UMR IRISA

Activity Report 2023

Team LOGICA

LOgic, Games, Information, Coordination, and Applications

D4 – Language and Software Engineering

Université de Rennes | rennes | INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES RENNES | cnrs | Inria | Inserm | CentraleSupélec | IMT Atlantique Bretagne-Pays de la Loire École Mines-Télécom | Université Bretagne Sud ubs

1 Team composition

Researchers and faculty

François Bodin, PR University of Rennes
Hervé Marchand, CR Inria
Sophie Pinchinat, PR University of Rennes
François Schwarzentruber, MCF ENS Rennes

Research engineers, technical staff

Alexandre Bettinger, Engineer, UR1 (100%)
Laurent Morin, Engineer, UR1 (100%)
Olivier Martineau, Engineer, CDD (100%)
Didier Vojtisek, Engineer, INRIA (20%)

PhD students

Dylan Bellier (CDSN and ATER Istic)
Victorien Desbois (ENS Rennes / NewLogUp)
Thibaut Le Marre (ANR epiRL, ENS Rennes)
Alexandre Terefenko (UR/UMONS)

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. A particular research interest concerns the use of 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: IoT, data Logistics and risk analysis in MAS (with attack tree specifications).

2.2 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.

2.3 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, dependencies between strategies, 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.

3 Scientific achievements

3.1 Multi-agent path finding

3.1.1 Complexity of planning for connected agents in a partially known environment

Participants: Arthur Queffelec, Ocan Sankur, François Schwarzentruber.

The Connected Multi-Agent Path Finding (CMAPF) problem asks for a plan to move a group of agents in a graph while respecting a connectivity constraint. We study a generalization of CMAPF in which the graph is not entirely known in advance, but is discovered by the agents during their mission. We present a framework introducing this notion and study the problem of searching for a strategy to reach a configuration in this setting. We prove the problem to be PSPACE-complete when requiring all agents to be connected at all times, and NEXPTIME-hard in the decentralized case. [4]

3.1.2 Improved Complexity Results and an Efficient Solution for Connected Multi-Agent Path Finding

Participants: Isseïnie Calviac, Ocan Sankur, François Schwarzentruber.

Connected multi-agent path finding (CMAPF) consists in computing paths for multiple agents which must reach a goal configuration while remaining connected at all steps. We prove the PSPACE-hardness of the problem when the underlying graph is a subgraph of a 3D grid and with range-based connectivity. Moreover, we provide an application of the WHCA* algorithm and show that it outperforms previously given algorithms by an order of magnitude in terms of the sizes of the instances it can handle. [5]

3.2 Epistemic reasoning

3.2.1 Reasoning about Uncertainty in AgentSpeak using Dynamic Epistemic Logic

Participants: Michael J. Vezina, Babak Esfandiari, Sandra Morley, François Schwarzentruber.

We present an extension of AgentSpeak using dynamic epistemic logic (DEL) to reason about uncertainty. The extension relies on minimal AgentSpeak syntax to describe

uncertainty, while augmenting the language with possibilistic reasoning via modalities. We apply the extension to a realistic navigation example with partial observability and vary the amount of uncertainty to evaluate scalability. Scalability is compared with an existing extension which relies on a less expressive form of DEL. We find that DEL's increased expressiveness comes with a linear cost in computational complexity. [9] [8]

3.2.2 Base-Based Model Checking for Multi-agent only Believing

Participants: Tiago de Lima, Emiliano Lorini, François Schwarzentruber.

We present a novel semantics for the language of multi-agent only believing exploiting belief bases, and show how to use it for automatically checking formulas of this language. We provide a PSPACE algorithm for model checking relying on a reduction to QBF, an implementation and some experimental results on computation time in a concrete example. [7]

3.2.3 On Simple Expectations and Observations of Intelligent Agents: A Complexity Study

Participants: Sourav Chakraborty, Avijeet Ghosh, Sujata Ghosh, François Schwarzentruber:.

