UMR IRISA

Activity report 2013

Dpt 7: **DATA AND KNOWLEDGE MANAGEMENT**

Team LogicA

Logics and Applications

Rennes

1 Team

Head of the team
Sophie Pinchinat

Université Rennes 1 personnel
Guillaume Aucher, Assistant Professor, INRIA Chair
Sophie Pinchinat, Professor

ENS Rennes personnel
François Schwarzentruber, Assistant Professor

PhD students
Stéphanie Georges, DGA/INRIA grant, since December 2011
Bastien Maubert, MENRT/Rennes 1 grant, since September 2010

Master students
Gaspard Douady, February-June 2013

2 Overall Objectives

2.1 Overview

Many of our activities which were in the past performed in the physical world and in interaction with other humans, are nowadays carried out in a digital world in interaction with both human and non-human 'agents': classic examples are e-commerce, e-voting, e-banking, e-government, etc... This transposition of some of our activities into the digital world already plays an important role in our everyday life. This transposition is expected to develop in the future, which is certainly desirable in order to harmonize the rate at which our society evolves. This large picture exhibits an urgent need for both taming already existing e-activities and assisting the birth of new ones.

Existing e-activities, such as e-voting, e-commerce, e-banking, e-government etc. rely on a combination of numerous technologies either at the physical/hardware level or at the digital/software one. The nature of interaction between different services that form the whole application is very complex and leads to critical issues regarding its quality that the research community together with industry try to resolve.

Among the main issues, we can mention privacy, legal process, correction of the functionalities. Also, the growing development of applications to support e-activities urges the designers to elaborate methodologies that would allow them to exploit adaptability or re-usability of

existing services. Whichever issue can be picked, rigorous settings are required in order to make evidence of the correctness, the quality, the robustness, etc. of the existing products. Moreover, some sectors of activity are currently far from being computerized or even computer-assisted: typically, legal processes, abilities to remote control some domestic processes such as closing roller blinds when a storm is forecast, and so on.

All in all, not only existing e-activities need to be coupled with meticulous development methodologies, but also accurate approaches need being set up to design new e-activities that support underdeveloped domains currently operated by hand. To that end, important efforts are required to bring out the capabilities to rigorously analyze or design the functionalities[1] of services in e-activities.

The LogicA project aims at contributing to this will, by focusing on interaction issues in e-activities with a logical-based perspective. The project will develop foundations, transfer to practical applications, and convey the tight coupling between research and education.

One of the most challenging feature in e-activities analysis is the ability to "predict/control" the interaction between the numerous involved entities. These entities can be artificial (software agents, distributed systems components) or human (users). As a first step, the project will focus on artificial entities, which are, ideally, designed to act *autonomously* on the behalf of users, *e.g.* for negotiating in an e-commerce activity. These entities are called *software agents*, and they gather into *multi-agent system (MAS).*

Since MAS are central objects, they need to be preliminary well understood at a mathematical level. The theories that will support their use in practical applications should give rise to different techniques, ranging from the ability to guarantee and certify before their deployment that they will behave properly (verification) to the ability of automatically generating skeletons of MAS (synthesis) or of coordination mechanisms between MAS (control/orchestration/choregraphy/communication).

Whereas successful logic-based techniques in computer science already exist for verification, synthesis and control, it is not clear yet how to transfer this know-how to the paradigm of MAS where interaction is central. Investigations to formally *reason about* and *infer properties of* interacting agents is currently a very active topic in computer science, which actually originates with, *e.g.* artificial intelligence and game theory. The LogicA project aims at cross-fertilizing logic-based techniques from verification in computer science, synthesis in discrete-event control theory, agency in artificial intelligence, concepts and solution concepts in game theory, and interaction concepts in philosophy. In particular, what typically differentiates the MAS framework from its pairs is the inherent information change/exchange in its dynamics, which gives evidence of, *e.g.* epistemic, strategic and normative features to be taken into account.

2.2 Key Issues

In its current state, the LogicA project studies the following key issues:

Logic, games and control Theoretical work on dynamic systems and the transfer of the well-tamed results to practical applications have experienced a boom in the 90s, leading to

[1] in terms of what an application offers to its users

automated tools for verification and synthesis in industry for hardware and software design [GV08]. Significant advances were made with the tight connection between logical formulas and automata on infinite objects [Tho90], and the automata semantics described as a two-player parity game [VW94,EJ91,Tho97], [AG11, Ch. 2 and 3]. About ten years later, the paradigm of multi-player infinite duration games was introduced to capture compositional and interactive features of systems: analysing the dynamics is by now carried out by taking into account the *components/modules* of a system as "open systems" [KVW01,KMTV00] evolving in an environment (the other components), or by seeing the system as interacting with controllers. This led to an enormous amount of scientific achievements in verification with two main directions: alternating-time temporal logics on concurrent game structures [AHK02] and infinite duration two-player games [GTW02]. However, the game paradigm was mostly developed in the setting of perfect information, with further extensions for quantitative aspects such as probabilities [AG11, Ch. 5], or in a setting with imperfect information involving only two-players for winning ω-regular objectives [AG11, Ch. 6].

Epistemic logics and logics of information change When agent interaction issues are concerned, ability to reason about knowledge is central. To this aim, epistemic logic has been extensively studied [FHMV95], and recent extensions that take dynamics into account draw the attention of a growing community of logicians and computer scientists (see for instance the very much cited book [vvK08] and the recent ERC grant on epistemic protocols coordinated by Hans van Ditmarsch (recently recruited as a DR CNRS, LORIA). The LogicA project explores

[GV08] O. Grumberg, H. Veith, *25 Years of Model Checking: History, Achievements, Perspectives*, *5000*, Springer, 2008.

[Tho90] W. Thomas, "Automata on Infinite Objects", *in : Handbook of Theoretical Computer Science, vol. B*, J. v. Leeuwen (editor), Elsevier, 1990, ch. 4, p. 133–191.

[VW94] M. Y. Vardi, P. Wolper, "Reasoning about infinite computations", *Information and Computation 115*, 1, 1994, p. 1–37.

[EJ91] E. A. Emerson, C. S. Jutla, "Tree Automata, Mu-Calculus and Determinacy", *in : Proceedings 32nd Annual IEEE Symp. on Foundations of Computer Science, FOCS'91, San Jose, Puerto Rico, 1–4 Oct 1991*, IEEE Computer Society Press, Los Alamitos, California, 1991, p. 368–377.

[Tho97] W. Thomas, "Languages, Automata, and Logic", *in : Handbook of Formal Language Theory, III*, Springer, 1997, p. 389–455.

[AG11] K. Apt, E. Grädel, *Lectures in Game Theory for Computer Scientists*, Cambridge University Press, 2011.

[KVW01] O. Kupferman, M. Y. Vardi, P. Wolper, "Module Checking", *Information and Computation 164*, 2, 2001, p. 322 – 344, `http://www.sciencedirect.com/science/article/pii/S0890540100928931`.

[KMTV00] O. Kupferman, P. Madhusudan, P. S. Thiagarajan, M. Y. Vardi, "Open Systems in Reactive Environments: Control and Synthesis", *in : Proc. 11th Int. Conf. on Concurrency Theory, LNCS, 1877*, Springer-Verlag, p. 92–107, 2000.

[AHK02] R. Alur, T. Henzinger, O. Kupferman, "Alternating-Time Temporal Logic", *Journal of the ACM 49*, 5, 2002, p. 672–713.

[GTW02] E. Grädel, W. Thomas, T. Wilke (editors), *Automata, Logics, and Infinite Games*, *LNCS*, *2500*, Springer, 2002.

[FHMV95] R. Fagin, J. Halpern, Y. Moses, M. Vardi, *Reasoning about knowledge*, MIT Press, 1995.

[vvK08] H. van Ditmarsch, W. van der Hoek, B. Kooi, *Dynamic Epistemic Logic*, Springer, Dordecht, 2008.

variants of epistemic logic that can easily mix with time, in order to reason about information change along time. As mixing knowledge and time easily yields to high complexity and even undecidability [HV89], the challenge is to identify settings where the formalism would enjoy good computational features while being expressive enough to capture useful properties.

3 Scientific Foundations

3.1 Strategic reasoning and automata-theoretic approaches

Participants: Guillaume Aucher, Sophie Pinchinat, Bastien Maubert, François Schwarzentruber.

Modeling strategic abilities is central for reasoning about MAS. We plan to carry on with logical formalism that were already proved or are currently foreseen as powerful approaches in many exciting domains, including software tools for information system security, robot teams with sophisticated adaptive strategies, and automatic players capable of beating expert human adversary, just to cite a few. All these examples share the challenge of developing novel theories and tools for agent-based reasoning that take into account the likely behavior of "adversaries".

