Fourth Cassting Meeting, Aachen

30th and 31st October 2014

Talks on Thursday, 30.10.2014

1. 11:30 - 12:15: *Laurent Fribourg* (LSV) and Romain Soulat (LSV)
   Control of switching systems by invariance analysis: application to power electronics

   Switched systems are embedded devices widespread in industrial applications such as power electronics and automotive control. They consist of continuous-time dynamical subsystems and a rule that controls the switching between them. Under a suitable control rule, the system can improve its steady-state performance and meet essential properties, such as safety and stability, in desirable operating zones. We explain in this talk that such controller synthesis problems are related to the construction of appropriate invariants of the state space, which approximate the limit sets of the system trajectories. We present several approaches of invariant construction based on techniques of state space decomposition and backward/forward fixed-point computation. All these approaches will be illustrated in a number of case studies, mainly taken from the field of power electronics.

2. 12:15 - 13:00: *Benjamin Monmege* (ULB) and Serge Haddad (LSV)
   Reachability in MDPs: Refining Convergence of Value Iteration

   Markov Decision Processes (MDP) are a widely used model including both non-deterministic and probabilistic choices. Minimal and maximal probabilities to reach a target set of states, with respect to a policy resolving non-determinism, may be computed by several methods including value iteration. This algorithm, easy to implement and efficient in terms of space complexity, consists in iteratively finding the probabilities of paths of increasing length. However, it raises three issues: (1) defining a stopping criterion ensuring a bound on the approximation, (2) analyzing the rate of convergence, and (3) specifying an additional procedure to obtain the exact values once a sufficient number of iterations has been performed. The first two issues are still open and for the third one a “crude” upper bound on the number of iterations has been proposed. Based on a graph analysis and transformation of MDPs, we address these problems. First we introduce an interval iteration algorithm, for which the stopping criterion is straightforward. Then we exhibit convergence rate. Finally we significantly improve the bound on the number of iterations required to get the exact values.

13:00 - 14:30: Lunch

3. 14:30 - 15:30: *Jiri Srba* (AAU)
   Soundness of Timed-Arc Workflow Nets

   Analysis of workflow processes with quantitative aspects like timing is of interest in numerous time-critical applications. We suggest a workflow model based on timed-arc Petri nets and study

the foundational problems of soundness and strong (time-bounded) soundness. We explore the decidability of these problems and show, among others, that soundness is decidable for monotonic workflow nets while reachability is undecidable. For general timed-arc workflow nets soundness and strong soundness become undecidable, though we can design efficient verification algorithms for the subclass of bounded nets.

Finally, we demonstrate the usability of our theory on the case studies of a Brake System Control Unit used in aircraft certification, the MPEG2 encoding algorithm, and a blood transfusion workflow. The implementation of the algorithms is freely available as a part of the model checker TAPAAL.

15:30 - 15:45: Coffee

4. 15:45 - 16:30: *Jakob Haahr Taankvist* (AAU)
   UPPAAL Stratego

   The tool Uppaal Stratego is a novel tool that allows to generate, optimize, compare and explore consequences and performance of strategies synthesized for stochastic priced timed games in a user-friendly manner. In particular, the tool allows for efficient and flexible "strategy-space" exploration before adaptation in a final implementation.

5. 16:30 - 17:15: *Namit Chaturvedi* (RWTH) and Marcus Gelderie (RWTH)
   Classifying regular infinitary trace languages using word automata

   We address the problem of providing a Borel-like classification of languages of infinite Mazurkiewicz traces, and provide a solution in the framework of omega-automata over infinite words - which is invoked via the sets of linearizations of infinitary trace languages. We identify trace languages whose linearizations are recognized by deterministic weak or deterministic Buechi (word) automata. We present a characterization of the class of linearizations of all omega-regular trace languages in terms of Muller (word) automata. Finally, we show that the linearization of any omega-regular trace language can be expressed as a Boolean combination of languages recognized by our class of deterministic Buechi automata.

