Third Cassting Meeting
Brussels (Belgium), 21st & 22nd May 2014

Programme of the meeting

Wednesday - Solvay Room NO5	
10:30	Welcome
11:00	Aaron Bohy (UMONS): Symblicit algorithms for optimal strategy synthesis in monotonic Markov decision processes
11:45	Thomas Brihaye (UMONS): Deciding the value 1 problem in 1-clock Decision Stochastic Timed Automata
12:30	Lunch
13:45	Benjamin Monmege (ULB): Priced timed games with negative costs
14:30	Kim Larsen (AAU): On Time with Minimal Expected Cost!
15:15	Coffee break
15:30	Noémie Meunier (UMONS): Secure equilibria in weighted games
16:15	Gilles Geeraerts (ULB): Reachability priced games
17:00	Preparation of the review meeting

Thursday - Morning: Solvay Room NO5, Afternoon: Forum F	
9:00	Mathias Grund Sørensen (AAU): Controller Synthesis for Home Automation
9:45	Namit Chaturvedi (RWTH): Classifying infinite behavior of distributed systems – New results on Ω-languages of Mazurkiewicz traces
10:30	Coffee break
10:45	Christof Löding (RWTH): Guaranteeing Stability and Delay in Dynamic Networks based on Infinite Games
11:30	Simon Laursen (AAU): Synchronization under Partial Observability
12:15	Lunch
13:30	Laurent Doyen (LSV): Games with a Weak Adversary
14:15	Piotr Hofman (University of Bayreuth): Infinite-state energy games
15:00	Dietmar Berwanger (LSV): Games with Recurring Certainty
16:00	Board Meeting

Abstract

Aaron Bohy (UMONS): Symblicit algorithms for optimal strategy synthesis in monotonic Markov decision processes

When treating Markov decision processes (MDPs) with large state spaces, using explicit representations quickly becomes unfeasible. Lately, Wimmer et al. have proposed a so-called symblicit algorithm for the synthesis of optimal strategies in MDPs, in the quantitative setting of expected mean-payoff. This algorithm, based on the strategy iteration algorithm of Howard and Veinott, efficiently combines symbolic and explicit data structures, and uses binary decision diagrams as symbolic representation. The aim of this paper is to show that the new data structure of pseudo-antichains (an extension of antichains) provides another interesting alternative, especially for the class of monotonic MDPs. We design efficient pseudo-antichain based symblicit algorithms (with open source implementations) for two quantitative settings: the expected mean-payoff and the stochastic shortest path. For two practical applications coming from automated planning and LTL synthesis, we report promising experimental results w.r.t. both the run time and the memory consumption.

Thomas Brihaye (UMONS): Deciding the value 1 problem in 1-clock Decision Stochastic Timed Automata

We consider reachability objectives on an extension of stochastic timed automata with nondeterminism. Decision stochastic timed automata (DSTA) are a model where delays are random and choices between enabled edges are left to the player. Given a reachability objective, the value 1 problem asks whether a target can be reached with probability arbitrary close to 1. In this paper, we prove that the value 1 problem is decidable for single clock DSTA by a non-trivial adaptation of the decision procedure for almost-sure reachability in finite Markov decision processes (MDP). The epsilon-optimal strategies are involved: although the precise probability distributions do not change the winning nature of a state, they impact in a crucial way the timings at which epsilon-optimal strategies change their decisions. DSTA thus form one of the rare models for which the value 1 problem is shown decidable and yet does not coincide with the almost-sure problem.
This is a joint work with Nathalie Bertrand and Blaise Genest.

Benjamin Monmege (ULB): Priced timed games with negative costs

Priced timed games (PTGs) are two-player zero-sum games played on the infinite graph of configurations of priced timed automata where two players take turns to choose transitions in order to optimize cost to reach target states. Bouyer et al. and Alur, Bernadsky, and Madhusudan independently proposed algorithms to solve PTGs with non-negative prices under certain divergence restriction over prices. Brihaye, Bruyère, and Raskin later provided a justification for such a restriction by showing the undecidability of the optimal strategy synthesis problem in the absence of this divergence restriction. This problem for PTGs with one clock has long been conjectured to be in polynomial time, however the current best known algorithm, by Hansen, Ibsen-Jensen, and Miltersen, is exponential. We extend this picture by studying PTGs with both negative and positive prices. We refine the undecidability results for optimal strategy synthesis problem, and show undecidability for several variants of optimal reachability cost objectives including reachability cost, time-bounded reachability cost, and repeated reachability cost objectives. We also identify a subclass with bi-valued price-rates and give a pseudo-polynomial (polynomial when prices are nonnegative) algorithm to partially answer the conjecture on the complexity of one-clock PTGs.
This is a joint work with Thomas Brihaye, Gilles Geeraerts, Shankara Narayanan Krishna, Lakshmi Manasa and Ashutosh Trivedi.