The natural setting for strategic reasoning is not surprisingly the one of multi-player games with imperfect information. Although discouraging results from the literature shows that three-player games with safety objectives are undecidable [PRA01], there are however promising results which show that some classes may be manageable. Basically, undecidability comes from the ability for some players to form a coalition: the resulting binary indistinguishability relation of the coalition would correspond to the intersection of the relations of its respective members. Now, it is well-known that intersection of binary relations yields more complex relations that may exit decidable classes (e.g. for membership or emptiness), like e.g., rational relations. Note that such phenomenon cannot arise in two-player games where safety objectives can be solved by a simple (although costly) power-set construction [Rei84]. Also, undecidability becomes even "stronger" when dealing with more realistic objectives with for epistemic properties, such as seeking a strategy of agent A an outcome "agent B does know Property P until agent C knows it".

More recently, the AI and Formal Methods communities moved closer because of the intrinsic similarity between multi-player games with imperfect information and MAS. Since then, attention has been paid on extensions of game-like settings to objectives intrinsically mixing knowledge and time[2], in order to be able to express, e.g. *opacity properties* in software security such as "Defender has a strategy so that Intruder never knows information I"

[2] even if not told this way

[HV89] J. Y. Halpern, M. Y. Vardi, "The complexity of reasoning about knowledge and time. 1. Lower bounds", *Journal of Computer and System Sciences 38*, 1, 1989, p. 195–237.

[PRA01] G. Peterson, J. Reif, S. Azhar, "Lower bounds for multiplayer noncooperative games of incomplete information", *Computers & Mathematics with Applications 41*, 7, 2001, p. 957–992.

[Rei84] J. H. Reif, "The complexity of two-player games of incomplete information", *Journal of computer and system sciences 29*, 2, 1984, p. 274–301.

[28, 27],[DDM10,MY13]. Note that, works on designing logics to feature both knowledge and time has been investigated long ago, with a very natural combination of temporal logics and epistemic logic [HV89,HvdMV04]. Handling these logics (model-checking or synthesis) already proved to be difficult, quickly yielding undecidability [HV89,vdMS99,Dim11]. The critical point lies in the interplay of two "orthogonal" fixed-points modalities when agents' perception ability on the actual system evolution is not bound, e.g. *perfect recall* or *imperfect* (but unbounded) *recall* [vdMS99]; basically, the perception abilities of agents can range from *perfect recall* to *memoryless* and include *imperfect recall*.

The most natural way to incorporate knowledge/agent's perception into logics for strategic reasoning is achieved by adding epistemic modalities into alternating-time logic [vdHW03a,Sch04, JÅ06,Dim09]. Still, merging perception and strategic abilities of agents can take different paths, as the two are not independent: the strategic abilities of agents should not overstep their perception abilities, in the sens that strategies should be defined at a level of abstraction at least equal to the level of what agent perceive from the actual situation: for example, if an agent does not recall the past, its strategies should be memoryless. Some pioneer papers put aside, this dependency is now well understood. Many frameworks lead to undecidability [Dim09]. There are however results relying on strong restrictions on the agents' perception (and thus on their strategic abilities), such as the obvious memoryless perception assumption [vdHW03a,JÅ06,BJL11], or very particular imperfect recall [Sch04], but The complete understanding of the landscape is not achieved yet.

Automata are wonderful mathematical tools, tightly coupled to logic, in order to represent sets of models. They offer computational facilities and often reveal intuitive algorithms to handle specifications. For example, tree automata [Tho97,FGW07] denote sets of infinite trees,

[DDM10] J. Dubreil, P. Darondeau, H. Marchand, "Supervisory control for opacity", *Automatic Control, IEEE Transactions on 55*, 5, 2010, p. 1089–1100.

[MY13] J. Mullins, M. Yeddes, "Opacity with Orwellian Observers and Intransitive Non-interference", *arXiv preprint arXiv:1312.6426*, 2013.

[HvdMV04] J. Y. Halpern, R. van der Meyden, M. Y. Vardi, "Complete Axiomatizations for Reasoning about Knowledge and Time", *SIAM J. Comput. 33*, 3, 2004, p. 674–703.

[vdMS99] R. van der Meyden, N. V. Shilov, "Model Checking Knowledge and Time in Systems with Perfect Recall (Extended Abstract)", *in : FSTTCS*, C. P. Rangan, V. Raman, R. Ramanujam (editors), *Lecture Notes in Computer Science*, *1738*, Springer, p. 432–445, 1999.

[Dim11] C. Dima, "Non-axiomatizability for the linear temporal logic of knowledge with concrete observability", *J. Log. Comput. 21*, 6, 2011, p. 939–958.

[vdHW03a] W. van der Hoek, M. Wooldridge, "Cooperation, knowledge, and time: Alternating-time temporal epistemic logic and its applications", *Studia Logica 75*, 1, 2003, p. 125–157.

[Sch04] P.-Y. Schobbens, "Alternating-time logic with imperfect recall", *Electronic Notes in Theoretical Computer Science 85*, 2, 2004, p. 82–93.

[JÅ06] W. Jamroga, T. Ågotnes, "What agents can achieve under incomplete information", *in : Proceedings of the fifth international joint conference on Autonomous agents and multiagent systems*, ACM, p. 232–234, 2006.

[Dim09] C. Dima, "Revisiting satisfiability and model-checking for CTLK with synchrony and perfect recall", *in : Computational Logic in Multi-Agent Systems*, Springer, 2009, p. 117–131.

[BJL11] F. Belardinelli, A. V. Jones, A. Lomuscio, "Model Checking Temporal-Epistemic Logic Using Alternating Tree Automata", *Fundam. Inform. 112*, 1, 2011, p. 19–37.

[Tho97] W. Thomas, "Languages, Automata, and Logic", *in : Handbook of Formal Language Theory, III*,

widely needed in verification to representation branching-time system executions. It is well known that tree automata equipped with the parity condition capture the expressive class of ω-regular tree languages, with the highly expressive propositional μ-calculus logic in the background [EJ91,AN01,GTW02].

Other approaches have been considered to combine knowledge, time and strategies. A fairly old one originates from the control theory of discrete-event systems, from the point of view of (controllers') strategic abilities only. Controllers are seen as state-transition devices, and such devices can be subject to structural constraints, such as looping e-transitions in every state to capture unobservability of event e by the device, or many variants of such constraints [Bri06b]. Structural constraints can be specified by extending temporal logics with a new atomic propositions to express, e.g. existence of looping transitions. The resulting logics, although no more bisimulation invariant, still has automata counterparts [AVW03]. Such automata can be used to synthesize controllers by *automata quotient techniques* [AVW03,PR05,Bri06b,Bri06a]. Note that these approaches cannot address epistemic features in the control objectives.

We believe that an automata-theoretic approaches is a promising track. For instance, we have started to identify classes solvable multi-player games with imperfect information allowing for epistemic objectives with a focus on the theoretical properties of agents' indistinguishable binary relation along plays [9, 8]. The starting point are rational binary relations. Foe example, we have shown that if binary relations are restricted to *recognizable*, objectives that mix knowledge and time with classic CTL* operators can be solved. These results stem from our pioneer studies on *uniform strategies* [4], which reveal very powerful and whose study should be pursued, as shown below.

Also, in our attempt to find clean mathematical settings to combine knowledge and time, one may think of an enrichment of the class of tree automata, in such a way that those devices can check properties not only in a given node of tree but also in "related" nodes, where the relation reflects the possible words for a given agent. This amounts to allowing the automata to make jumps between different branches of the tree. Recently, we have developed a class of

Springer, 1997, p. 389–455.

[FGW07] J. Flum, E. Grädel, T. Wilke, *Logic and Automata: History and Perspectives*, Amsterdam University Press, 2007.

[EJ91] E. A. Emerson, C. S. Jutla, "Tree Automata, Mu-Calculus and Determinacy", *in : Proceedings 32nd Annual IEEE Symp. on Foundations of Computer Science, FOCS'91, San Jose, Puerto Rico, 1–4 Oct 1991*, IEEE Computer Society Press, Los Alamitos, California, 1991, p. 368–377.

[AN01] A. Arnold, D. Niwiński, *Rudiments of μ-calculus*, *Studies in Logic and the Foundations of Mathematics*, *146*, North-Holland, 2001.

[GTW02] E. Grädel, W. Thomas, T. Wilke (editors), *Automata, Logics, and Infinite Games*, *LNCS*, *2500*, Springer, 2002.

[Bri06b] X. Briand, *Sur la décidabilité de certains problèmes de synthèse de contrôleurs*, PdD Thesis, Université de Bordeaux I, June 2006.

[AVW03] A. Arnold, A. Vincent, I. Walukiewicz, "Games for synthesis of controllers with partial observation", *Theoretical Computer Science 1*, 303, 2003, p. 7–34.

[PR05] S. Pinchinat, S. Riedweg, "A decidable class of problems for control under partial observation.", *Inf. Process. Lett. 95*, 4, 2005, p. 454–460.

