UMR IRISA

Activity Report 2021

Team LOGICA

LOgic, Games, Information, Coordination, and
Applications

D4 – Language and Software Engineering

1   Team composition

Researchers and faculty

Sophie Pinchinat, PR University of Rennes 1
François Bodin, PR University of Rennes 1
François Schwarzentruber, MCF ENS Rennes

Research engineers, technical staff

Laurent Morin, Engineer, UR1 (100%) Didier Vojtisek, Engineer, INRIA (20%)

PhD students

Arthur Queffelec, Florence Wacheux, Dylan Bellier, Pierre Le Scornet, Alexandre
Terefenko

Administrative assistant

Sophie Maupilé

2 Overall objectives

2.1 Overview

The LOGICA team studies theoretical and practical aspects of *multi-agent systems* (MAS). The notion of MAS is finding a wide range of applications: multi-robot systems (e.g. drones), web services, distributed systems, decentralized control, cyber-physical systems, games, etc. Therefore, an agent could be either a physical entity, a computer program, or a human being. Its behaviour can be cooperative, adversarial, or malicious. In a more abstract view, MAS are systems composed of agents that are autonomous entities deciding by themselves which actions to perform in order to meet their objectives.

Noticeably, in a MAS, agent may not have perfect information about their environment. As a consequence, agent decisions are taken on the basis of the available information, that changes dynamically due to events occurring over time.

Reasoning about MAS requires their formal modeling and the development of theories. Such theories should support their deployment in practice, by providing guarantees and certification of their proper functioning. This can be achieved by various means: verification (model-checking), automated generation (synthesis), and coordination mechanisms between agents (control/orchestration/choreography/communication). The LOGICA group contributes to the foundations of MAS by developing innovative ideas in these lines. The focus is put on logical approaches where both the models for MAS and the languages for the specification of their properties lead to effective methods.

Additionally to contributing to the foundations of MAS, the LOGICA team investigates several application domains: multi-drone rescue missions (with plan synthesis), IoT, data Logistics and risk analysis in MAS (with of attack tree specifications).

2.2 Scientific foundations

The team activities are spread in theoretical aspects of computer science as well as applied ones.

Most of its members work on developing a wide spectrum of ideas and results, in particular in logic, for the analysis of automated reasoning methods in multi-agents systems (MAS): epistemic reasoning, strategic reasoning, synthesis of correct behavior. In most cases, a careful study of the computational complexity of the exhibited problems is conducted. Main research topics are reasoning under uncertainty in MAS, planning problems, strategic reasoning, foundations of attack trees in risk analysis, and automata techniques for system verification and synthesis.

Other researchers are involved in collaborative research and technological design and developments with the territorial authorities to conduct research in IoT and data Logistics.

2.2.1   Reasoning under uncertainty in multi-agent systems

- Thomas Bolander, Tristan Charrier, Sophie Pinchinat, François Schwarzentruber: DEL-based Epistemic Planning: Decidability and Complexity. 30th International Joint Conference on Artificial Intelligence (IJCAI-21), journal Track, Montreal, Canada, from August 21st to August 26th, 2021.

  Epistemic planning can be used for decision making in multi-agent systems with distributed knowledge and capabilities. Dynamic Epistemic Logic (DEL) has been shown to provide a very natural and expressive framework for epistemic planning. In this paper, we present a systematic overview of known complexity and decidability results for epistemic planning based on DEL, as well as provide some new results and improved proofs of existing results based on reductions between the problems.

- Thomas Eiter, Aaron Hunter, François Schwarzentruber: How Hard to Tell? Complexity of Belief Manipulation Through Propositional Announcements. IJCAI 2021: 1866-1872

  Consider a set of agents with initial beliefs and a formal operator for incorporating new information. Now suppose that, for each agent, we have a formula that we would like them to believe. Does there exist a single announcement that will lead all agents to believe the corresponding formula? This paper studies the problem of the existence of such an announcement in the context of model-preference definable revision operators. First, we provide two characterisation theorems for the existence of announcements: one in the general case, the other for total partial orderings. Second, we exploit the characterisation theorems to provide upper bound complexity results. Finally, we also provide matching optimal lower bounds for the Dalal and Ginsberg operators.

