. International Research Visitors

9.4.1. Visits to International Teams

- Meghyn Bienvenu visited the Birkbeck College, University of London for 1 week during February 2017 as for her collaboration with Michael Zacharyschev, Roman Kontchakov, Stanislav Kikot. She also visited the
- Rallou Thomopoulos visited the team of Alexandros Koulouris and Maria Papageorgiou atATEI Thessaloniki, Greece (November 2017). He gave also the talk "Science for Food and Bioproduct Engineering at INRA: a knowledge engineering perspective".

9.4.1.1. Research Stays Abroad

- Meghyn Bienvenu will be visiting the Department of Computer Science of the University of Toronto from early August 2017 for nearly 12 months. She will collaborate with Sheila McIlraith and the rest of the Knowledge Representation group.

10. Dissemination

10.1. Promoting Scientific Activities

10.1.1. Scientific Events Organisation

- **Organization of DL 2017 (30th Workshop on Description Logics)**, Montpellier, July 2017. The DL workshop is the major annual event of the Description Logic research community. It is the forum at which those interested in description logics, both from academia and industry, meet to discuss ideas, share information and compare experiences. Meghyn Bienvenu and Marie-Laure Mugnier were general co-chairs and the team GraphIK was in charge of the local organisation (Jean-François Baget, Pierre Bisquert, Stathis Delivorias, Abdelraouf Hecham, Federico Ulliana, Bruno Yun, and the team assistant, Annie Aliaga, were members of the organisation committee).
  https://project.inria.fr/dl2017
- **Co-organization of the Graph Based Knowledge Representation and Reasoning Workshop** associated with the **IJCAI 2017** international conference. Madalina Croitoru, with Sebastian Rudolph (Univ Dresden), Pierre Marquis (Univ Artois) and Gem Stapleton (Univ Brighton), organized this event. This is the 5th edition of this workshop series that Madalina Croitoru initiated for IJCAI 2011.
  http://www.lirmm.fr/~hecham/GKR/index.html
- **Co-organization of the Workshop Reasoning on Data** associated with **The Web 2018** international conference (Lyon, March 2018). Marie-Laure Mugnier, with Catherine Roussey (Irstea) and Pierre Senellart (ENS Paris, Inria Valda team), are chairs of this workshop linked to the French national action 'Reasoning on Data' common to GDR MaDICS and IA.
  https://sites.google.com/site/2018rod/
- **Co-organization of the International Workshop on ASP technologIes for Querying large scale multisource heterogeneous web information (WASPIQ 2017)** associated with the **IEA/AIE 2017** conference (30th International Conference on Industrial, Engineering and Other Applications of Applied Intelligent Systems). M.-L. Mugnier, with Odile Papini (LSIS), Salen Benferhat (CRIL) and Laurent Garcia (LERIA), organized this workshop linked to the ANR ASPIQ project.
  http://waspiq2017.lsis.org.
- **Organization of a Special Track on "Agronomy and Artificial Intelligence"** associated with the **IEA/AIE 2017** conference (30th International Conference on Industrial, Engineering and Other Applications of Applied Intelligent Systems). M. Croitoru and P. Bisquert organized this event.
  http://www.cril.univ-artois.fr/ieaaie2017/main/specialtracks

10.1.2. Scientific Events Selection

10.1.2.1. Chair of Conference Program Committees

- Meghyn Bienvenu will be tutorial co-chair for the International Joint Conference on Artificial Intelligence (IJCAI) 2018.

10.1.2.2. Member of the Conference Program Committees

We are regularly members of the program committees of major conferences in AI or in databases (i.e., IJCAI, AAAI, ECAI, AAMAS, ICDT, PODS) and more focused conferences and workshops (such as RuleML+RR —Web reasoning and Rule Systems— and Description Logics). We also take part in the animation of the national community (JIAF, EGC, IC, BDA).