[Bri06a] X. Briand, "Dynamic Control with Indistinguishable Events.", *Discrete Event Dynamic Systems 16*, 3, September 2006.

such devices called *jumping tree automata (JTA)* [9] which permit to consider agents whose distinguishing inabilities are *rational relations*. JTA are promising objects. Even though their language emptiness is undecidable in general, they may enjoy several good properties when. e.g. restricting to *recognizable* relations. Also, we conjecture that JTA coincide with the extension of the propositional μ-calculus by knowledge modalities. Last but not least, the connection between JTA and second-order logic needs being addressed as in essence, JTA handle two binary relations between the nodes of the trees.

Finally, our notion of uniform strategy needs being challenge with aforementioned approaches and in particular with the automata quotient techniques of [AVW03],[30],[Bri06b,Bri06a]. Both approaches give a way to handle agent's abilities but with different angle of view: the former focuses on perception abilities, while the latter focuses on strategic reasoning abilities by constraining the model of the strategy to be used. It is important to investigate the link between the two, whether they are complementary or similar, etc.

3.2 Control theory

Participants: Guillaume Aucher.

The theory of supervisory control deals with problems related to the existence and the synthesis of supervisors, whose role is to control the behavior of a discrete-event system so as to produce a specified behavior [RW89,CL08]. These problems are addressed under various assumptions like partial control or partial observation of the events, or decentralization of the supervisor. More recently, this theory has started to consider distributed control with communication. In that case, local supervisors can interact, send and receive information from other supervisors and they need to make local decisions without resorting to a central authority gathering all the information from the local supervisors. However, with the current methods that are used, the formalism tends to be quite complex and it is difficult to derive automatically algorithms that solve the problems of the theory of supervisory control.

In parallel, it turns out that several other research fields like distributed artificial intelligence, game theory and recent developments in logic deal with the same kind of situation: a group of agents (alias local supervisors) interact, send and receive information from other agents (alias supervisors) and they need to make local decisions without resorting to a central agent (authority). Independently from the community of supervisory control theory, numerous researchers from these other research fields already gather regularly to address problems dealing with this kind of situations but from a different perspective in conferences such as TARK, LORI, AAMAS, LOFT, ... These related research fields traditionally use different methods. For example, several logics like ATL [AHK02], ATEL [vdHW03b], etc. are the result of the interaction between logicians and game-theorists. They provide formal systems to express

[RW89] P. Ramadge, W. Wonham, "The control of discrete event systems", *Proceedings of the IEEE 77*, 1, 1989, p. 81–98.

[CL08] C. Cassandras, S. Lafortune, *Introduction to discrete event systems*, Springer, 2008.

[AHK02] R. Alur, T. Henzinger, O. Kupferman, "Alternating-Time Temporal Logic", *Journal of the ACM 49*, 5, 2002, p. 672–713.

[vdHW03b] W. van der Hoek, M. Wooldridge, "Cooperation, Knowledge, and Time: Alternating-time Temporal Epistemic Logic and its Applications", *Studia Logica 75*, 1, 2003, p. 125–157.

perfect information and imperfect information game properties. Also, they provide algorithmic methods to reason automatically about those properties.

These related fields often cover a larger spectrum of interactive situations and phenomena than the ones usually considered in supervisory control theory. While the study of epistemic reasoning in distributed computing has led to a nuanced understanding of how communication mechanisms enrich and limit co-ordination, incorporating goal orientedness is challenging; on the other hand, game theoretic methods are rich in goal-orientation but communication tends to be primitive. Combining these methods is likely to enrich both paradigms.

3.3 Epistemic planning and epistemic protocol synthesis

Participants: Guillaume Aucher, Sophie Pinchinat, Bastien Maubert.

Planning is the process of organizing activities required to achieve a desired goal. In the "classical" planning community [GNT04], planning under uncertainty and with multiple agents is acknowledged to be a real challenge. It has been shown that the Dynamic Epistemic Logic framework [vvK08] is a good setting to address planning for goals that may involve agents' knowledge, and even agents' knowledge about other agents' knowledge, etc. [BA11]. The approach is promising with applications to, e.g., privacy issues stemming from the growing use of social networks (for example, we may want to achieve some task while being sure that some adversary will never come to *know* a sensitive fact/information). The area of epistemic planning is becoming very active (cf. Dagstuhl seminar on "Planning with epistemic goals", January 2014), and extends to even more general aims where an entire protocol has to be synthesized.

The LogicA project members are among the leaders of the area: Guillaume Aucher has published on epistemic planning [8, 2, 3, 9], Sophie Pinchinat with Bastien Maubert have published on games with epistemic conditions [28, 27],[4], and recently on *epistemic protocol synthesis* [5].

The members have an ongoing active collaborations on these topics with Thomas Bolander (Technical University of Denmark) and the group CELLO of Hans van Ditmarsch (LORIA, Nancy).

Also, members of the team keep investigating in logical formalisms for dynamic information changes. The logic RML for "Refinement Modal Logic" is an abstract framework where it is possible to quantify over informative events, or a possible control [3]. This logic has several variants with fixed-points, multi-agents setting, etc. We are currently working on its theoretical properties, among which classic decision problems [35, 16, 15],[6, 3].

[3] depending on the interpretation of the accessibility relation in the Krikpe structures

[GNT04] M. Ghallab, D. Nau, P. Traverso, *Automated Planning: Theory & Practice*, Morgan Kaufmann, San Francisco, 2004.

[vvK08] H. van Ditmarsch, W. van der Hoek, B. Kooi, *Dynamic Epistemic Logic*, Springer, Dordecht, 2008.

[BA11] T. Bolander, M. B. Andersen, "Epistemic planning for single- and multi-agent systems", *Journal of Applied Non-Classical Logics 21*, 1, 2011, p. 9–34.

3.4 Epistemic spatial reasoning

Participants: François Schwarzentruber.

By *epistemic spatial reasoning*, we mean reasoning about the knowledge agents can infer from what they perceive. It has several important potential applications such as designing systems of camera surveillance, programming drone systems, video games. Note that since perception depends of the locations, geometry issues are central and in particular the dimension of the space in which we reason.

Nowadays, the behavior of artificial agents is mostly described by low-level imperative languages, whereas the use of knowledge programs [FHMV95], which are based on logic, is very little developed and yet could offer high-level descriptions together with clean analysis tools.

Recently, we proposed a grounded variant of Dynamic Epistemic Logic [vvK08], called *Flatland Logic*, properties about what agents perceive and know about the world [2] can be specified. At the moment, we master the one-dimensional setting by providing an axiomatization of the logic and an elimination procedure for the notoriously complex common knowledge operator [33]. The model checking problem and the satisfiability problem are PSPACE-completeness. On the contrary, such results for the two-dimensional setting are mostly all open. For example, we only know that the problem is decidable for dimensions greater than 2. In the case where there is common knowledge of the positions of the agents, we know that the model checking problem is PSPACE-complete [7]. Additionally, there is still no robust implementation of the framework, but very preliminary ones:

- `http://www.irisa.fr/prive/fschwarz/flatland/`
- `http://www.irisa.fr/prive/fschwarz/publications/AAMAS2014/`

A Master student is currently working on a prototype of a model checker. We plan to solve some open issues and to extend the framework to planning in multi-agent scenarios. Results for static cameras have already been published [10].

We plan to adapt the setting of Flatland logic motion planning/multi robots: for instance, we may wonder if (or make queries like) "it is possible for agent a to move in such a way that b knows that a sees agent c at least three times during the move". This is a starting collaboration with Valentin Goranko (Technical University of Denmark) and Hans van Ditmarsch (LORIA, CNRS) where the central application is camera surveillance.

4 Application Domains

4.1 Cour de Cassation project

Participants: Guillaume Aucher, François Schwarzentruber.

This project is a starting collaboration with Cour de Cassation, with a very modest objective which at a first glance does not fall into the main scientific objectives of the LogicA project. However, our will to promote logical approaches for societal concerns is strong. This

[FHMV95] R. Fagin, J. Halpern, Y. Moses, M. Vardi, *Reasoning about knowledge*, MIT Press, 1995.

very opportunity may lead to a long term collaboration where richer languages than first order logic can be useful: in particular, Guillaume Aucher and François Schwarzentruber have strong background in Deontic Logic and Normative Systems [GHvdM+], as witnessed by their publication lists, and wish to end up with its use for legacy purposes.

The Cour de Cassation is aware of the following problem: judges have to handle legal cases that are not frequent. Such a legal case may be the following one: contest the union's representational capacity. It is really difficult for a judge to acquire all the experience in solving such legal cases. Up to now, writing judgments for such legal cases is done manually with the help of documents explaining how to write them. In this subsection, we refer to these documents as the how-to documents.