- Emiliano Lorini, François Schwarzentruber: Multi-Agent Belief Base Revision. IJCAI 2021: 1959-1965

  We present a generalization of belief base revision to the multi-agent case. In our approach agents have belief bases containing both propositional beliefs and higher-order beliefs about their own beliefs and other agents' beliefs. Moreover, their belief bases are split in two parts: the mutable part, whose elements may change under belief revision, and the core part, whose elements do not change. We study a belief revision operator inspired by the notion of screened revision. We provide complexity results of model checking for our approach as well as an optimal model checking algorithm. Moreover, we study complexity of epistemic planning formulated in the context of our framework.

- Emiliano Lorini, François Schwarzentruber: A Computationally Grounded Logic of Graded Belief. JELIA 2021: 245-261

  We present a logic of graded beliefs with a formal semantics grounded on the notion of belief base. It has modal operators which represent what an agent would believe if she removed k pieces of information from her belief base. We provide a sound and complete axiomatics for our logic as well as an optimal model checking algorithm. To illustrate its expressive power, we apply it to modeling social influence and epistemic explanation.

2.2.2   Planning

- Arthur Queffelec, Ocan Sankur, François Schwarzentruber: Connected Multi-Agent Path Finding: Generation and Visualization. IJCAI 2021: 5008-5011

  We present a generic tool to visualize missions of the Connected Multi-Agent Path Finding (CMAPF) problem. This problem is a variant of MAPF which requires a group of agents to navigate from an initial configuration to a goal configuration while maintaining connection. The user can create an instance of CMAPF and can play the generated plan. Any algorithm for CMAPF can be plugged into the tool.

2.2.3   Strategic reasoning: strategy dependencies

Sophie Pinchinat and François Schwarzentruber supervise Dylan Bellier to explore logic-based mathematical settings to specify and handle dependencies of agent strategies in decision making systems.

Although there are no still yet publications, for not having submitted to regular conferences, the results of Dylan Bellier have been presented to four scientific events and were very welcome. Dylan Bellier gave a talk on different aspects of his work at the International Workshop on Logical Aspects in Multi-Agent Systems and Strategic Reasoning (`https://lamassr.github.io/editions/2021/`), Workshop on Logics of Dependence and Independence organized as part of ESSLLI 2021, Workshop on Automated Synthesis organized as part of ESSLLI 2021, and the International Workshop Spotlight on Transducers.

2.2.4   Theoretical aspects in security

Members of the team involved in this research line are Sophie Pinchinat, Didier Vojtisek, Alexandre Terefenko and Pierre Le Scornet.

- Sophie Pinchinat and Didier Vojtisek have initiated a tight collaboration (contract Ouest Valorisation number 2020 00161) with the start-up SYA Digital to tune a well-thought Domain Specific Language dedicated to the specification of asset-based systems. This collaboration aims at enlarging the ATSyRA platform (`http://atsyra2.irisa.fr/`) to the risk analysis of information systems, on top of previous analysis tools for physical systems.

  Sophie Pinchinat dedicates 20% of her time for this collaboration, and Didier Vojtisek 10%.

- Sophie Pinchinat and Pierre Le Scornet (PhD started in September 2021) have worked on attack plan synthesis for virtualized networks, inspired by the approach of Pernelle Mensah[Men19]. Significant decidability results have been established and are currently under submission.

[Men19]   P. MENSAH, *Generation and Dynamic Update of Attack Graphs in Cloud Providers Infrastructures*, Theses, CentraleSupélec, June 2019, `https://hal.inria.fr/tel-02416305`.

- Sophie Pinchinat and Alexandre Terefenko collaborate with Prof. Thomas Brihaye from University of Mons, Belgium, to design a strategy-based semantics of attack trees that will allow to reason on systems that involve several agents, attackers and/or defenders, in order to generalize the correctness criteria of attack trees for single-agent systems as developed in the thesis of Maxime Audinot[APK17], former PhD student of the team.

2.2.5 Automata techniques for system verification and synthesis

- Raphaël Berthon, Nathanaël Fijalkow, Emmanuel Filiot, Shibashis Guha, Bastien Maubert, Aniello Murano, Laureline Pinault, Sophie Pinchinat, Sasha Rubin, Olivier Serre: Alternating Tree Automata with Qualitative Semantics. ACM Transactions on Computational Logic (22)1, January 2021.

  We study alternating automata with qualitative semantics over infinite binary trees: Alternation means that two opposing players construct a decoration of the input tree called a run, and the qualitative semantics says that a run of the automaton is accepting if almost all branches of the run are accepting. In this article, we prove a positive and a negative result for the emptiness problem of alternating automata with qualitative semantics.

