GT ALGA – Annual Meeting 2016
Marseille, April 11th & 12th 2016
Aix-Marseille Université - Campus St Charles - Amphi Chavre

Monday	
10:00	Welcome
10:30	Béatrice Bérard (LIP6): *Verification of Polynomial Interrupt Timed Automata*
11:00	Daniel Stan (LSV): *Reachability in Networks of Register Protocols under a Fair Stochastic Scheduler*
11:30	**Keynote**: Stefan Göller (LSV): *Reachability of subclasses of (branching) vector addition systems*
12:30	Lunch
14:00	**Keynote**: Pierre Bourhis (CRIStAL): *Tree Automata for Reasoning in Databases and Artificial Intelligence*
15:00	Olivier Serre (IRIF): *Automata on Infinite Trees with Equality and Disequality Constraints Between Siblings*
15:30	Coffee break
16:00	Olivier Carton (IRIF, Université Paris Diderot): *Transfinite Lyndon Words*
16:30	Nathan Lhote (LaBRI): *Towards an Algebraic Theory of Rational Word Functions*
17:00	Nathanaël Fijalkow (University of Oxford): *The Theory of Regular Cost Functions At No Extra Cost*
17:30	Discussion
20:00	Dinner at restaurant *Les Arcenaulx*

Tuesday	
9:00	Antoine Durand-Gasselin (LIF): *Regular Transformations of Data Words Through Origin Information*
9:30	Laure Daviaud (LIP): *A Generalised Twinning Property for Minimisation of Cost Register Automata*
10:00	Félix Baschenis (LaBRI): *Ressource Minimization and One-Way Definability of Two-Way Transducers*
10:30	Coffee break
11:00	**Keynote**: Helmut Seidl (TU München): *Equivalence of Deterministic Top-Down Tree-to-String Transducers is Decidable*
12:00	Lunch
13:30	Denis Kuperberg (TU München): *Good-for-Games Automata*
14:00	Rodica Condurache (LACL): *The Complexity of Rational Synthesis*
14:30	Stéphane Le Roux (ULB): *Extending Finite Memory Determinacy*
15:00	Coffee break
15:30	Joanna Ochremiak (Universitat Politècnica de Catalunya): *Homomorphism Problems for First-Order Definable Structures*
16:00	Bastien Maubert (Università degli Studi di Napoli Federico II): *Relating Paths in Transition Systems: The Fall of the Modal mu-Calculus*
16:30	Florent Capelli (IMJ, Université Paris Diderot): *Compilation of CNF-formulas: New Algorithms and Lower Bounds*

Abstract

Félix Baschenis (LaBRI, Université de Bordeaux): *Ressource Minimization and One-Way Definability of Two-Way Transducers*

While adding to automata the possibility of their reading head to move freely from left to right and right to left does not change their expressive power, this is not the case for transducers. In this talk, we will present several models of transducers that are strictly more expressive than one way transducers, and study how to decide when a transduction defined by a two-way transducer with a bounded number of reversal (this class corresponds to what we call sweeping transducers) is definable by a one-way transducer. We will also see how the ressources of different models are related, in particular the number of reversals of some sweeping transducer and the number of variable of Alur's streaming string transducers. As we can use the one-way definability problem to minimize the number of reversals of two-way transducers, this yields to a procedure for the variable minimization of a large class of streaming string transducers.

Béatrice Bérard (LIP6, Université Pierre et Marie Curie): *Verification of Polynomial Interrupt Timed Automata*

Interrupt Timed Automata (ITA) form a subclass of stopwatch automata where reachability and some variants of timed model checking are decidable even in presence of parameters. They are well suited to model and analyze real-time operating systems. Here we extend ITA with polynomial guards and updates, leading to the class of polynomial ITA (PolITA). We prove that reachability is decidable in 2EXPTIME on PolITA, using an adaptation of the cylindrical algebraic decomposition algorithm for the first-order theory of reals. We also obtain decidability for the model checking of a timed version of CTL and for reachability in several extensions of PolITA. In particular, compared to previous approaches, our procedure handles parameters and clocks in a unified way. We also study expressiveness questions for PolITA and show that PolITA are incomparable with stopwatch automata.