The Cour de Cassation expressed the need to develop a computer-aided judgment writer. This software should analyze the reasoning process made by the judge, assist him/her in his/her decisions. Meanwhile, the software generates the text of the judgment.

Bridging law and logic The software will take as an input the logical description of a legal case, nowadays described informally in how-to documents. For instance the input may be a file describing formally the contest of a union's representational capacity (such a logical description may have been designed before by experts). Then the engine of the software will propose coherent questions to the user. The first part of the project is to understand the reasoning part of the documents explaining how to write a judgment in order to define the logical description of a legal case and the algorithms in the engine.

We currently have identified the following in the how-to documents.

Some paragraph may be applied to several instances. For instance, there may be one paragraph about the description of a current member of the union, and the conditions explained in that paragraph should be verified for several members. This naturally leads to the use of First-order logic.

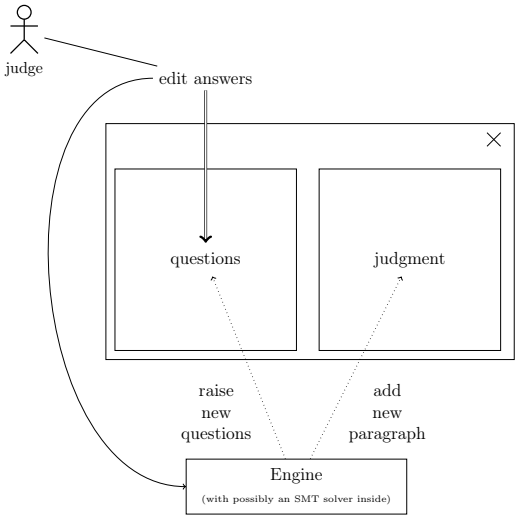
Some statements are purely syllogisms. Description logic is a suitable decidable logic for representing such kind of statements.

In the how-to documents, we may find general rules about a situation and then exceptions. From a logical point of view, exceptions are generally difficult to represent and to add dynamically while elaborating legal texts.

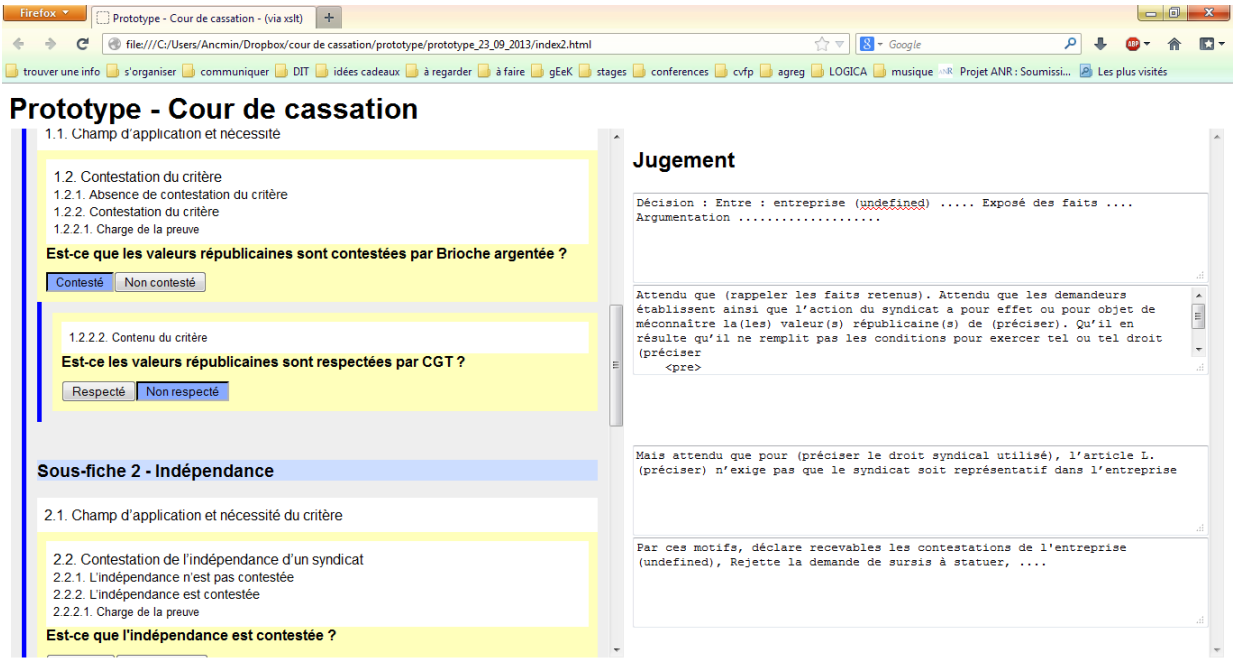
We should also define correctly the completeness of a judgment.

Implementation issues After having designed the logical language for representing the description of a legal case, we will study decidability and complexity issues on the theoretical part. On the practical part, we will first start by using an existing solver, possibly a SMT solver. This solver may check the consistency of the reasoning done up to now by the judge and it is also used to raise new relevant questions. Figure 1(a) shows the global architecture of the software, and screen shot of the user interface as it is for the moment is given in Figure 1(b). After having configured the software to solve a given legal case, the left-part of the screen shows questions the judge should answer. The right-part shows the generated judgment. Of

[GHvdM+] D. Gabbay, J. Horty, R. van der Meyden, X. Parent, L. van der Torre (eds), "*Handbook of Deontic Logic and Normative Systems*", To appear with College Publications, London.



(a) Architecture of the Cour de Cassation software



(b) Interface of the Cour de Cassation software

Figure 1: The Cour de Cassation software

course, questions should be relevant and consistent. At the end, the software should certify that the judgment is complete. This project is the realization of the dream of the jurist and logician Leibniz: use logic to solve legal cases.

4.2 Physical security

Participants: Stéphanie Georges, Sophie Pinchinat.

Risk Analysis is a discipline consisting in identifying and evaluating risks that threaten a given system in order to reduce or annihilate them by defining actions to engage (risk management). Such analysis is central when the aim is to ensure the security of an information system means guaranteeing data availability, integrity and confidentiality.

As seen in [Bur08], current methods follow mostly the same outline : one decomposes the system into subsystems and produces a model, then draws up a list of feared events, and finally determines the potential reasons of their emergence.

For the particular case of risk analysis in physical security, these steps are mostly processed by hand, based on knowledge and experiences of analysts and technicians. In order to match the standards of experts in risk analysis, the whole process is conducted in two steps:

Step 1 One produces an *attack/defense tree*, that is a tree-like structure where one easily reads the attacker's abilities to achieve her attack and the weaknesses of the defender's capabilities to counter them. The attack/defense tree levels describe successful attacks at different level of abstraction. The attack/defense tree is meant to describe all successful attacks, independently of their realism due to intrinsic cost of their application.

Step 2 The attack/defense tree obtained in Step 1 is reworked to incorporate cost features on actions and then exploited to reveal the more realistic scenarios.

The project is a collaboration with the French Defense Ministry (2011-1014, contract 2011 81 0323) for physical security. The collaboration involves a PhD student whose research should lead to a assistant tool for semi-automatically synthesizing an attack/defense tree (Step 1. above), given a specification of a building and some critical resource to protect from attacks (a safe containing a classified document).

Following [BLE10], we have developed an entire methodology to achieve the attack/defense tree synthesis: we have first designed a language to specify buildings. Then using a compilation technique, these specifications are compiled into the target language GAL, a modelling language dedicated to the description of data manipulation for formal verification of concurrent systems `http://move.lip6.fr/software/DDD/gal.php`. The resulting describes an *attack*

[Bur08] E. Bursztein, *Anticipation Games - Théorie des Jeux appliquée à la sécurité réseau*, PdD Thesis, ENS Cachan, 2008.

[BLE10] E. Bornette, J.-P. Lebée, D. Eymery, "Nouvelle approche méthodologique de l'analyse de risques reposant sur le point de vue de l'attaquant", *in : Proceedings of of the 5th Conference on Network and Information Systems Security (SAR/SSI 2010), Rocquebrune Cap-Martin, France*, 2010.

graph/one-player arena where attacks are simply sequences of low level actions, like plans, from the initial situations to dangerous ones. In order to extract these plans, a collaboration with the GAL plate-form designer (Yann Thierry-Mieg, LIP6 lab, Paris) has started: the tools of the plate-form have tuned to adapt the model-checking counter-example (the plans) generation techniques for safety properties into a controlled generation of multiple plans. By coupling the specification with a hierarchy of actions (high-level actions described e.g. by some rewriting system/context-free grammar), these scenarios can be abstracted as trees (using classic syntactic analysis), then gathered together to yield an attack/defense that highlights flaws to bring down and the counter-measures that apply. The results of the current state of the methodology and tool has been presented at the poster session of the national conference "Modélisation des systèmes ráctifs 2013" (`http://hal.inria.fr/MSR2013`) and in [11].

