2018-00718 - PhD : Deep Inference for Modal Logics

Level of qualifications required : Graduate degree or equivalent
Function : PhD Position

About the research centre or Inria department

Located at the heart of the main national research and higher education cluster, member of the Université Paris Saclay, a major actor in the French Investments for the Future Programme (Idex, LabEx, IRT, Equipex) and partner of the main establishment present on the plateau, the centre is particularly active in three major areas: data and knowledge; safety, security and reliability; modelling, simulation and optimisation (with priority given to energy).

The 450 researchers and engineers from Inria and its partners who work in the research centre's 31 teams, the 100 research support staff members, the high-level equipment at their disposal (image walls, high-performance computing clusters, sensor networks), and the privileged relationships with prestigious industrial partners, all make Inria Saclay Île-de-France a key research centre in the local landscape and one that is oriented towards Europe and the world.

Context

Modal logics are obtained from propositional logics by adding the modalities “Box” and “Diamond”, meaning necessity and possibility. Originally studied by philosophers in order to reason about knowledge and belief, modal logics have nowadays many applications in computer science. Well known examples are epistemic logics that allow to formally reason about the knowledge of independently acting and interacting agents, and temporal logics that allow to reason about temporal properties of processes. Another possible application is access control via authentication protocols. To formally reason about such protocols, we use authentication logics which are a special case of modal logics.

In the last 10 years, foundational research in proof theory has seen the development of a new paradigm, deep inference, which allow to rewrite formulas deep inside and not just along their main connective as it is done in sequent calculus or natural deduction. The two main deep inference formalisms are the calculus of structures and nested sequents. Recent research has shown that these are much better suited for treating modal logics than the traditional formalisms.

Assignment

For turning these theoretical application of modal logics into real world applications, we need a well developed proof theory, providing tools for proof normalization, proof search, and proof checking. Unfortunately, most proof theory developed for modal logics so far; only works for basic variants of classical modal logic. For example, temporal logics use modalities beyond the standard “Box” and “Diamond”, and authentication logics are based on constructive logic, which rejects the law of excluded middle: We cannot say anymore that a formula is either true or false; the logic allows for the case that we do not (yet) know. This is a surprising situation: whereas most proof theory developed for computer science is based on constructive logic and its relation to the lambda-calculus (in fact, all functional programming languages are based on that) the proof theory of constructive modal logic is embarrassingly underdeveloped.

Main activities

The work of the PhD student will consist in further pursuing this development and investigate the proof theory of various modal logics, classical and constructive, within the formalisms of nested sequents and the calculus of structures. This means not only studying the proof normalization of existing nested deductive systems for various modal logics, but also designing new nested deductive systems for logics which have not yet seen any proof system. New ways of presenting proofs can lead to new methods in proof search, which is one of the applications of proof theory that is explored by the Parsifal team. Consequently, the doctoral student might also provide prototype implementations of new proof search methods based on his or her theoretical results.

Skills

The successful candidate should be familiar with propositional and first-order logic, and should have working knowledge in at least one of the following: proof theory, model theory, graph theory.
Benefits package

- Subsidised catering service
- Partially-reimbursed public transport
- Social security
- Paid leave
- Flexible working hours
- Sports facilities

Remuneration

Gross monthly salary: 1982 euros (first and second year)

Gross monthly salary: 2085 euros (third year)