  The positive result is the decidability of the emptiness problem for the case of Büchi acceptance condition. An interesting aspect of our approach is that we do not extend the classical solution for solving the emptiness problem of alternating automata, which first constructs an equivalent non-deterministic automaton. Instead, we directly construct an emptiness game making use of imperfect information.

  The negative result is the undecidability of the emptiness problem for the case of co-Büchi acceptance condition. This result has two direct consequences: the undecidability of monadic second-order logic extended with the qualitative path-measure quantifier and the undecidability of the emptiness problem for alternating tree automata with non-zero semantics, a recently introduced probabilistic model of alternating tree automata.

2.2.6 Smart-city and IoT

The smart-city activities of Logica in 2021 have been focused on the RUDI project (`https://rudi.datarennes.fr`/). This project aims at designing and developing a federated metropolitan data infrastructure. This large project (12 partners) covers many aspects of an open data at a territory scale: citizen implication, development, cyber-security and self data. The main task performed by the team has been the design and development of a software component denoted "producer node" (PN). The PN aims at simplifying the data sets publication. It serves as a proxy between the data

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[APK17] M. AUDINOT, S. PINCHINAT, B. KORDY, "Is My Attack Tree Correct?", *in: Computer Security - ESORICS 2017 - 22nd European Symposium on Research in Computer Security, Oslo, Norway, September 11-15, 2017, Proceedings, Part I*, S. N. Foley, D. Gollmann, E. Snekkenes (editors), *Lecture Notes in Computer Science, 10492*, Springer, p. 83–102, 2017, `https://doi.org/10.1007/978-3-319-66402-6\_7`.

producer information system and the RUDI portal (which provide a dataset catalog). All developed software is under open-source license. The team is also in charge of animating a group of ten data producer pilots. This group includes companies, public bodies and cities.

This is part of the Fundation Rennes 1 chair "mobility in a sustainable city" co-held by François Bodin.

2.3 Application domains

- Development of a platform for IoT that allows experiments with data logistics.

- Vulnerability analysis of virtualized networks.

- Information systems risk analysis via attack generation and attack tree design.

3 Software development

3.1 Generation and Visualization for Connected Multi-Agent Path Finding

Participants: Arthur Queffelec, François Schwarzentruber and Ocan Sankur..

We developed a generic graphical user interface to visualize missions of the Connected Multi-Agent Path Finding (CMAPF), that we presented at IJCAI 2021. Agents start at initial positions and have to move to goal positions while remaining connected during all the execution. Any algorithm for CMAPF can be plugged into the tool. Over the period, we implemented a variant of so-called Conflict Based-Search. We supervised the bachelor thesis of Isseïnie Calviac (ENS Rennes) that contributed to the tool. The code is available through `https://github.com/francoisschwarzentruber/cmapf-gui`

3.2 Risk analysis in information systems: ATSyRA platform

Participants: Didier Vojtisek and Sophie Pinchinat.

We keep on with the ATSyRA platform development (`http://atsyra2.irisa.fr/`) to address the risk analysis of information systems, on top of previous analysis tools for physical systems. Most of our research code is being made available through `http://atsyra2.irisa.fr/`. The software functionalities are essentially the specification of an information system, reachability analysis with scenario synthesis, and an attack tree design assistant tool with correctness criteria checking of the specified attack trees via model checking techniques.

3.3 AQMO IoT Platform

Participants: François Bodin, Laurent Morin.

An IoT platform has been setup in the context of the AQMO european project (`http://aqmo.irisa.fr/fr/accueil/`). The platform is still in operation and collects air quality data with sensors installed on buses.

4   Contractual partnership

- Research collaboration contract between Université de Rennes 1 (scientific leader Sophie Pinchinat, software development Didier Vojtisek) entitled "Participation au développement de l'outil de cybersécurité de SYA (registered in the Rennes Trade and Companies Register under number B 894 428 747).

- European project RUDI with Rennes Métropole (2019 - 2022) "Rennes Urban Data Interface"

5   Dissemination

5.1   Promoting scientific activities

5.1.1   Scientific Events Selection

Chair of Conference Program Committees

- François Schwarzentruber: JFPDA (16èmes Journées Francophones sur la Planification, la Décision et l'Apprentissage pour la conduite de systèmes).