Impact Existing tedious hand-made analysis to extract the attacker's scenarios prevents from dealing with substantial inputs (buildings with numerous features). We believe the tool will significantly reduce the human cost, push back the current threshold, and appear to be amenable to more realistic situations.

4.3 Tools for teaching logic

Participants: Sophie Pinchinat, François Schwarzentruber.

This action of the project may appear unconventional, as, as opposed to other axis which are about "meeting applications", it is about "meeting people". Still, one should keep in mind that behind applications, one faces people, and that it is hopeless to give evidence of the usefulness of logic in applications while neglecting the guarantee that developers will comply with its use.

Information technologies incite the promotion of logic, mostly by the fact that logical languages provides accurate specification languages/declarative programming languages, and that their semantics yields efficient procedures to solve problems. Nevertheless, the relevance of logic in the numeric world seems to be appreciated solely by specialists in computer sciences (NASA engineers that check their critical embedded softwares, mathematicians fascinated by verification of proofs, etc.), which impedes its potential transfer towards practical applications ([Var09]).

The computer science community together with logicians is now aware of the need for conveying what logic is about, demonstrating its relevance and revealing its accessibility. Following this present-day opinion, we commit to breaking the impediment to logic promotion, so that society can fully enjoy the benefits. In particular, we target to investigate the pedagogy to familiarize students with logic and to teach them what logic is about, and to identifying potential users of logic and filling them in on the feasibility of designing dedicated logics. Our actions will get inspirations from the many efforts made in constructing software tools and also in ways of teaching logic, but also from our own investigations.

[Var09] M. Vardi, "From philosophical to industrial logics", *Logic and Its Applications*, 2009, p. 89–115.

Courses in logic.	
Openproof Courseware	Package of undergraduate logic courses `http://ggweb.stanford.edu/`
Logic in action	Undergraduate logic course `http://www.logicinaction.org/`
Kripke's world [?]	A book for learning tableau methods for modal logic
Software tools for teaching logic.	
Pandora [BMSS07]	`http://www.doc.ic.ac.uk/pandora/`
Lotrec [dCFG+01]	`http://www.irit.fr/Lotrec/`
SAToulouse [21]	`http://www.irit.fr/satoulouse/`
Panda [20]	(up to now, used in teaching classes at the University of Toulouse) `http://www.irit.fr/panda/`
LotrecScheme [32]	`http://www.irisa.fr/prive/fschwarz/lotrecscheme/`
Plaza's world [22]	`http://www.irisa.fr/prive/fschwarz/flatland/`
SATRennesPA	`http://satrennespa.irisa.fr/`

Table 1: Courses and tools for teaching logic.

Promoting logic Many efforts are made to improve courses in logic, as well as software tools for teaching logic have already been developed. Table 1, although not exhaustive, provides a reasonable list of them. Among the tools, *SAToulouse/SATRennesPA*, *Panda*, *LotrecScheme*, and *Plaza's world* are developed by members of LogicA. The tool *SAToulouse* [21] and its new generation *SATRennesPA*[4], which are surprisingly one of the firsts – and even maybe the only ones – offer user-friendly SAT solver applications to address, e.g. Sudoku games, planning problems, etc.

Our, fairly short-term, perspective is to advocate the introduction of propositional logic in this course and to promote its relevance via *SATRennesPA* at the Bachelor level and even in high-school. Note that, the actual version of french high-school computer science course entitled "Informatique et sciences du numérique" does not approach logic as a declarative programming language. The feedback of teachers and students should lead us to tune the tool so as to reach a equilibrium between its expressive power and the needs for teaching/understanding the convenient ways to model concrete problems into propositional logic. This perspective will be addressed at the *International Congress on Tools for Teaching Logic 2015* (the 4th edition) the members of LogicA will take on in June 2015 in Rennes (`http://ttl2015.irisa.fr/`).

A certainly longer-term promising project is to make the use proof assistants attractive and natural to students. The current experience in Master 1 with the use of Isabelle/HOL to verify and generate Scala code makes evidence of a lack of acquaintance with such tools. We will start training the students one year earlier (Bachelor) with a software adaptive to the audience based on the first-order proof assistant Panda ([20]), already developed in the team. The aim of this instruction is twofold: reconcile logic and students and show the pertinence of computer science

[4]Currently, four students of M1 MIAGE are improving the web interface SATRennesPA of the Sat4j library `http://www.sat4j.org/`.

in checking proofs, while keeping the process amusing. For this, a version of the tool Panda as a video game is currently in progress, see `http://www.irisa.fr/prive/fschwarz/pravdaweb/`.

5 Software

5.1 SATRennesPA

Participants: François Schwarzentruber.

SATRennesPA (`http://satrennespa.irisa.fr`) is a front-end for the SAT solver SAT4J. The aim of the project is to enable students to easily write formulas of propositional logic. The project was developped by two MIAGE (Méthodes Informatiques Appliquées à la GEstion) Bachelor students (Maxime Bourdel and Brendan Carnot) and their work is based on SAToulouse (`http://www.irit.fr/satoulouse/`).

6 New Results

6.1 Axioms .2 and .4 as Interaction Axioms

Participants: Guillaume Aucher.

In epistemic logic, some axioms dealing with the notion of knowledge are rather convoluted and it is difficult to give them an intuitive interpretation, even if some of them, like axioms .2 and .3, are considered by some epistemic logicians to be key axioms. I showed that they can be characterized in terms of understandable interaction axioms relating knowledge and belief or knowledge and conditional belief. In order to show it, I first sketch a theory dealing with the characterization of axioms in terms of interaction axioms in modal logic. I then apply the main results and methods of this theory to obtain specific results related to epistemic and doxastic logics.

6.2 DEL as a substructural logic

Participants: Guillaume Aucher.

Dynamic Epistemic Logic (DEL) is an influential logical framework for reasoning about the dynamics of beliefs and knowledge. It has been related to older and more established logical frameworks. Despite these connections, DEL remains, arguably, a rather isolated logic in the vast realm of non-classical logics and modal logics. This is problematic if logic is to be viewed ultimately as a unified and unifying field and if we want to avoid that DEL goes on "riding off madly in all directions" (a metaphor used by van Benthem about logic in general). In this article, I show that DEL can be redefined naturally and meaningfully as a two-sorted substructural logic. In fact, it is even one of the most primitive substructural logics since it does not preserve any of the structural rules. Moreover, the ternary semantics of DEL and its dynamic interpretation provides a conceptual foundation for the Routley & Meyer's semantics of substructural logics.

6.3 Update Logic

Participants: Guillaume Aucher.

I introduce a two-sorted substructural logic called 'Update Logic' where the central objects of study are updates, which are represented formally by ternary relations. I develop a basic correspondence theory which relates properties of ternary relations with axioms and inference rules stating properties of updates. I claim that update logic can capture various logic-based formalisms dealing with belief change. As case study, I consider the logical framework of Dynamic Epistemic Logic (DEL) and I show that I can embed it within update logic. Also, I identify axioms and inference rules that completely characterize the DEL product update. Moreover, I introduce Gentzen calculi which extend Gentzen calculi for modal logic and which axiomatize our update logic and DEL. Our completeness proof techniques are new compared to the standard proof techniques used to prove completeness of Gentzen calculi.

6.4 An alternative axiomatization of DEL and its applications

Participants: Guillaume Aucher, Yanjing Wang [University of Peking].

In this paper, we provide a new axiomatization of the event-model-based Dynamic Epistemic Logic, based on the completeness proof method proposed in [?]. This axiomatization does not use any of the standard reduction axioms, but naturally captures the essence of the update product. I demonstrate the use of our new axiomatization and the corresponding proof techniques by three sets of results: characterization theorems of the update operations, representation theorems of the DEL-generatable epistemic temporal structures given a fixed event model, and a complete axiomatization of DEL on models with protocols.

6.5 Supervisory control theory in epistemic temporal logic

Participants: Guillaume Aucher.

Supervisory control theory deals with problems related to the existence and the synthesis of supervisors. The role of a supervisor in a system is to control and restrict the behavior of this system in order to realize a specific behavior. When there are multiple supervisors, such systems are in fact multi-agent systems. The results of supervisory control theory are usually expressed in terms of operations like intersection and inclusion between formal languages. I reformulate them in terms of model checking problems in an epistemic temporal logic. Our reformulations are very close to natural language expressions and highlight their underlying intuitions. From an applied perspective, they pave the way for applying model checking techniques developed for epistemic temporal logics to the problems of supervisory control theory.

6.6 Undecidability in epistemic planning

Participants: Guillaume Aucher.

