# Index appearance record for transforming Rabin automata into parity automata

Jan Křetínský, Tobias Meggendorfer, Clara Waldmann, and Maximilian Weininger

Technical University of Munich

Constructing correct-by-design systems from specifications given in linear temporal logic (LTL) is a classical problem [PR89], called *LTL synthesis*. The automata-theoretic solution to this problem is to translate the LTL formula to a deterministic automaton and solve the corresponding game on the automaton. Although different kinds of automata can be used, a reasonable choice is parity automata (DPA) due to the practical efficiency of parity game solvers [FL09,ML16] and the fact they allow for optimal memoryless strategies. Thus, the bottleneck of the automata-theoretic approach is to create a reasonably small DPA.

The classical way to transform LTL formulae into DPA is to first create a nondeterministic Büchi automaton (NBA) and then determinize it, as implemented in e.g. `ltl2dstar` [KB06]. Since determinization procedures [Pit06,Sch09] based on Safra's construction [Saf88] are inefficient in practice, many alternative approaches to LTL synthesis arose. For example, some try to avoid determinization and/or focus on fragments of LTL, e.g. [KV05,PPS06,AL04].

Fortunately, new results on translating LTL directly and efficiently into deterministic automata [KE12,EK14] have been discovered recently. This opens new possibilities for the automata-theoretic approach. Indeed, tools such as Rabinizer [KK14] or LTL3DRA [BBKS13] can produce reasonably small deterministic Rabin automata (DRA) for complex formulae. Consequently, the task is to efficiently transform DRA into DPA, which is the aim of this paper.

Various kinds of deterministic automata can be transformed into deterministic parity automata by using variants of the traditional appearance-record construction. This construction intuitively introduces finite memory of recent, important events into the state space, which allows to formulate the acceptance condition. We present an efficient variant of this approach, specifically tailored to Rabin automata. Further, we introduce several optimizations applicable to all appearance records.

Experimental evaluation suggests an inherent advantage over exiting approaches solving the DRA to DPA translation. Moreover, the experiments demonstrate the potential of our method for LTL synthesis when combined with LTL-to-Rabin translators like Rabinizer. Especially, our "toolchain" leads to significantly smaller parity automata when compared to state-of-the-art approaches on various formulae.

This work has been presented at TACAS 2017.

## References


AL04. Rajeev Alur and Salvatore La Torre. Deterministic generators and games for LTL fragments. *ACM Trans. Comput. Log.*, 5(1):1–25, 2004.

BBKS13. Tomás Babiak, Frantisek Blahoudek, Mojmír Kretínský, and Jan Strejcek. Effective translation of LTL to deterministic Rabin automata: Beyond the (F, G)-fragment. In Dang Van Hung and Mizuhito Ogawa, editors, *ATVA*, volume 8172 of *LNCS*, pages 24–39. Springer, 2013.

EK14. Javier Esparza and Jan Křetínský. From LTL to deterministic automata: A safraless compositional approach. In *CAV*, pages 192–208, 2014.

FL09. Oliver Friedmann and Martin Lange. Solving parity games in practice. In *ATVA*, pages 182–196, 2009.

KB06. Joachim Klein and Christel Baier. Experiments with deterministic $\omega$-automata for formulas of linear temporal logic. *Theoretical Computer Science*, 363(2):182–195, 2006.

KE12. Jan Křetínský and Javier Esparza. Deterministic automata for the (F, G)-fragment of LTL. In *CAV*, pages 7–22, 2012.

KK14. Zuzana Komárková and Jan Křetínský. Rabinizer 3: Safraless translation of LTL to small deterministic automata. In *ATVA*, pages 235–241, 2014.

KV05. Orna Kupferman and Moshe Y. Vardi. Safraless decision procedures. In *FOCS*, pages 531–542, 2005.

ML16. Philipp J. Meyer and Michael Luttenberger. Solving mean-payoff games on the GPU. In *ATVA*, 2016. To appear.

Pit06. Nir Piterman. From nondeterministic Buchi and Streett automata to deterministic parity automata. In *LICS*, pages 255–264, 2006.

PPS06. Nir Piterman, Amir Pnueli, and Yaniv Sa'ar. Synthesis of reactive(1) designs. In *VMCAI*, pages 364–380, 2006.

PR89. Amir Pnueli and Roni Rosner. On the synthesis of a reactive module. In *POPL*, pages 179–190, 1989.

Saf88. Shmuel Safra. On the complexity of omega-automata. In *FOCS*, pages 319–327, 1988.

Sch09. Sven Schewe. Tighter bounds for the determinisation of Büchi automata. In *FOSSACS*, pages 167–181, 2009.