Public observation logic (POL) reasons about agent expectations and agent observations in various real world situations. The expectations of agents take shape based on certain protocols about the world around and they remove those possible scenarios where their exceptions and observations do not match. This in turn influences the epistemic reasoning of these agents. In this work, we study the computational complexity of the satisfaction problems of various fragments of POL. In the process, we also highlight the inevitable link that these fragments have with the well-studied Public announcement logic. [6]

3.3 Analysis and control of Discrete Event Systems

3.3.1 Verification of Inference Observability in Supervisory Control of Discrete-Event Systems

Participants: Hervé Marchand.

Recently, we have been interested in the verification of inference observability in supervisory control of discrete-event systems in a decentralized setting where multiple controllers act in parallel in order to take the correct control decision. This idea is that a control decision can be performed after an observed traced whenever at least one of the controller is sure of its decision of enabling or disabling an action. This year, we explored the idea of inferencing cycles in a special automaton, called U-Structure and its role in determining when an inferencing solution exists. Most notably, when an inferencing solution exists, our algorithm computes all the possible ambiguity values to

express an overall solution [10].

3.3.2 Dealing with sensor and actuator deception attacks in supervisory control

Participants: Hervé Marchand.

In collaboration with the university of Michigan, we considered feedback control systems where sensor readings and actuator commands may be compromised by an attacker intending to damage the system. We studied this problem at the supervisory layer of the control system [3]. The attacker can edit the outputs from the sensors of the system before they reach the supervisory controller as well as it can edit actuator commands before they reach the system. In this context, we formulate the problem of synthesizing a supervisor that is robust against a large class of edit attacks on the sensor readings and actuator commands. Intuitively, we search for a supervisor that guarantees the safety of the system even when sensor readings and actuator commands are compromised. Our solution methodology reduces the problem of synthesizing a robust supervisor against deception attacks to a supervisory control problem.

3.3.3 Logic for Opacity - DES To Logic Formalization

Participants: Florian Epain, Hervé Marchand, Sophie Pinchinat.

The analysis of security properties aspects in designing reactive system, particularly regarding the opacity property, has been widely studied in the literature, mostly in an abstract formal- language centric setting, where the two main concerns are its verification and the ability to control the system so that, for the remaining behavior, the opacity property holds. we recently made use of First-order Logic (FOL) to specify the property of opacity for systems with synchronous observations, and use the extension of FOL with fix-points to characterize the maximal sub-behavior of a system where opacity holds.

3.4 Logics for strategic reasonning

3.4.1 Good-for-Game QPTL: An Alternating Hodges Semantics

Participants: Dylan Bellier.

An extension of QPTL is considered where functional dependencies among the quantified variables can be restricted in such a way that their current values are independent of the future values of the other variables. This restriction is tightly connected to the notion of behavioral strategies in game-theory and allows the resulting logic to naturally express game-theoretic concepts. The fragment where only restricted quantifications are considered, called behavioral quantifications, can be decided, for both model checking and satisfiability, in 2EXPTIME and is expressively equivalent to QPTL, though significantly less succinct[2].

3.4.2 Alternating Dependence/Independence-Friendly Logic

Participants: Dylan Bellier.

Hintikka and Sandu originally proposed Independence Friendly Logic (IF) as a first-order logic of imperfect information to describe game-theoretic phenomena underlying the semantics of natural language. The logic allows for expressing independence constraints among quantified variables, in a similar vein to Henkin quantifiers, and has a nice game-theoretic semantics in terms of imperfect information games. However, the IF semantics exhibits some limitations. It treats the players asymmetrically, considering only one of the two players as having imperfect information when evaluating truth, resp., falsity, of a sentence. In addition, the truth and falsity of sentences coincide with the existence of a uniform winning strategy for one of the two players in the semantic imperfect information game. As a consequence, IF does admit undetermined sentences, which are neither true nor false, thus failing the law of excluded middle. In this paper, we investigate an extension of IF, called Alternating Dependence/Independence Friendly Logic (ADIF), tailored to overcome these limitations. To this end, we introduce a novel compositional semantics, generalising the one based on trumps proposed by Hodges for IF. The new semantics (i) allows for meaningfully restricting both players at the same time, (ii) enjoys the property of game-theoretic determinacy, (iii) recovers the law of excluded middle for sentences, and (iv) grants ADIF the full descriptive power of Second Order Logic. We also provide an equivalent Herbrand-Skolem semantics and a game-theoretic semantics for the prenex fragment of ADIF, the latter being defined in terms of a determined infinite-duration game that precisely captures the other two semantics on finite structures[1].