[?] *** ERROR: citation '**WC12**' undefined ***

Dynamic epistemic logic (DEL) provides a very expressive framework for multi-agent planning that can deal with nondeterminism, partial observability, sensing actions, and arbitrary nesting of beliefs about other agents' beliefs. However, as we showed in this paper, this expressiveness comes at a price. The planning framework is undecidable, even if we allow only purely epistemic actions (actions that change only beliefs, not ontic facts). Undecidability holds already in the S5 setting with at least 2 agents, and even with 1 agent in S4. It shows that multi-agent planning is robustly undecidable if we assume that agents can reason with an arbitrary nesting of beliefs about beliefs. We also proved a corollary showing undecidability of the DEL model checking problem with the star operator on actions (iteration).

6.7 Supervisory control theory in epistemic temporal logic via supervisory control theory

Participants: Guillaume Aucher.

I embedded the framework of infinite two-player turn-based games with safety objectives played on finite graphs in the epistemic temporal logic $\mathsf{CTL}^*\mathsf{K}$. This is made possible thanks to concepts and methods of supervisory control theory. I showed how to determine whether a player has a winning strategy from a given state, and in that case I provide means to synthesize *all* his winning strategies. The originality of my results stems from the fact that they are all formulated in terms of model checking problems. This reformulation enables to compute winning strategies 'on the fly', while the game is being played, instead of fully computing them before the beginning of the game, as is usual in game theory. This novel approach cuts down tremendously the complexity of computing winning strategies. It highlights as well the underlying intuitions of infinite games in terms of expressions involving the modalities of action, time and knowledge. I believe that our work paves the way for applying model checking techniques to infinite games.

6.8 The Complexity of Synthesizing Uniform Strategies

Participants: Laura Bozzelli [Universidad Politécnica de Madrid], Bastien Maubert, Sophie Pinchinat.

We investigate uniformity properties of strategies. These properties involve sets of plays in order to express useful constraints on strategies that are not mu-calculus definable. Typically, we can state that a strategy is observation-based. We propose a formal language to specify uniformity properties, interpreted over two-player turn-based arenas equipped with a binary relation between plays. This way, we capture e.g. games with winning conditions expressible in epistemic temporal logic, whose underlying equivalence relation between plays reflects the observational capabilities of agents (for example, synchronous perfect recall). Our framework naturally generalizes many other situations from the literature. We establish that the problem of synthesizing strategies under uniformity constraints based on regular binary relations between plays is non-elementary complete.

6.9 The complexity of one-agent Refinement Modal Logic

Participants: Laura Bozzelli [Universidad Politécnica de Madrid], Hans van Ditmarsch [CNRS, LORIA], Sophie Pinchinat.

Best paper Award

We investigate the complexity of satisfiability for one-agent refinement modal logic (RML), an extension of basic modal logic (ML) obtained by adding refinement quantifiers on structures. RML is known to have the same expressiveness as ML, but the translation of RML into ML is of non-elementary complexity, and RML is at least doubly exponentially more succinct than ML. In this paper we show that RML-satisfiability is "only" singly exponentially harder than ML-satisfiability, the latter being a well-known PSPACE-complete problem.

6.10 Emptiness Of Alternating Tree Automata Using Games With Imperfect Information

Participants: Nathanael Fijalkow [LIAFA, Paris 7], Sophie Pinchinat, Olivier Serre [LIAFA, Paris 7].

We consider the emptiness problem for alternating tree automata, with two acceptance semantics: classical (all branches are accepted) and qualitative (almost all branches are accepted). For the classical semantics, the usual technique to tackle this problem relies on a Simulation Theorem which constructs an equivalent non-deterministic automaton from the original alternating one, and then checks emptiness by a reduction to a two-player perfect information game. However, for the qualitative semantics, no simulation of alternation by means of non-determinism is known. We give an alternative technique to decide the emptiness problem of alternating tree automata, that does not rely on a Simulation Theorem. Indeed, we directly reduce the emptiness problem to solving an imperfect information two-player parity game. Our new approach can successfully be applied to both semantics, and yields decidability results with optimal complexity; for the qualitative semantics, the key ingredient in the proof is a positionality result for stochastic games played over infinite graphs.

6.11 Jumping Automata for Uniform Strategies

Participants: Bastien Maubert, Sophie Pinchinat.

The concept of uniform strategies has recently been proposed as a relevant notion in game theory for computer science. It relies on properties involving sets of plays in two-player turn-based arenas equipped with a binary relation between plays. Among the two notions of fully-uniform and strictly-uniform strategies, we focus on the latter, less explored. We present a language that extends CTL* with a quantifier over all related plays, which enables to express a rich class of uniformity constraints on strategies. We show that the existence of a uniform strategy is equivalent to the language non-emptiness of a jumping tree automaton. While the existence of a uniform strategy is undecidable for rational binary relations, restricting to ecognizable relations yields a 2EXPTIME-complete complexity, and still captures a class of two-player imperfect-information games with epistemic temporal objectives. This result

relies on a translation from jumping tree automata with recognizable relations to two-way tree automata.

6.12 Specifying Robustness

Participants: John Christopher McCabe-Dansted [University Western Australia], Tim French [University Western Australia], Mark Reynolds [University Western Australia], Sophie Pinchinat.

This paper proposes a new logic RoCTL* to model robustness in concurrent systems. RoCTL* extends CTL* with the addition of Obligatory and Robustly operators, which quantify over failure-free paths and paths with one more failure respectively. We present a number of examples of problems to which RoCTL* can be applied. The core result of this paper is to show that RoCTL* is expressively equivalent to CTL* but is non-elementarily more succinct. We present a translation from RoCTL* into CTL* that preserves truth but may result in non-elementary growth in the length of the translated formula as each nested Robustly operator may result in an extra exponential blowup. However, we show that this translation is optimal in the sense that any equivalence preserving translation will require an extra exponential growth per nested Robustly. We also compare RoCTL* to Quantified CTL* (QCTL*) and hybrid logics.

6.13 Normative Reasoning and Consequence

Participants: Stephen Cranefield [University of Otago], Yehia Elrakaiby [University of Luxembourg], Dov M. Gabbay [King's College London], Davide Grossi [University of Liverpool], Emiliano Lorini [CNRS, IRIT] Xavier Parent [University of Luxembourg], Leendert W. N. van der Torre [University of Luxembourg], Luca Tummolini [CNR], Paolo Turrini [Imperial College London], François Schwarzentruber.

In this chapter we first provide a general introduction to the research area methodology and relevance, then we discuss normative reasoning for multi-agent systems, and finally we discuss current research challenges. We cover the main issues in modern deontic logic, which is much broader than the traditional modal logic framework of deontic logic, with an emphasis to our in- tended audience. To emphasize this broadness, we typically refer to "deontic logic and normative systems" rather than deontic logic only.

6.14 Agents that look at one another

Participants: Philippe Balbiani [IRIT, CNRS], Olivier Gasquet [IRIT, CNRS], François Schwarzentruber.

Despite the fact that epistemic connectives are sometimes interpreted in concrete structures defined by means of runs and clock time functions, one of the things that strikes one when studying multiagent logics is how abstract their semantics are. Contrasting this fact is the fact that real agents like robots in everyday life and virtual characters in video games have strong links with their spatial environment. In this article, we introduce multiagent logics

which semantics can be defined by means of purely geometrical notions: possible states are defined by means of the positions in $\mathbb{R}^n$ occupied by agents and the sections of $\mathbb{R}^n$ seen by agents whereas accessibility relations are defined by means of the ability of agents to imagine possible states compatible with what they currently see.

6.15 Listen to Me! Public Announcements to Agents That Pay Attention - or Not

Participants: Hans P. van Ditmarsch [LORIA, CNRS, Nancy], Andreas Herzig [IRIT, CNRS], Emiliano Lorini [IRIT, CNRS], François Schwarzentruber.

In public announcement logic it is assumed that all agents pay attention (listen to/observe) to the announcement. Weaker observational conditions can be modelled in event (action) model logic. In this work, we propose a version of public announcement logic wherein it is encoded in the states of the epistemic model which agents pay attention to the announcement. This logic is called attention-based announcement logic, abbreviated ABAL. We give an axiomatization and prove that complexity of satisfiability is the same as that of public announcement logic, and therefore lower than that of action model logic [1]. We exploit our logic to formalize the concept of joint attention that has been widely discussed in the philosophical and cognitive science literature. Finally, we extend our logic by integrating attention change.

6.16 On the Complexity of Dynamic Epistemic Logic

Participants: Guillaume Aucher, François Schwarzentruber.

Although Dynamic Epistemic Logic (DEL) is an influential logical framework for representing and reasoning about information change, little is known about the computational complexity of its associated decision problems. In fact, we only know that for public announcement logic, a fragment of DEL, the satisfiability problem and the model-checking problem are respectively PSPACE-complete and in P. We contribute to fill this gap by proving that for the DEL language with event models, the model-checking problem is, surprisingly, PSPACE-complete. Also, we prove that the satisfiability problem is NEXPTIME-complete. In doing so, we provide a sound and complete tableau method deciding the satisfiability problem.