For 2017, we served in the following program committees:

International

- IJCAI 2017 (International Conference on Artificial Intelligence) : 1 Senior PC + 2 PC
- AAAI 2017 (AAAI Conference on Artificial Intelligence) : 2 PC
- PODS 2017 (ACM SIGMOD-SIGACT-SIGAI Symposium on Principles of Database Systems) : 1 PC
- ICDT 2017 (International Conference on Database Theory) : 1PC
- ISWC 2017 (International Semantic Web Conference) : 1 PC
- AAMAS 2017 (International Conference on Autonomous Agents and Multiagent Systems) : 1 PC
- RuleML+RR 2017 (International Joint Conference on Rules and Reasoning) : 2 PC
- EFITA 2017 (European Federation for Information Technology in Agriculture, Food and the Environment) : 2 PC
- IEA/AIE 2017 (International Conference on Industrial, Engineering, Other Applications of Applied Intelligent Systems) : 1 PC
- FQAS 2017 (International Conference on Flexible Query Answering Systems) : 1 PC

National

- JIAF 2017 (Journées Françaises d'Intelligence Artificielle Fondamentale) : 1 PC
- EGC 2017 (Extraction et Gestion des Connaissances) : 2 PC
- IC 2017 (Ingénierie des Connaissances) : 1 PC
- BDA 2017 (Conférence sur la gestion de données) : 1 PC

For 2018, we will serve in the following international program committees (list not exhaustive yet):

- IJCAI-ECAI 2018 (International Joint Conference on Artificial Intelligence joint with the the 23rd European Conference on Artificial Intelligence) : 2 Senior PC + 2 PC
- AAAI 2018 (AAAI Conference on Artificial Intelligence) 1 Senior PC + 1 PC
- RuleML+RR 2018 (International Joint Conference on Rules and Reasoning) : 1PC
- FOIKS 2018 (International Symposium on Foundations of Information and Knowledge Systems) : 1 PC
- ROD 2018 (Reasoning on Data Workshop) @ The Web 2018 : 1 PC

10.1.3. Journal

10.1.3.1. Member of the Editorial Boards

- ARIMA : "Revue africaine de la recherche en informatique et mathématiques appliquées" (P. Buche)

10.1.3.2. Reviewer - Reviewing Activities

- Journal of Artificial Intelligence Research (JAIR)
- ACM Transactions on Computational Logics (ToCL)
- Information Systems Journal
- Distributed and Parallel Databases Journal (DAPD)
- EURO Journal on Decision Processes (EJPD) : Special issue on Supporting and Explaining Decision Processes by means of Argumentation

10.1.4. Invited Talks and Seminars

- J.-F. Baget, "Computing repairs (and more) with Answer Set Programming", Workshop on ASP technologIes for Querying large scale multisource heterogeneous web information (WASPIQ 2017) June 2017.
- F. Ulliana, "Ontology-Mediated Query Answering and Heterogeneous Data" 1ère journée ROD (Reasoning on Data), June 2017.

- M. Bienvenu, "Query Rewriting: Limits and Possibilities", KR seminar, Department of Computer Science of the University of Toronto, December 2017.
- R. Thomopoulos, 'Science for Food and Bioproduct Engineering at INRA: a knowledge engineering perspective", Seminar at ATEI Thessaloniki, Greece (November 2017).
- P. Buche, "Ingénierie des connaissances pour l'aide à la décision dans la filière agroalimentaire", 6ème rencontre ESOF (EuroScienceOpen Forum) sur la transformation numérique des agrochaînes, Toulouse, October 2017.
- M.-L. Mugnier, "Accès aux données médiatisé par une ontologie", 25th Anniversary of the LIRMM laboratory, November 2017.
- Marie-Laure Mugnier, "Accès aux données médiatisé par des connaissances", First seminar of the axis "Système d'information, stockage et transfert de données" of #DigitAg, November 2017
- P. Buche, "Retour d'expérience d'une pratique Open Science au sein du département CEPIA", Séminaire annuel du département INRA CEPIA à Magny-le-Hongre, Session Open Science, Octobre 2017.
- J. Fortin, "Capitaliser l'expertise et la rendre accessible : la démarche Docamex", Séminaire INRA/CEPIA, 2017.