Kim Larsen (AAU): On Time with Minimal Expected Cost!

(Priced) timed games are two-player quantitative games involving an adversary (modeling the environment) which is assumed to be completely antagonistic. Classical analysis consists in the synthesis of strategies ensuring safety, time-bounded or cost-bounded reachability objectives. Assuming a randomized environment —with delays being resolved stochastically—the (priced) timed game essentially defines an infinite-state Markov (reward) decision process. In this setting the objective is to find a strategy that will minimize the expected reachability cost, but with no guarantees on worst-case behaviour. In this talk, we describe methods for synthesizing reachability strategies that subject to guaranteeing a given worst case time-bound, will provide (near-) minimal expected reachability cost. Our method combines synthesis of most permissive strategies time-bounded reachability objectives with suitable adapted reinforcement learning techniques. The resulting method is implemented as a new branch of UPPAAL demonstrating several orders of magnitude improvements with respect to previously automated synthesis methods.

Noémie Meunier (UMONS): Secure equilibria in weighted games

We consider two-player non zero-sum infinite duration games played on weighted graphs. We extend the notion of secure equilibrium introduced by Chatterjee et al., from the Boolean setting to this quantitative setting. As for the Boolean setting, our notion of secure equilibrium refines the classical notion of Nash equilibrium. We prove that secure equilibria always exist in a large class of weighted games which includes common measures like sup, inf, lim sup, lim inf, mean-payoff, and discounted sum. Moreover we show that one can synthesize such strategy profiles that are finite-memory and use few memory. We also prove that the constrained existence problem for secure equilibria is decidable for sup, inf, lim sup, lim inf and mean-payoff measures. Our solutions rely on new results for zero-sum quantitative games with lexicographic objectives that are interesting on their own right.

Gilles Geeraerts (ULB): Reachability priced games

Reachability-cost games are two-player zero-sum games played on directed graphs with weights on edges, where two players take turns to choose transitions in order to optimize the total cost to reach a target set of vertices. More precisely, Player 1 wants to reach the target by minimizing its cost, whereas Player 2 wants to avoid the target, or, if not possible, maximize the cost of Player 1. When weights of edges are non-negative, polynomial algorithms are known in order to compute optimal values as well as optimal strategies for both players, see, e.g., an adaptation of Dijkstra's shortest path algorithm by Khachiyan et al. Moreover, both players are known to have optimal memoryless strategies. The case where weights can be any integer is more complex, especially in the presence of negative cycles. Filiot, Gentilini and Raskin prove that deciding whether the value of such a game is positive can be done in NP $\cap$ co-NP, by using methods similar to the one used for mean-payoff games: this holds even though optimal strategies may require memory, contrary to the nonnegative case. Our contribution is threefold. First, we present a value iteration algorithm to compute the optimal values, as well as optimal strategies for both players when they exist. This iterative algorithm has a pseudo-polynomial complexity (i.e., polynomial if weights of edges are encoded in unary). We also show that Player 2 always has optimal memoryless strategies and that a memory of size pseudo-polynomial is sufficient (and sometimes necessary) for Player 1. Finally, we show that deciding whether the value of the game is $-\infty$ (that is Player 1 has a family of strategies to secure a cost as small as possible) is as hard as solving mean-payoff games.
This is a joint work with Thomas Brihaye and Benjamin Monmege.

Mathias Grund Sørensen (AAU): Controller Synthesis for Home Automation

A large remaining challenge in Home Automation is the construction of control programs to dictate behavior in a Home Automation setup and to exploit inter-device information exchange. The design of such a control program is a technically challenging task which is commonly left for the (unaided) end-user. To address this, we present an approach to construct control programs from a high-level specification of desired system behavior using game theory. We provide a complete toolchain based on the HomePort platform and using UPPAAL TiGa for control strategy synthesis. The toolchain is implemented on a Raspberry Pi as a completely automated process from behavior specification in a simple web-interface to an effectuated control program.