3.4.3 Complexity analysis of some decision problems for Plan Logic

Participants: Dylan Bellier, Sophie Pinchinat, Gaëtan Regaud.

In classic Quantified (linear-time) Temporal Logic, QPTL for short, the alternation of "exists" and "for all" quantifiers yields a semantic game in which two players, existential (Eve) and universal (Adam), compete to prove or respectively disprove the quantified linear-time temporal formula. In this game, Eve chooses the temporal valuation of propositions that are existentially quantified, and Adam, her opponent, chooses those that are universally quantified. Eve wins this game if, and only if, the trace resulting from the choices of both players satisfies the linear-time temporal formula.

Plan Logic, PL for short, has been develop in the LogicA research group to express finer dependencies than what can be expressed in QPTL, inspired from Strategy Logic. PL generalizes QPTL by considering a model for the player arena – a QPTL formula need not be confronted to any arena but the trivial universal one.

The goal of this internship is twofold:

- develop the formal argument that the non-elementary complexity of QPTL [1] carries over the Model Checking problem PL,
- study the computational complexity of the Satisfiability problem for PL, under

the light of what is known about Strategy logic.

4 Software development

4.1 Risk analysis in information systems: ATSyRA platform

Participants: Sophie Pinchinat, Didier Vojtisek.

Joint work with Maxime Audinot, Laurent Collet (head), William Ragot of the SYA Digital company from Rennes.

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.

This year, the software development is performed in the context of an industrial collaboration with the start-up SYA Digital from Rennes.

5 Contracts and collaborations

5.1 National Initiatives

5.1.1 PEPR Numpex/Exa-AToW Architectures and Tools for Large-Scale Workflows

Participants: François Bodin, Olivier Martineau, Laurent Morin.

- Project type: PEPR
- Dates: 2022–2028
- PI institution: University of Rennes
- Other partners: CEA, CNRS, Inria

The deployment of exascale supercomputers meets the increasing demand for computational capacity in numerical models. Concurrently, there's an exponential growth in data volume from large scientific instruments, the Internet of Things (IoT), and numerical simulations (e.g., CMIP 6). In this scenario, designing scientific applications necessitates the consideration of distributed processing chains across data centers, processing/computation infrastructures, and scientists' labs (e.g., through large-scale workflows).

These infrastructures are often managed by different administrative authorities and are technically heterogeneous. This poses a challenge in implementing data logistics

and orchestrating processing/computation at such a scale. Data logistics must adhere to several constraints:

1. Comply with the storage limitations of the infrastructure.
2. Account for the capabilities (including topology, latency, and transfer protocols) of communication networks and computing infrastructures.
3. Maintain overarching security.
4. Reduce energy consumption.
5. Streamline the writing, deployment, and debugging of applications.

Thus, the implementation of these logistics is a multi-criteria optimization challenge within collaborative systems-of-systems. Key aspects of these logistics include the traceability of operations and adherence to the FAIR policy for all scientific data. Incorporating metadata - related to data or processes - in analyzing constraints and logistical solutions is crucial.

More at `https://numpex.org/`

5.1.2 Breizh Decarbonated Mobility

Participants: François Bodin, Olivier Martineau, Laurent Morin, Alexandre Bettinger.