Pierre Bourhis (CNRS, CRIStAL, Université de Lille): *Tree Automata for Reasoning in Databases and Artificial Intelligence*

In database management, one of the principal task is to optimize the queries to evaluate them efficiently. It is in particular the case for recursive queries for which their evaluation can lead to crawl all the database. In particular, one of the main question is to minimize the queries in order to avoid to evaluate useless parts of the query. The core theoretical question around this line of work is the problem of inclusion of a query in another. Interestedly, this question is related to an important question in IA which is to answer a query when the data is incomplete but rules are given to derive new information. This problem is called certain query answering. In both context, if both problem are undecidable in general, there are fragments based on guardedness that are decidable due to the fact there exists witness of the problems that have a bounded tree width and that their encoding in trees is regular. Furthermore, the queries can be translated in MSO. In both contexts, Courcelle's Theorems imply the decidability of both problems. I will present to the different results on the translation of logic class of formula for our problems into tree automata to obtain tight bounds to the problems of inclusion of recursive queries or certain query answering.

Florent Capelli (IMJ, Université Paris Diderot): *Compilation of CNF-formulas: New Algorithms and Lower Bounds*

Knowledge compilation aims to transform knowledge bases, often represented as CNF-formulas, into a (small) data structure that supports numerous queries in polynomial time such as model counting or enumeration. In this talk, we first present the main different form of data structure supporting interesting queries in polynomial times. We then present new algorithms that produce a small compiled version of a CNF-formula, if it meets some restrictions on the way its variables interact with its clauses. We then study the question of whether it is always possible to find (not necessarily in polynomial time) such polynomial size compiled form. By relating the communication complexity of boolean functions and the size of their compiled forms, we show how to leverage known lower bound from communication complexity to the framework of knowledge compilation. As a result, we get the first non-conditional separation of CNF-formulas and DNNF, one of the most general compilation language that still support decision and enumeration in polynomial time.

Olivier Carton (IRIF, Université Paris Diderot): *Transfinite Lyndon Words*

In this talk, we extend the notion of Lyndon word to transfinite words. We first recall the notion of Lyndon words for finite words and Duval's algorithm to compute the factorization of a given word in Lyndon words. Then, we present the extension to transfinite words and we describe an algorithm to compute the factorization of rational words.

Rodica Condurache (LACL, Université Paris-Est Créteil, Université libre de Bruxelles): *The Complexity of Rational Synthesis*

In this paper, we study the computational complexity of the cooperative and non-cooperative rational synthesis problems, as introduced by Kupferman, Vardi and coauthors in recent papers for general LTL objectives. From the previous papers we get that the cooperative and non-cooperative rational synthesis problems are 2ExpTime-complete for specifications expressed in linear temporal logic (LTL), thus matching exactly the complexity of classical zero-sum two-player LTL synthesis. We investigate these problems on multiplayer turn-based games played on graphs, and provide complexity results for the classical omega-regular objectives, namely reachability, Safety, Buchi, coBuchi, parity, Rabin, Streett and Muller objectives. Most of these complexity results are tight and shed light on how to solve those problems optimally. We also study the computational complexity of solving those

games when the number of players is fixed. This parametrized analysis makes sense as the number of components forming the environment may be limited in practical applications.
Joint work with Emmanuel Filiot, Raffaella Gentilini and Jean-François Raskin.

Laure Daviaud (LIP, ENS Lyon): *A Generalised Twinning Property for Minimisation of Cost Register Automata*

Weighted automata extend finite-state automata by associating with transitions weights from a semiring S, defining functions from words to S. Recently, cost register automata have been introduced as an alternative model to describe any function realised by a weighted automaton by means of a deterministic machine. Unambiguous weighted automata over a group G can equivalently be described by cost register automata whose registers take their values in G, and are updated by operations of the form x:=y.c, with c in G, and x,y registers. This class is denoted by CRA(G). In this talk, I will introduce a twinning property and a bounded variation property parametrised by an integer k, such that the corresponding notions introduced originally by Choffrut for finite-state transducers are obtained for k=1. Our main result links these notions with the register complexity of CRA(G). More precisely, we prove that given an unambiguous weighted automaton W over an infinitary group G realizing some function f, the three following properties are equivalent: i) W satisfies the twinning property of order k, ii) f satisfies the k-bounded variation property, iii) f can be described by a CRA(G) with at most k registers. Actually, this result is proved in a more general setting, considering machines over the semiring of finite sets of elements from G and is extended to prove a similar result for finite-valued finite-state transducers. Finally, the effectiveness of the constructions leads to decidability/complexity results about the register complexity (i.e. what is the minimal number of registers needed to compute a given function) of cost register automata.
This is a joint work with Pierre-Alain Reynier and Jean-Marc Talbot.