Namit Chaturvedi (RWTH): Classifying infinite behavior of distributed systems – New results on Ω-languages of Mazurkiewicz traces

The family of regular languages of infinite words is structured into a hierarchy where each level is characterized by a class of deterministic Ω-automata—the class of deterministic Büchi automata being the most prominent among them. In this paper, we analyze the situation of regular languages of infinite Mazurkiewicz traces that model non-terminating, concurrent behaviors of distributed systems. Here, a corresponding classification is still missing. We introduce the model of "synchronization-aware asynchronous automata", which allows us to initiate a classification of regular infinitary trace languages in a form that is in nice correspondence to the case of Ω-regular word languages.

Christof Löding (RWTH): Guaranteeing Stability and Delay in Dynamic Networks based on Infinite Games

We study stability and delay in dynamic networks under adversarial conditions. The networks that we consider have a fixed set of nodes but the capacity of the links varies and is controlled by an adversary, subject to some constraints. We use two-player games to analyse such networks, and obtain a characterization of networks for which there is a routing algorithms keeping the number of packets in the network bounded. We also determine conditions under which a delay bound for packet forwarding under these adversarial conditions exists.

Simon Laursen (AAU): Synchronization under Partial Observability

Embedded devices usually share only partial information about their current configurations as the communication bandwidth can be restricted. Despite this, we may wish to bring a failed device into a given predetermined configuration. This problem, also know as resetting or synchronizing words, has been intensively studied for systems that do not provide any information about their configurations. In order to capture more general scenarios, we extend the existing theory of synchronizing words to synchronizing strategies, and study the synchronization, short-synchronization and subset-to-subset synchronization problems under partial observability. We provide a comprehensive complexity analysis of these problems, concluding that for deterministic systems the complexity of the problems under partial observability remains the same as for the classical synchronization problems, whereas for nondeterministic systems the complexity increases already for systems with just two observations, as we can now encode alternation.

Laurent Doyen (LSV): Games with a Weak Adversary

We consider multi-player graph games with partial observation and parity objective. While the decision problem for three-player games with a coalition of the first and second players against the third player is undecidable in general, we present a decidability result for partial-observation games where the first and third player are in a coalition against the second player, thus where the second player is adversarial but weaker due to partial observation. We establish tight complexity bounds in the case where player 1 is less informed than player 2, namely 2-EXPTIME-completeness for parity objectives. The symmetric case of player 1 more informed than player 2 is much more complicated, and we show that already in the case where player 1 has perfect observation, memory of size non-elementary is necessary in general for reachability objectives, and the problem is decidable for reachability and safety objectives.

Piotr Hofman (University of Bayreuth): Infinite-state energy games

Energy games are a well-studied class of 2-player turn based games on a finite graph where transitions are labelled with integer vectors which represent changes in a multidimensional resource (the energy). One player tries to keep the cumulative changes non-negative in every component while the other tries to frustrate this. We consider a generalization of energy games by replacing the finite game graph with an infinite game graph derived from a pushdown automaton (modelling recursion) or its subclass of a one-counter machine. Our main technical result is that energy games are decidable in the case where the game graph is induced by a one-counter machine and the energy is one-dimensional. However during the talk we will focus on different aspect, namely on inter-reducibility between energy games and simulation games. This not complicated result is intriguing, due to a fact that it gives a new way of seeing energy games.

Dietmar Berwanger (LSV): Games with Recurring Certainty

Infinite games where several players need to coordinate under imperfect information are known to be intractable. One typical feature of hard instances is that the players become uncertain about the current state of the game, and this uncertainty lasts forever. In contrast, we consider finite-state games where the players can deduce the current state over and over again, however the play proceeds. For such games with recurrent certainty, we note that they satisfy a stronger condition, of periodic certainty: the intervals where players may not know the state of the game are uniformly bounded. We show that it is decidable whether a given game presents recurring certainty and that, if so, the synthesis problem for coordination strategies under Ω-regular winning conditions is solvable.