- Project type: Feder / Brittany Region
- Dates: 2021–2024
- PI institution: Setur
- Other partners: University of Rennes (Irisa, Crem), RatpDev

Transportation is a major source of greenhouse gas emissions. Optimizing transport and promoting sustainable mobility can help reduce these emissions. This requires understanding the decision-making patterns of users regarding modes of transport, through the collection of personal and contextual data.

The BMDec project focuses on urban and peri-urban home-to-work mobility. It is a multidisciplinary initiative bringing together the SETUR consultancy, the Logica research team from Irisa, CREM, UrbanThink, and RatpDev. The project is funded by the Brittany Region and is part of the activities of the Chair of Mobility in a Sustainable City of the Rennes 1 Foundation. The project aims to analyze user behavior to encourage a reduction in greenhouse gas emissions and to integrate these behaviors into decision-support tools. Thus, the BMDec project relies on the creation of a panel of users who are questioned daily about their modes of transportation.

The project consists of two main components. The first involves the collection and analysis of data related to user behavior. The second aims to design a decision-support system based on machine learning (ML) to generate a model of user behavior.

More at `https://project.inria.fr/bmdec/fr/`

5.1.3 Rennes Urban Data Interface (RUDI)

Participants: François Bodin, Olivier Martineau, Laurent Morin.

- Project type: UIA
- Dates: 2019–2023
- PI institution: Rennes Métropole
- Other partners: University of Rennes, Lego/UBS, Fing, Ouishare, Keolis Rennes, Enedis Bretagne, GRDF, Audiar, Tiriad, Ouest-France

RUDI is proposing an original approach for aligning its technical architecture with governance principles. The articulation of both dimensions is especially important when the considered data perimeter includes open data, sensitive data and personal data. Indeed, the technical architecture may or may not allow to implement the governance induced protocols, data protection, responsibilities tracking, data management, etc.

The main contribution of the Logica's team to RUDI is the producer node. The RUDI Producer Node groups all the modules required for the deployment of fully managable RUDI producer Node as defined in RUDI Open-Data project.

The purpose of a RUDI producer node is to provide the technology able to store and manage the metadata and data (media) of the datasets owned by a particular contributor in the open-data RUDI federation. This software was designed with the following principles:

- It proposes a reference implementation of the standard RUDI API.
- It is able to publish the metadata of datasets to the main Rennes-Métropole RUDI platform (rudi.bzh)
- It is completely independent, and can be used as a standalone OpenData platform.
- It is modular and relies and a set of micro-services.
- Its is only based on free and open-source technologies and release under an open-source license.

More at `rudi.bzh`

5.1.4 ANR epiRL - Epistemic reinforcement learning

Participants: Thibaut Le Marre, François Schwarzentruber.

EpiRL project (ANR-22-CE23-0029) aims at investigating the combination of epistemic planning and reinforcement learning (RL), by proposing new algorithms that are efficient, adaptive, and capable of computing decisions relying on theory of knowledge and belief. We expect from this approach an efficiency in the generation of epistemic plans, while decisions made RL algorithms will be explainable. Moreover, the algorithms of EpiRL will be tested and evaluated within a real application that exploits

autonomous agents. The project will address the weaknesses of both epistemic planning and RL: on the one hand, existing epistemic planning algorithms are costly, do not adapt to the environment, and concepts are hand-crafted and are not learned; on the other hand, in reinforcement learning, agents adapt to their environments but are unable to reason about beliefs of other agents. The newly developed algorithms will combine the strengths of both fields. We propose four workpackages:

1. Study representations of states
2. Develop RL algorithms
3. Study representations of policies
4. Validating our algorithms with our industrial partner DAVI. In particular, we aim at developing a debunking chatbot whose use case will apply to raising awareness about environmental issues.

More at `https://epirl.irisa.fr/`

5.2 Bilateral industry grants

5.2.1 PhD project (CIFRE) with NewLogUp: Multi-objective optimization for the vehicule rescheduling problem

Participants: Victorien Desbois, Ocan Sankur, François Schwarzentruber.