Member of Conference Program Committees

- Sophie Pinchinat:

  - A*/A conferences: IJCAI (Senior PC), AAMAS, AAAI, ICALP, CSL;
  - International workshops: Workshop on Automated Synthesis (at ESSLLI 2021), Logical Aspects of Multi-Agent Systems and the International Workshop on Strategic Reasoning, Formal Methods in Artificial Intelligence;
  - National events: Journées d'Intelligence Artificielle Fondamentale, 16èmes Journées Francophones sur la Planification, la Décision et l'Apprentissage pour la conduite de systèmes.

- François Schwarzentruber:

  - A*/A conferences: IJCAI, AAMAS, AAAI;
  - International workshops: Formal Methods in Artificial Intelligence.

Member of Conference Steering Committees

- Sophie Pinchinat: LAMAS&SR (Logical Aspects of Multi-Agent Systems and the International Workshop on Strategic Reasoning)

Reviewer

- Sophie Pinchinat: IJCAI, AAMAS, AAAI, ICALP, CSL, QEST, DLT.

- François Schwarzentruber: TARK, Wollic, KR, IJCAI-demo track, ICALP, CSL.

5.1.2 Journal

Member of the Editorial Boards

- Information and Computation: Sophie Pinchinat, with Johann Gamper (Free University of Bozen-Bolzano, Italy) and Guido Sciavicco (Department of Mathematics and Computer Science, University of Ferrara, Italy), participated to the selection of papers from the 26th International Symposium on Temporal Representation and Reasoning for publication in Information and Computation 280: 104635 (http://www.sciencedirect.com/science/article/pii/S0890540120301231).

Reviewer - Reviewing Activities

- François Schwarzentruber AIJ, ROIA (Revue Ouverte d'Intelligence Artificielle)

5.1.3 Invited Talks

- Sophie Pinchinat: "On the Role of Postconditions in Dynamic First-Order Epistemic Logic" at the Interbational Workshop on Automated Synthesis, co-located with the European Summer School in Logic, Language and Information (ESSLLI 2021).

5.1.4 Scientific Expertise

- François Schwarzentruber Reviewing a project submitted to ANR (agence nationale de la recherche)

5.2 Teaching, supervision

5.2.1 Teaching

- Licence: Dylan Bellier, Calculabilité, 24h, L2 Informatique Univ. Rennes 1.
- Master: François Schwarzentruber, Complexity theory, 20h, M1, ENS Rennes.
- Master: Sophie Pinchinat, Méthodes de vérification formelle par automates, 24h, M1 Science Informatique (SIF), ENS Rennes. Sophie Pinchinat, Écriture scientifique, 20h, M1 Science Informatique (SIF), ENS Rennes.
- Master: Sophie Pinchinat, Combinatorial optimisation and related algorithms, 20h, M1 informatique, Univ. Rennes 1.
- CAPES: François Schwarzentruber, Algorithms, 14h, Capes mathématiques, Univ. Rennes 1.

- CAPES François Schwarzentruber, Web technologies, 14h, Capes informatique, Univ. Rennes 1.
- François Schwarzentruber, Algorithms, 14h, Capes informatique, Univ. Rennes 1. Sophie Pinchinat, "Recherche", 24h, Capes informatique, Univ. Rennes 1.
- Agrégation: François Schwarzentruber, jury à l'agrégation de mathématiques, option informatique, ENS Rennes. Pierre Le Scornet, le con d'agrégation, 4h, agrégation de mathématiques, option informatique, ENS Rennes.

5.2.2 Supervision

- PhD: Florence Wacheux (2019-2021) working on "Une plateforme multi-domaine d'aide à la conception et à 1'analyse d'arbres d'attaque" supervised by Sophie Pinchinat. The PhD has been aborted in September 2021.
- PhD: Arthur Queffelec (2018-2021) working on "Trade-off between Robustness and Optimality in Strategic Reasoning" supervised by Ocan Sankur and François Schwarzentruber. Defended the 11th october 2021.
- PhD: Dylan Bellier (2020-2023) working on "Designing languages for expressing dependencies in strategic reasoning" supervised by Sophie Pinchinat and François Schwarzentruber.
- MSc: Sophie Pinchinat and François Schwarzentruber supervised Pierre La Scornet on "Formal analysis of dynamic attack graphs".
- MSc: Sophie Pinchinat with Prof. Thomas Brihaye (UMONS) supervised Alexandre Terefenko at UMONS on "Sémantiques pour l'analyse des arbres d'attaque".