6.17 Ceteris Paribus Structure in Logics of Game Forms

Participants: Davide Grossi [University of Liverpool], Emiliano Lorini [IRIT, CNRS] François Schwarzentruber.

The article introduces a ceteris paribus modal logic interpreted on the equivalence classes induced by sets of propositional atoms. This logic is used to embed two logics of agency and games, namely atemporal STIT and the coalition logic of propositional control (CLPC). The embeddings highlight a common ceteris paribus structure underpinning the key modal operators of both logics, they clarify the relationship between STIT and CLPC, and enable the transfer of complexity results to the ceteris paribus logic.

7 Contracts and Grants with Industry

7.1 French Ministry of Defense on Physical Security

Participants: Stéphanie Georges, Sophie Pinchinat.

The project is a collaboration with the French Defense Ministry (2011-1014, contract 2011 81 0323) for physical security. The collaboration involves a PhD student, Stéphanie Georges who develops an assistant tool for semi-automatically synthesizing an attack/defense tree, given a specification of a building and some critical resource to protect from attacks (a safe containing a classified document).

7.2 Cour de Cassation

Participants: Guillaume Aucher, François Schwarzentruber.

The contract was signed on the 22^{nd} of April 2013 and started soon afterwards. Since then, I have developped a software prototype as well as an editor prototype. This eased a lot the communication with the jurists. I have also elicited the different requirements that the language for lawyers should fulfill and have written a short paper on this topic. The software prototype was presented on the 18^{th} of November 2013 to the 30 presidents of the 'Cour d'appels' of France who all met at the Cour de cassation on this occasion (this meeting is annual). Their reaction after our presentation of the prototype was rather enthusiastic and positive. An interview about the project has also been published on the emergence newsletter `http://emergences.inria.fr/lettres2013/newsletter-n28/L28-OUTILDECISION`.

8 Other Grants and Activities

8.1 International Collaborations

- Guillaume Aucher collaborates with Thomas Bolander [DTU Copenhagen] on epistemic planning, with Yanjing Yang [University of Peking, China] on dynamic epistemic logic, with Vaishak Belle [University of Toronto, Canada] on epistemic logic and knowledge representation.
- Sophie Pinchinat collaborates with Tim French [University of Western Australia] on logical foundations of multi-agent systems, and with Laura Bozzelli [Universidad Politécnica de Madrid] on complexity issues in verification.
- François Schwarzentruber collaborates with the team of Leon van der Torre [University of Luxembourg] on normative multi-agent systems and with Davide Grossi [University of Liverpool] for logics in Artificial Intelligence.

8.2 National Collaborations

- Guillaume Aucher is involved in the associated team of INRIA (DISTOL project, for "DIStributed and STOchastic systems, Logic").

- Sophie Pinchinat is collaborating with the DGA (French Defense Ministry) on Physical Security, supervising a PhD student Stéphanie Georges. She is involved in an associated team of INRIA (DISTOL project, for "DIStributed and STOchastic systems, Logic") `http://www.irisa.fr/sumo/DISTOL/` with the Institute of Mathematical Sciences, Chennai and the Chennai Mathematical Institute (2013-2017). She has a strong collaboration with Hans van Ditmarsch (DR CNRS) at LORIA, Nancy, principal of the ERC starting grant project 313360 EPS "Epistemic Protocol Synthesis" (2013-2018) `http://personal.us.es/hvd/313360eps_publiccontentonly.pdf`.

- François Schwarzentruber is collaborating with researchers of IRIT (Toulouse). He is also involved in the associated team of INRIA (DISTOL project, for "DIStributed and STOchastic systems, Logic"). He has also strong collaboration with Hans van Ditmarsch.

9 Dissemination

9.1 Scientific Responsabilities

- Guillaume Aucher was reviewer for the international journal *Synthese* and was in the Program Committee of AAMAS 2014, EUMAS 2014, DEON 2014, CLIMA 2014 and the workshops DARE 2014, IDAS@ESSLLI 2014. He also served as auxiliary reviewer for TACAS 2014 and WODES 2014.

- Sophie Pinchinat is an Associate Editor of the Journal of Discrete-event Dynamic Systems.

  She is a permanent member of the Advisory Board Marie Curie Fellows Association (Public Relations Associate and Science Policy Adviser).

  She is the scientific adviser at the International Affairs of the IRISA laboratory.

  She is member of the consortium of the ERC starting grant 313360 "EPS Epistemic Protocol Synthesis" (2013-2018)
  `http://personal.us.es/hvd/313360eps_publiccontentonly.pdf`.

  She has been a program committee member of the French conference "Modélisation des Systèmes Réactifs" (MSR'13).

  She is a member of the Computer Science and Electrical Engineering Department (ISTIC) Education Council, and also in charge of the International Affairs.

- François Schwarzentruberhas been reviewer for TARK 2013, AAMAS 2013, MSR 2013, MAROC 2013.

9.2 Involvement in the Scientific Community

- Guillaume Aucher has been invited and participated to a Dagstuhl Seminar 14032 entitled "planning with epistemic goals" which took place between the 12^{th} and the 15^{th} of January 2014. I also participated to the Dagstuhl Seminar 13181 entitled "Verification and Testing

of Multi-Agent Systems" which took place between the 28^{th} of April and the 3^{rd} of May 2013.

- Sophie Pinchinat and Bastien Maubert has participated to the national research group GDR-IM GDR-IM `http://www.gdr-im.fr/` for the working group GT-Verif and the GDR-GPL `http://gdr-gpl.cnrs.fr/` for the working group GT-FORWAL.

  Sophie Pinchinat has has co-organized the Dagstuhl seminar 13181 VaToMAS - Verification and Testing of Multi-Agent Systems (2013) `http://www.dagstuhl.de/en/program/calendar/semhp/?semnr=13181`.

  Sophie Pinchinat has given a turorial on "Jeux á durée infinie: applications à la synthèse de circuits et de programmes" at the French meeting IPR 2013 (for Inspecteurs de mathématiques de l'éducation nationale) at ENS Rennes.

  Sophie Pinchinat has given the following other talks: "Specifying Robustness" at the GImInAL workshop on Games of Imperfect Information via Automata and Logic `http://www.imsc.res.in/\%7Ejam/giminal/giminal.html` in Chennai; "The project LogicA" at the French national working group GT FORWAL, LIP6 Paris; "Extensions of the mu-calculus for strategic reasoning" at the French national working group GT Verif, ENS Cachan.

- François Schwarzentruberhas been given a talk (On the Complexity of Dynamic Epistemic Logic) at the international workshop "Believing, planning, acting, revising", 5 july 2013 (Toulouse).

  François Schwarzentruberhas been given a talk 'Flatland logic' at VaToMAS Dagstuhl seminar, 1 may 2013.

9.3 Teaching

- Guillaume Aucher taught the exercise labs of logic at the university of Rennes 1 (L3) during the second semester of 2013–2014 and introduction to Programming (L1). This year, he is also creating a new course entitled "Logic and Knowledge Representation for Multi-Agent Systems" at the University of Rennes 1 (M1). This course gather students of the University of Rennes 1, ENS Rennes and it is also open to the students of the Master KIC of the EIT-ICT Lab.

- I completed the co-supervision of Bastien Maubert's PhD together with Sophie Pinchinat. He defended his PhD on the 17^{th} of January in Rennes.

- Sophie Pinchinat teaches at Université de Rennes 1, Suélec, and ENS Rennes.

  – At Université de Rennes 1: Advanced Techniques for Verification (Master 2 Research), Software Formal Analysis and Design (Master 1), Advanced Algorithmics (Master 1), Automata-theoretic approach for Formal Verification (Master 1), An introduction to Writing and Research (Master 1), Project Supervision (Master 1), Algorithmics (Bachelor), Introductory course in Logic (Bachelor).

  - At Supélec: Game Theory
  - At ENS Rennes: Logic and Computability (Agrégation de Mathématiques)

  She also participates to numerous jurys for training students of ENS Rennes at "Agrégation de Mathématiques".

  She is in co-charge of the stream "Parcours Recherche et Innovation" of the Master Informatique of Computer Science and Electrical Engineering Department of University of Rennes 1.

- François Schwarzentruber teaches at ENS Rennes: Introduction to algorithms (L3), Advanced algorithms (L3), Design and verification (M1), Computability and complexity theory ("Agrégation de Mathématiques"), Programming a robot in C++ ("Agrégation de Mathématiques"), Introduction to research (L3), organization of seminars for students (L3, M1).

  François Schwarzentruber has given a talk in front of the new students at ENS Rennes about SAT and has given a talk about computer science at 'Cordées de la réussite'.

10 Bibliography

Major publications by the team in recent years

[1] G. Aucher, G. Boella, L. van der Torre, "A dynamic logic for privacy compliance", *Journal of artificial intelligence and law 19*, 2–3, 2011, p. 187–231.