NewLogUp plans to develop software to help transportation companies automatically handle unexpected events. Our goal is to develop optimization algorithms to improve these solutions. There are several objectives to satisfy when computing updates to a given schedule:

- optimality of the cost of the new schedule,
- quality of service (e.g. minimizing delays),
- favoring robust schedules, that is, those that can be easily revised in case of further incidents,
- the simplicity of the revision, for instance, changing the routes for the least number of trucks.

5.3 Collaborations

- Hervé Marchand: Mount Allison University, Canada (Laurie Ricker): This collaboration focused on the problem of *Decentralized control* of discrete event systems as well as *the opacity control problem*. In 2023, we obtained a 2000€ grant (IRISA) for a visit of L. Ricker in August 2023 for 2 weeks.

- Hervé Marchand: University of Michigan (Stéphane Lafortune & Romulo Meira-Goes) about the *Synthesis of Supervisors Robust Against Sensor Deceptions Attacks*.
- Dylan Bellier & Sophie Pinchinat: Università degli Studi di Napoli Federico II (Massimo Benerecetti & Fabio Mogavero) on logic for expressing dependences in strategic reasoning.

6 Dissemination

6.1 Promoting scientific activities

6.1.1 Scientific Events Selection

Steering Committees

- Hervé Marchand:
  - President of the Steering Committee of MSR (conférence sur la modélisation des systmes réactifs);

Chair of Conference Program Committees

- François Schwarzentruber:
  - Co-chair of JIAF-JFPDA 2023 (Journées d'Intelligence Artificielle Fondamentale) `https://pfia23.icube.unistra.fr/conferences/jiaf/index.html`

Member of Conference Program Committees

- Hervé Marchand:
  - MSR 2023 (conférence sur la modélisation des systèmes réactifs);
  - Wodes'2024 (International Workshop on Discrete Event Systems).
- Sophie Pinchinat:
  - JIAF-JFPDA 2023 (Journées d'Intelligence Artificielle Fondamentale & Journées Francophones sur la Planification, la Décision et l'Apprentissage);
  - LAMAS&SR-2023 (International Workshop on Logical Aspects in Multi-agent Systems and Strategic Reasoning);
  - MFCS 2023 (48th International Symposium on Mathematical Foundations of Computer Science);
  - RADICAL-2023 (Recent Advances in Concurrency and Logic);
  - WoLLIC 2023 (29th Workshop on Logic, Language, Information and Computation).

- Dylan Bellier:
  - OVERLAY 2023 (Artificial Intelligence and fOrmal VERification, Logic, Automata, and sYnthesis).
- François Schwarzentruber:
  - IJCAI 2023, IJCAI demo 2023, AAMAS 2023, ECAI 2023

Reviewer

- Hervé Marchand was reviewer for MSR'2023, IFAC World Congress 2023, IEEE American Control Conference (ACC'2023), IEEE Conference on Decisions and Control (CDC'2023).
- Dylan Bellier was reviewer for GandALF 2023, JIAF-JFPDA 2023, MFCS 2023, WOLLIC 2023 and AAMAS 2024.
- François Schwarzentruber was reviewer for the journals *Artificial Intelligence* and *Autonomous Agents and Multi-Agent Systems*, and the conferences TARK 2023, MFCS 2023, LORI 2023.

6.1.2 Journal

Member of the Editorial Boards

- Hervé Marchand is Associate Editor of the Journal Discrete event dynamical systems - Theory and applications.

Reviewer - Reviewing Activities

- Hervé Marchand was reviewer for Discrete event dynamical systems - Theory and applications, IEEE Transaction Automatic and Control, Automatica
- Dylan Bellier was reviewer for IEEE Transactions on Computational Logic.

