Charles Grellois' research activities

I have several research experiences, as my studies at ENS Cachan featured an internship every year.

My first contact with research was during Summer 2009, when I spent ten weeks in Turku University, supervised by Prof. Karhümaki. I worked on understanding the disproof by Kunc's of a Conway's conjecture, stating that the centralizers of regular languages should be regular as well. In fact, it turns out that even some finite languages have an undecidable centralizer. I restated the original proof, which used Minsky machines, in the framework on Turing machines, obtaining an estimation of the minimal size of a finite language with a non-recursively enumerable centralizer thanks to the existing work on minimal Turing machines. I later gained a better understanding of this astonishing result, by relating the definition of centralizers to the concept of coinduction.

In year 2010, I discovered during Dr. Paul-André Melliès' course at ENS that a bridge connecting verification and (game) semantics had been recently established by Prof. Ong. I started studying the subject as a project for the validation of his course, and I really enjoyed this result, which at the same time was a point of convergence of several fields, and appeared as the starting point of many new interesting and challenging questions. This led me to ask Prof. Ong for an internship, and I visited him for ten weeks during Summer 2010. At this occasion, I widened my understanding of the field, and wrote a Master thesis explaining and relating the two first proofs of Ong's decidability result for higher-order model-checking. I later translated in French and expanded this thesis to a full survey, which has been accepted after revision (which shall be finished soon) by the French journal « Technique et Science Informatiques ».

During the next academic year (2010-2011), I choosed to study a Master 2 in Pure Mathematics (I already had a Bachelor and a Master 1 in both Computer Science and Mathematics) before taking one of Computer Science, so that my five-month work during Summer 2011 was lesser related to Computer Science. I wrote a comprehensive survey, entitled « Algebraic theories, monads, and arities » (available on the arXiv), which was originally based on an article by Dr. Paul-André Melliès, « Segal condition meets computational effects ». The point was there is a duality between a certain class of monads, called finitary (monads on sets whose values on all sets can be recovered from their values on finite sets) and algebraic theories, a categorification by Lawvere of the usual presentations by generators and relations of universal algebras. Using categorical tools from algebraic topology, one can extend the idea of skeleton that is behind finitary monads in order to describe bigger theories. This has some repercussions in semantics, allowing to give an equational presentation of some computational monads for instance, but also in mathematics, as in higher-dimensional (categorical) algebra and operad theory for example – the monads being in this framework used to generate free n-dimensional algebraic structures.

In the academic year 2011-2012, I took a Master 2 of Computer Science and thus made a five-month internship at the PPS lab (University Paris 7), under the supervision of Dr. Paul-André Melliès. The goal was to work on a subject closer to Ong's decidability result, in a purely semantic way. We therefore studied the categorical semantics of recursion (e.g. Bloom and Esik's iteration theories), trying to extract from them a canonical formulation of game-semantics for recursive types – a difficult issue we are still looking to address today. We also studied Santocanale's circular proofs, which give type systems with recursion and parity conditions, and fixpoint extensions of linear logic by Baelde. This research experience was more of a preliminary work to my thesis than a short-term project. I wrote a report on the subject, compiling most of the result of this internship, which is available on my webpage – but written in French due to the requirements of the Master.

Right after this internship, in September 2012, I started my PhD, entitled « A semantic study of higher-order model-checking », advised by Dr. Paul-André Melliès (PPS), Dr. Olivier Serre

(LIAFA), Prof. Luke Ong (OUCL), the point of this multiple supervision being the convergent nature of the subject : Prof. Ong « built the bridge » with his first result, Dr. Melliès is an expert in semantics, and Dr. Serre, on the other bank, has a wide knowledge of the game-theoretic aspects of higher-order recursion schemes and of their MSO verification.

During the first year of my PhD thesis preparation, I mainly discovered the type-theoretic approach which led to a third proof, by Kobayashi and Ong, of Ong's decidability result. I formulated translations and equi-expressivity results between their type system and new type systems reflecting models of linear logic, after Terui's work on semantic evaluation and intersection types, and Bucciarelli and Ehrhard's work on indexed linear logic, which features a linear way to interpret intersection types. In this way, I gave faithful interpretations of the original system – and thus of the runs of alternating tree automata – in both qualitative and quantitative models of linear logic, the former being a finitary model, belonging to the realm of decidability, while the latter, in its infinitary nature, describes precisely the resource usage of the computation. A pending issue is to extend Ehrhard's extensional collapse to this framework, which would result in a precise relation between both interpretations.

I also gave a semantic interpretation of the runs of alternating automata (without parity condition so far) on trees produced by higher-order recursion schemes in a cartesian closed category obtained from the relational model of linear logic.

During the present year – the second of my PhD – I studied with Dr. Melliès the original type system by Kobayashi and Ong again, but in a different direction. We restated it into an equivalent infinitary type system, which allows us to interpret automata runs in tensorial logic – a variant of linear logic with an emphasis on continuations, and which reflects asynchronous game semantics.

We now look at several pending questions : the one of the extensional collapse enriched with a parity condition, the one of taking further the game-semantics interpretation of automata runs, and the one of obtaining a stand-alone proof of Ong's decidability result with our system, instead of relying on good enough translations to decidable systems.