17:15 - 17:30: Coffee

17:30 - 18:30: Governing Board Meeting

19:30 - late: Dinner at Restaurant La Finestra

Talks on Friday, 31.10.2014

6. 09:00 - 09:45: *Amit Kumar Dhar* (ULB)
   Equivalence between Model-checking Flat Counter Systems and Presburger Arithmetic

   We show that model-checking flat counter systems over CTL* (with arithmetical constraints on counter values) has the same complexity as the satisfiability problem for Presburger arithmetic. The lower bound already holds with the temporal operator EF only, no arithmetical constraints in the logical language and with guards on transitions made of simple linear constraints. This complements our understanding of model-checking flat counter systems with linear-time temporal logics, such as LTL for which the problem is already known to be (only) NP-complete with guards restricted to the linear fragment.

7. 09:45 - 10:30: *Peter G. Jensen* (AAU)
   Memory Efficient Data Structures for Explicit Verification of Timed Systems

   Timed analysis of real-time systems can be performed using continuous (symbolic) or discrete (explicit) techniques. The explicit state-space exploration can be considerably faster for models with moderately small constants, however, at the expense of high memory consumption. In the setting of timed-arc Petri nets, we explore new data structures for lowering the used memory: PTries for efficient storing of configurations and time darts for semi-symbolic description of the state-space. Both methods are implemented as a part of the tool TAPAAL and the experiments document at least one order of magnitude of memory savings while preserving comparable verification times.

10:30 - 10:45: Coffee

8. 10:45 - 11:30: *Axel Haddad* (UMONS), Thomas Brihaye (UMONS), Gilles Geeraerts (ULB), and Benjamin Monmege (ULB)
   To Reach or not to Reach? Efficient Algorithms for Total-Payoff Games

   Quantitative games are two-player zero-sum games played on directed weighted graphs. We consider variants of usual payoff functions: total-payoff, mean-payoff, discounted-payoff, where we add a reachability objective, i.e., Player 1 wants to reach a target while minimising his payoff. In the case of reachability total-payoff, we have introduced an efficient value iteration algorithm to compute the values and optimal strategies (when they exist), that runs in pseudo-polynomial time. This contribution allows us to derive the first (to our knowledge) value iteration algorithm for classical total-payoff games, running in pseudo-polynomial time, that will be the main focus of this talk.

9. 11:30 - 12:15: *Gabriel Renault* (UMONS)
   About misère dicot games

   Combinatorial games are finite two-player games with complete information and no-chance. Under the normal convention, a player loses when they have no available move, whereas that player wins under the misère convention. The misère version of a combinatorial game is in general a harder problem than its normal version. We thus restrict ourselves to a simpler set of games, called dicot games, give them a canonical form and prove that invertible elements have a natural inverse.

12:15 - 13:45: Lunch

10. 13:45 - 14:30: *Samy Alexandre Jaziri* (LSV)
    Robustness and optimization in weighted timed games

    Weighted timed games are a convenient framework to model both interactions between several components, and quantitative aspects. It is known that the existence of an optimal strategy in those games is undecidable. In a first part, we study the value problem for those games, and prove that it also is undecidable. Surprisingly, this was not known, and the proof is rather difficult and (re)uses a diagonal argument. In a second part, we extend weighted timed games with imprecision on the value of the costs, with the objective of recovering decidability. We present our first results on the topic, which unfortunately are negative, and then propose some directions for future work.

11. 14:30 - 15:15: *Erwin Fang* (RWTH), Patricia Bouyer (LSV), Nicolas Markey (LSV) and Wolfgang Thomas (RWTH)
    Quantitative synthesis of permissive strategies in real-time systems

    We consider real-time systems that continuously interact with its environment. As a consequence, automatically reasoning about these systems becomes notoriously difficult.

    Since the environment is usually of unpredictable nature, it is of utmost significance to correctly build such systems that are robust to timing perturbations. Therefore, we present a synthesis approach modeled as a two-player game on timed automata, where the goal is to compute the most permissive strategy with respect to timing imprecisions that fulfills a certain goal (winning condition). Decidability and complexity results will be discussed for several settings.