Antoine Durand-Gasselin (LIF): *Regular Transformations of Data Words Through Origin Information*

Regular language theory allows to verify qualitative properties over words. This theory provides many models (MSO logic, automata, monoids, regular expressions, etc). Rather than extending this regular language theory to cost functions (for quantitative analysis) we address a more ambitious problem and study word transformations. I will present a class of word transformations which admits a logical characterisation based on MSO, as well as two equivalent computational characterisations: the first one is based on an extension of two-way deterministic transducers, the second one on an extension of streaming string transducers. This class of transformations can be extended to data words which while still preserving this triple characterisation.
Joint work with Peter Habermehl.

Nathanaël Fijalkow (University of Oxford): *The Theory of Regular Cost Functions At No Extra Cost*

The theory of regular cost functions aims at constructing algorithms answering boundedness questions. It has been introduced by Colcombet and developed by several people for over ten years, allowing to reformulate and solve many problems from automata theory and logics. Along with its successes, the theory of regular cost functions suffers from one shortcoming: its combinatorially intricate proofs and constructions. This era is gone! We present one new simple idea, inspired by Mikołaj Bojańczyk, allowing to obtain most of the results without any extra effort.
Joint work with Thomas Colcombet.

Stefan Göller (CNRS, LSV, ENS Cachan): *Reachability of subclasses of (branching) vector addition systems*

I will survey some of the recent results on the reachability and coverability problem for subclasses of (branching) vector addition systems with states. The talk will include a PSPACE-completeness result for the reachability of two-dimensional vector addition systems with states, closing a doubly-exponential complexity gap and PTIME-completeness of the reachability problem for unary branching vector addition systems with states, hereby establishing a first decidability result for reachability of (a subclass of) branching vector addition systems.

Denis Kuperberg (Technische Universität München): *Good-for-Games Automata*

A nondeterministic automaton on infinite words is said to be Good-for-Games (GFG), if its nondeterminism can be resolved solely with knowledge about the prefix read so far, i.e. if there is no need to guess the future.
This formalism can be seen as a compromise between determinism and nondeterminism, and retain good properties of determinism such as sound composition with trees and games. This notion appeared independently in several contexts such as synthesis and quantitative models. In this work, we address the question of the state-space blow-up between deterministic automata and GFG ones, i.e. are GFG automata more succinct than deterministic ones ? It was conjectured by Colcombet than parity GFG automata always contain deterministic sub-automata for the same language, meaning that there is no state blow-up when determinizing GFG automata. We show that for Büchi condition, the blow-up is at most quadratic, while for coBüchi and general parity condition, GFG automata can be exponentially more succinct. We also study the complexity of deciding whether an input nondeterministic automaton is GFG. Surprisingly, in the coBüchi case, this can be done in PTime although it amounts to checking the existence of an object of exponential size (the strategy for resolving nondeterminism).
This is joint work with Michał Skrzypczak.

Stéphane Le Roux (Université libre de Bruxelles): *Extending Finite Memory Determinacy*

We show that under some general conditions the finite memory determinacy of a class of two-player win/lose games played on finite graphs implies the existence of a Nash equilibrium built from finite memory strategies for the corresponding class of multi-player multi-outcome games. This generalizes a previous result by Brihaye, De Pril and Schewe. For most of our conditions we

provide counterexamples showing that they cannot be dispensed with. Our proofs are generally constructive, that is, provide upper bounds for the memory required, as well as algorithms to compute the relevant winning strategies.
This is joint work with Arno Pauly.