[2] G. Aucher, B. Maubert, F. Schwarzentruber, "Tableau Method and NEXPTIME-Completeness of DEL-Sequents", *Electronic Notes in Theoretical Computer Science 278*, 2011, p. 17–30.

[3] G. Aucher, B. Maubert, F. Schwarzentruber, "Generalized DEL-Sequents", *in : JELIA 2012*, p. 54–66, 2012.

[4] G. Aucher, "A Combined System for Update Logic and Belief Revision", *in : PRIMA*, p. 1–17, 2004.

[5] G. Aucher, "BMS revisited", *in : TARK*, p. 24–33, 2009.

[6] G. Aucher, "Generalizing AGM to a multi-agent setting", *Logic Journal of the IGPL 18*, 4, 2010, p. 530–558.

[7] G. Aucher, "An internal version of epistemic logic", *Studia Logica 1*, 2010, p. 1–22.

[8] G. Aucher, "DEL-Sequents for progression", *Journal of Applied Non-Classical Logics 21*, 3-4, 2011, p. 289–321.

[9] G. Aucher, "DEL-sequents for regression and epistemic planning", *Journal of Applied Non-Classical Logics 22*, 4, 2012, p. 337–367.

[10] G. Aucher, *Interdisciplinary Works in Logic, Epistemology, Psychology and Linguistics*, *Logic, Argumentation and Reasoning*, *3*, Springer, 2014, ch. Principles of Knowledge, Belief and Conditional Belief.

[11] G. Aucher, "Supervisory Control Theory in Epistemic Temporal Logic", *in : AAMAS*, to appear, 2014.

[12] G. Aucher, "Update Logic", *Journal of Logic and Computation to appear*, 2014.

[13] P. Blackburn, H. P. van Ditmarsch, M. Manzano, F. Soler-Toscano (editors), *Tools for Teaching Logic - Third International Congress, TICTTL 2011, Salamanca, Spain, June 1-4, 2011. Proceedings*, *Lecture Notes in Computer Science*, *6680*, Springer, 2011.

[14] O. Bournez, I. Potapov (editors), *Reachability Problems, 3rd International Workshop, RP 2009, Palaiseau, France, September 23-25, 2009. Proceedings*, *Lecture Notes in Computer Science*, *5797*, Springer, 2009.

[15] L. Bozzelli, H. van Ditmarsch, S. Pinchinat, "The Complexity of One-Agent Refinement Modal Logic", *Logics in Artificial Intelligence*, 2012, p. 120–133.

[16] L. Bozzelli, H. P. van Ditmarsch, S. Pinchinat, "The Complexity of One-Agent Refinement Modal Logic", *in : JELIA 2012*, p. 120–133.

[17] S. Chédor, H. Marchand, C. Morvan, S. Pinchinat, "Analysis of partially observed recursive tile systems", *in : 11th edition of Workshop on Discrete Event Systems*, Guadalajara, Mexico, Oct 2012.

[18] G. D'Agostino, S. La Torre (editors), *Proceedings of Second International Symposium on Games, Automata, Logics and Formal Verification, GandALF 2011, Minori, Italy, 15-17th June 2011*, *EPTCS*, *54*, 2011.

[19] L. F. del Cerro, A. Herzig, J. Mengin (editors), *Logics in Artificial Intelligence - 13th European Conference, JELIA 2012, Toulouse, France, September 26-28, 2012. Proceedings*, *Lecture Notes in Computer Science*, *7519*, Springer, 2012.

[20] O. Gasquet, F. Schwarzentruber, M. Strecker, "Panda: A Proof Assistant in Natural Deduction for All. A Gentzen Style Proof Assistant for Undergraduate Students", *in : TICTTL 2011*, p. 85–92, 2011.

[21] O. Gasquet, F. Schwarzentruber, M. Strecker, "Satoulouse: The Computational Power of Propositional Logic Shown to Beginners", *in : TICTTL 2011*, p. 77–84, 2011.

[22] O. Gasquet, F. Schwarzentruber, "Concrete Epistemic Modal Logic: Flatland", *in : TICTTL2011*, p. 70–76, 2011.

[23] A. Herzig, F. Schwarzentruber, "Properties of logics of individual and group agency", *in : Advances in Modal Logic 2008*, p. 133–149, 2008.

[24] E. Lorini, F. Schwarzentruber, "A Logic for Reasoning about Counterfactual Emotions", *in : IJCAI 2009*, p. 867–872, 2009.

[25] E. Lorini, F. Schwarzentruber, "A Modal Logic of Epistemic Games", *Games 1*, 4, 2010, p. 478–526.

[26] E. Lorini, F. Schwarzentruber, "A logic for reasoning about counterfactual emotions", *Artif. Intell. 175*, 3-4, 2011, p. 814–847.

[27] B. Maubert, S. Pinchinat, L. Bozzelli, "Opacity Issues in Games with Imperfect Information", *in : GandALF 2011*, p. 87–101, 2011.

[28] B. Maubert, S. Pinchinat, "Games with Opacity Condition", *in : RP 2009*, p. 166–175, 2009.

[29] B. Maubert, S. Pinchinat, "Uniform strategies", *in : 10th Conference on Logic and the Foundations of Game and Decision Theory*, Online Proceedings, 2012.

[30] S. Pinchinat, S. Riedweg, "A decidable class of problems for control under partial observation.", *Inf. Process. Lett. 95*, 4, 2005, p. 454–460.

[31] F. Schwarzentruber, S. Vesic, T. Rienstra, "Building an Epistemic Logic for Argumentation", *in : JELIA 2012*, p. 359–371, 2012.

[32] F. Schwarzentruber, "LotrecScheme", *Electr. Notes Theor. Comput. Sci. 278*, 2011, p. 187–199.

[33] F. Schwarzentruber, "Seeing, knowledge and common knowledge", *in : Logic, Rationality, and Interaction*, Springer, 2011, p. 258–271.

[34] F. Schwarzentruber, "Complexity Results of STIT Fragments", *Studia Logica 100*, 5, 2012, p. 1001–1045.

[35] H. P. van Ditmarsch, T. French, S. Pinchinat, "Future Event Logic - Axioms and Complexity", *in : Advances in Modal Logic 2008*, p. 77–99, 2010.

Articles in referred journals and book chapters

[1] G. Aucher, F. Schwarzentruber, "On the Complexity of Dynamic Epistemic Logic", *CoRR abs/1310.6406*, 2013.

[2] P. Balbiani, O. Gasquet, F. Schwarzentruber, "Agents that look at one another", *Logic Journal of IGPL 21*, 3, 2013, p. 438–467.

[3] L. Bozzelli, H. P. van Ditmarsch, T. French, J. Hales, S. Pinchinat, "Refinement Modal Logic", *Information and Computation*, 2014, To appear.

[4] B. Maubert, S. Pinchinat, "A General Notion of Uniform Strategies", *International Game Theory Review 16*, 01, 2014.

Publications in Conferences and Workshops

[5] G. Aucher, B. Maubert, S. Pinchinat, "Automata Techniques for Epistemic Protocol Synthesis", *in : Proceedings 2nd International Workshop on Strategic Reasoning, SR 2014, Grenoble, France, April 5-6, 2014*, F. Mogavero, A. Murano, M. Y. Vardi (editors), 2014. To appear.

[6] L. Bozzelli, H. P. van Ditmarsch, S. Pinchinat, *in : IJCAI*.

[7] O. Gasquet, V. Goranko, F. Schwarzentruber, "Big Brother Logic: Logical modeling and reasoning about agents equipped with surveillance cameras in the plane", *in : Proc. of AAMAS'2014*, 2014. To appear.

[8] B. Maubert, S. Pinchinat, L. Bozzelli, "The Complexity of Synthesizing Uniform Strategies", *in : SR*, F. Mogavero, A. Murano, M. Y. Vardi (editors), *EPTCS*, *112*, p. 115–122, 2013.

[9] B. Maubert, S. Pinchinat, "Jumping Automata for Uniform Strategies", *in : FSTTCS*, A. Seth, N. K. Vishnoi (editors), *LIPIcs*, *24*, Schloss Dagstuhl - Leibniz-Zentrum fuer Informatik, p. 287–298, 2013.

[10] V. G. Olivier Gasquet, F. Schwarzentruber, "Big Brother Logic: Logical modeling and reasoning about agents equipped with surveillance cameras in the plane", *in : Proc. of AAMAS'2014*, p. ??, 2014.

Miscellaneous

[11] S. Georges, S. Pinchinat, "Towards Attack Trees Synthesis for Computer-aided Risk Analysis", SCITEPRESS Digital Library, Doctoral Consortium of International Conference on Agents and Artificial Intelligence 2014, March 6-8, Angers, France, 2014, To appear.