5.2.3 Juries

- HDR:

  - Sophie Pinchinat: Reviewer, Frédéric Maris, "Automated Planning with Solvers: Concurrent and Epistemic Aspects", IRIT, December 14, 2021.

- PhD:

  - Sophie Pinchinat: President, Clément Elbaz, "Reacting to N-Day Vulnerabilities in Information Systems" IRISA, March 30, 2021. item Sophie Pinchinat: President, Aurélien Lamercerie, "Principe de transduction sḿantique pour l'application de théories d'interface sur des documents de spécification", IRISA, April 8, 2021.

  - Sophie Pinchinat: Examinator, Line van den Berg, "Cultural Knowledge Evolution in Dynamic Epistemic Logic", Univ. Grenoble Alpes & INRIA, October 29, 2021.

  - Sophie Pinchinat: President, Solène Moreau, "Formal verification of unlinkability for stateful protocols", IRISA, November 18, 2021.

  - Sophie Pinchinat: President,Suman Sadhukhan, "A Verification Viewpoint on Network Congestion Games", IRISA, December 9, 2021.

5.3 Popularization

- Sophie Pinchinat and François Schwarzentruber, in collaboration with Pierre Le Barbenchon, took over a year to publish a textbook on logic entitled "Logique : fondements et applications Cours et exercices corrigés" (Dunod publisher), that will be released in January 2022. This textbook is meant to be used at university to teach classical logic.

6   Bibliography

Articles in referred journals and book chapters

[1] R. BERTHON, N. FIJALKOW, E. FILIOT, S. GUHA, B. MAUBERT, A. MURANO, L. PINAULT, S. PINCHINAT, S. RUBIN, O. SERRE, "Alternating Tree Automata with Qualitative Semantics", *ACM Trans. Comput. Log. 22*, 1, 2021, p. 7:1–7:24, `https://doi.org/10.1145/3431860`.

[2] J. GAMPER, S. PINCHINAT, G. SCIAVICCO, "Special Issue - Selected Papers from the 26th International Symposium on Temporal Representation and Reasoning", *Inf. Comput. 280*, 2021, p. 104635, `https://doi.org/10.1016/j.ic.2020.104635`.

Publications in Conferences and Workshops

[3] T. BOLANDER, T. CHARRIER, S. PINCHINAT, F. SCHWARZENTRUBER, "DEL-based Epistemic Planning: Decidability and Complexity", *in: Proceedings of the Thirtieth International Joint Conference on Artificial Intelligence, IJCAI-21*, Z.-H. Zhou (editor), International Joint Conferences on Artificial Intelligence Organization, 8 2021. Journal Track.

[4] T. EITER, A. HUNTER, F. SCHWARZENTRUBER, "How Hard to Tell? Complexity of Belief Manipulation Through Propositional Announcements", *in: Proceedings of the Thirtieth International Joint Conference on Artificial Intelligence, IJCAI-21*, Z.-H. Zhou (editor), International Joint Conferences on Artificial Intelligence Organization, p. 1866–1872, 8 2021. Main Track, `https://doi.org/10.24963/ijcai.2021/257`.

[5] E. LORINI, F. SCHWARZENTRUBER, "A Computationally Grounded Logic of Graded Belief", *in: 17th European Conference on Logics in Artificial Intelligence (JELIA 2021)*, W. Faber, G. Friedrich, M. Gebser, M. Morak (editors), *Lecture Notes in Computer Science book series (LNCS)*, *12678*, Springer International Publishing, p. 245–261, virtual event, France, May 2021, `https://hal.archives-ouvertes.fr/hal-03453909`.

[6] E. LORINI, F. SCHWARZENTRUBER, "Multi-Agent Belief Base Revision", *in: Proceedings of the Thirtieth International Joint Conference on Artificial Intelligence, IJCAI-21*, Z.-H. Zhou (editor), International Joint Conferences on Artificial Intelligence Organization, p. 1959–1965, 8 2021. Main Track, `https://doi.org/10.24963/ijcai.2021/270`.

[7] A. QUEFFELEC, O. SANKUR, F. SCHWARZENTRUBER, "Connect Multi-Agent Path Finding: Generation and Visualization", *in: Proceedings of the Thirtieth International Joint Conference on Artificial Intelligence, IJCAI-21*, Z.-H. Zhou (editor), International Joint Conferences on Artificial Intelligence Organization, p. 5008–5011, 8 2021. Demo Track, `https://doi.org/10.24963/ijcai.2021/714`.