Nathan Lhote (LaBRI, Université de Bordeaux): *Towards an Algebraic Theory of Rational Word Functions*

In formal language theory, several different models characterize regular languages, such as finite automata, congruences of finite index, or monadic second-order logic (MSO). Moreover, several fragments of MSO have effective characterizations based on algebraic properties. When we consider transducers instead of automata, such characterizations are much more challenging, because many of the properties of regular languages do not generalize to regular word functions. In this paper we consider word functions that are definable by one-way transducers (rational functions). We show that the canonical bimachine of Reutenauer and Schützenberger preserves certain algebraic properties of rational functions, similar to the case of word languages. In particular, we give an effective characterization of functions that can be defined by an aperiodic one-way transducer.

Bastien Maubert (Università degli Studi di Napoli Federico II): *Relating Paths in Transition Systems: The Fall of the Modal mu-Calculus*

We revisit Janin and Walukiewicz's classic result on the expressive completeness of the modal μ-calculus with respect to Monadic Second Order logic (MSO). This result, which states that every bisimilar-closed class of transition systems that is definable in MSO is also definable in the mu-calculus, contributed to establish the central role of the μ-calculus amongst logics of programs. We show that it no longer holds when we consider imperfect information. More precisely, we consider a general setting where finite paths in transition systems are linked by means of a fixed binary relation, that may represent an agent's observation of these paths. This setting gives rise to natural extensions of MSO and the μ-calculus, that we call MSO with paths relation and the jumping μ-calculus, the expressivities of which we aim at comparing. We exploit a natural "infinite-memory" binary relation arising from the setting of games with imperfect information and show that the existence of a winning strategy in such games, though expressible in the bisimilar-invariant fragment of MSO with paths relation, cannot be expressed in the jumping μ-calculus. This result crucially relies on the equivalence between the jumping μ-calculus and the recently introduced jumping automata.

Joanna Ochremiak (Universitat Politècnica de Catalunya): *Homomorphism Problems for First-Order Definable Structures*

First-order definable relational structures are usually infinite but can be finitely described. We study the homomorphism problem for such structures: given two first-order definable structures A and B, does there exist a homomorphism from A to B? We determine the decidability status of this problem depending on whether the signature or/and number of tuples in relations are allowed to be infinite.
Joint work with Bartek Klin, Eryk Kopczyński, Sławek Lasota and Szymon Toruńczyk.

Helmut Seidl (Technische Universität München): *Equivalence of Deterministic Top-Down Tree-to-String Transducers is Decidable*

Abstract: Top-down tree-to-string transducers recursively process their structured input data while producing output in an unstructured way, namely as a string. Let yDT denote the class of all deterministic top-down tree-to-string transducers. In the presentation, we show that equivalence of two such transducers is decidable - a problem which has been open for more than 30 years. As non-equivalence can be witnessed by an input on which the two transducers differ, decidability of equivalence follows if only an effective proof system can be provided for certifying equivalence whenever it holds. We indicate how such a proof system can be constructed using powerful techniques from commutative algebra. While in general not much is known about the complexity of the decision problem, we also present special cases where polynomial upper bounds can be obtained. [Joint work with Sebastian Maneth (Edinburgh) and Gregor Kemper (München).]

Olivier Serre (IRIF, Université Paris Diderot, CNRS): *Automata on Infinite Trees with Equality and Disequality Constraints Between Siblings*

This talk is inspired by two works from the early 90s. The first one is by Bogaert and Tison who considered a model of automata on finite ranked trees where one can check equality and disequality constraints between direct subtrees: they proved that this class of automata is closed under Boolean operations and that both the emptiness and the finiteness problem of the accepted language are decidable. The second one is by Niwinski who showed that one can compute the cardinality of any ω-regular language of infinite trees. Here, we generalise the model of automata of Tison and Bogaert to the setting of infinite binary trees. Roughly speaking we consider parity tree automata where some transitions are guarded and can be used only when the two direct sub-trees of the current node are equal/disequal. We show that the resulting class of languages encompasses the one of ω-regular languages of infinite trees while sharing most of its closure properties, in particular it is a Boolean algebra. Our main technical contribution is then to prove that it also enjoys decidable emptiness and finiteness problems.
Joint work with Arnaud Carayol & Christof Löding.