6.1.3 Invited Talks

- Sophie Pinchinat:
  - IEEE CSS TC DES "Virtual Lecture Series" `https://ieeecss.org/tc/discrete-event-systems/talk-series-2023` May 25, 2023;
  - Highlights of Logic, Games and Automata `https://highlights-conference.org/2023/` june 27, 2023, Kassel Germany;
  - Journées annuelles du GDR RADIA (Raisonnement, Apprentissage, et Décision en Intelligence Artificielle) `https://gdr-radia.cnrs.fr/event/journees-annuelles-du-gdr/` July 2, 2023, Strasbourg, France;
  - GandALF 23 (14th International Symposium on Games, Automata, Logics, and Formal Verification) `http://gandalf23.uniud.it/` September 20, 2023, Udine, Italy;

6.1.4 Scientific Expertise

– Sophie Pinchinat: Trond Mohn Foundation Starting Grant Programme - Call 2023.

6.1.5 Research Administration

- Sophie Pinchinat was involved in two Comités de Sélection:
  - 27MCF334-335-336 at IRIF, Paris.
  - 27MCF1634 at École des Mines de Nancy/LORIA.

6.2 Teaching, supervision

6.2.1 Teaching

For researchers, all activities are given. For professors and assistant professors, only courses at the M. Sc. level are listed.

- Hervé Marchand: L1 Informatique et électronique: Découverte Informatique : 16h eq TD.
- Dylan Bellier: M1 École Normale Supérieure Rennes: Modélisation et Vérification Formelle par Automates : 24h eq TD.
- Dylan Bellier: L1 Informatique et électronique: Fondamentaux mathématiques : 42h eq TD.
- Dylan Bellier: L1 Informatique et électronique: Algorithmique 1 : 21h eq TD.
- Dylan Bellier: L3 Informatique et électronique: Logique : 36h eq TD.
- François Schwarzentruber: M1SIF ENS Rennes, Complexity theory, 24 eq TD

6.2.2 Supervision

- Florian Emmanuelle Epain (L3, Univ Rennes): Logic for Opacity - DES To Logic Formalization (Hervé Marchand & Sophie Pinchinat)
- C. Sharpe (≈ M1, Univ mount Allison, Canada): Inference Observability in Supervisory Control (Hervé Marchand & Laurie Ricker)
- Gaëtan Regaud (L3, ENS Rennes): Complexity analysis of some decision problems for Plan Logic (Dylan Bellier & Sophie Pinchinat)
- Fran cois Pierre (M1, Univ Rennes): Les liens entre la logique du premier ordre, les langages Star-free et les automates Counter-free (Sophie Pinchinat).
- Benjamin DE ZORDO (ESIR2), juin-août 2023: Projet BMDec (François Bodin)
- Yelli Coulibaly (ESIR2), juin-août 2023: Projet RUDI (Olivier Martineau)
- Gloria Merveille (ESIR2), juin-août 2023: Projet RUDI (Laurent Morin)
- Kone Mory (ESIR2), juin-septembre 2023: Projet RUDI (Laurent Morin)
- Yawa Germaine Renate Nyatsikor (ESIR2), juillet-septembre 2023: Projet BMDec (François Bodin)
- Victorien Desbois (PhD, ENS Rennes / NewLogUp, CIFRE), starting in December 2023: Multi-bjective optimization for the vehicule rescheduling problem (Ocan Sankur and François Schwarzentruber)

- Thibaut Le Marre (PhD, ENS Rennes, ANR epiRL), starting in September 2023: Imperfect information multi-agent learning: a deep reinforcement learning approach (Jilles Dibangoye, Ocan Sankur and François Schwarzentruber)
- PhD in progress:
  - Sophie Pinchinat supervises Dylan Bellier to explore logic-based mathematical settings to specify and handle dependencies of agent strategies in decision making systems.
  - Sophie Pinchinat co-supervises Alexandre Terefenko with Thomas Brihaye (Université de Mons, Belgium). This PhD is in "co-tutelle" between University of Rennes and University of Mons.

6.2.3 Juries

- Sophie Pinchinat was an examinor of the PhD committee of Mo Liu at LORIA, Nancy, France (defended on June 23, 2023).
- Sophie Pinchinat was an examinor of the PhD committee of Benjamin Bordais at Université Paris-Saclay, Nancy, France (defended on October 12, 2023

7 Bibliography

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Miscellaneous

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