10.1.5. Leadership within the Scientific Community

- Marie-Laure Mugnier, together with Marie-Christine Rousset (LIG), Véronique Bellon (ITAP, IRSTEA/SupAgro) and Olivier Palombi (LDAF-CHU Grenoble-Alpes) launched a national action (2017-2018, 2 years), named Reasoning on Data (Rod), common to CNRS research groups ('GDR') IA (formal and algorithmic aspects of artificial intelligence) and MaDICS (Big Data, Data Science). The aim of this action is to build a national community on the issue of knowledge representation and reasoning oriented towards better exploiting data. The first meeting was held in June 2017 within the MaDICS annual workshop. The second meeting will be held in March 2017 in association with the RoD workshop at the conference The Web 2018. For more detail, see http://www.lirmm.fr/rod/
- Patrice Buche he coordinates both the CATI (Ingénierie des Connaissances et Analyse Textuelle) INRA group (https://www6.inra.fr/cati-icat) and the INRA IN-OVIVE group (www6.inra.fr/reseau-in-ovive) for which he organized an invited session at EFITA'2017.
- Rallou Thomopoulos is coordinator of the INRA-CEPIA transversal programs on knowledge and model integration, multiperformance design, and ethical issues.
- Marie-Laure Mugnier is member of the animating committee of the GDR IA (formal and algorithmic aspects of artificial intelligence).

10.1.6. Scientific Expertise

- Rallou Thomopoulos has been elected member of the Scientific Committee of the INRA-CEPIA research division for the period 2016-2020.

10.2. Teaching - Supervision - Juries

10.2.1. Teaching

The six faculty members teach at all university levels (IUT, Licence, Master). The main courses they are in charge of are: Logics (L), Databases (M), Web Technologies (IUT), Artificial Intelligence (M), Knowledge Representation and Reasoning (M), Social and Semantic Web (M). Concerning full-time researchers in 2017, Jean-François Baget gave Master courses (40 h) and Rallou Thomopoulos was instructor for "Participative modelling and simulation", a one week full time training school for INRA-CIRAD researchers (which is held once to twice a year, since 2016).

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

- Michel Leclère (Faculty): from 2011 to 2017, he managed the program "Data, Knowledge and Natural Language Processing" (DECOL), part of the Master of Computer Science (about 30 students). This program was co-managed with Federico Ulliana (Faculty) 2016, which became the coordinator for 2017.
- Marie-Laure Mugnier (Faculty): from 2011 to 2017, she was (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).

10.2.2. 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. He is also coordinator for the Information Systems ("sytèmes d'Informations et salles informatiques") for the Science Faculty, University of Montpellier.
- Marie-Laure Mugnier: since 2016, she is member of the Council of the Scientific Department MIPS (Mathematics Informatics Physics and Systems) of the University of Montpellier - Marie-Laure Mugnier.

10.2.3. Supervision

PhD in progress are:

- Stathis Delivorias. 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.

10.2.4. Juries

- Marie-Laure Mugnier was reviewer for the HDR of Mantas Šimkus - TU Wien (Vienna University of Technology).
- Rallou Thomopoulos was jury member of Jérémy Bénard's PHD thesis "Exploitation of an ontology of knowledge representation languages for the semantic and generic import, export and translation of knowledge representations", Université de La Réunion, June 2017.

10.3. Popularization

- M. Chein, "Sur la science informatique et son installation à Montpellier" Association Française pour l'Avancement des Sciences, Montpellier, April 2017.
- M. Chein, "L'informatique : la science au coeur du numérique", Académie des Sciences et Lettres de Montpellier, May 2017.
- J.-F. Baget, Animation of a panel on "Artificial Intelligence", Lycée Jean Monnet, Montpellier, December 2017.

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