Real-time Model Checking: Algorithms and Complexity

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Abstract

In this talk we describe a new automata-theoretic approach to model checking real-time systems. We show how this approach yields both upper and lower complexity bounds for various decision problems involving timed automata and temporal logics. To put these developments in context we survey some classical results concerning automata, temporal logic and monadic predicate logic over the reals.

This talk is about the fundamentals of model checking timed systems, focusing mainly on algorithmic and complexity-theoretic issues. The questions we consider are posed within the framework of *timed automata* and *metric temporal logic* introduced and developed by Alur, Courcoubetis, Dill, Henzinger, Koymans, Manna and Pnueli [2, 3, 4, 7, 8], among many others. To set these questions in context we describe some of the classical results about the complexity of decision procedures for automata, temporal logic and predicate logic over the reals, going all the way back to the results of Shelah [9] and Burges and Gurevich [5] on the first and second-order monadic logic of order over the reals.

The main subject of our talk concerns a novel automata-theoretic approach to model checking real-time systems. In general, the automata-theoretic approach to verification reduces questions about systems and their specifications to decision problems about automata. Expressing verification problems as questions about automata provides an appropriate framework to tackle the essential combinatorial difficulties. Here we study algorithmic and complexity theoretic problems for timed automata and metric temporal logics by reducing them to questions about *channel machines*—finite state automata equipped with unbounded buffers or queues. Depending on the problem at hand we study various classes of channel machines, including alternating channel machines, cycle-bounded channel machines, channel machines with insertion errors, and fair channel machines. Although discrete, these devices are intrinsically infinite-state and their algorithmic analysis requires non-trivial symbolic and graph-theoretic techniques, including techniques from regular model checking [1] and well-structured transition systems [6]. The translation from timed automata and metric temporal logics to channel machines generalises the *clock regions* abstraction [3] that underlies many of the classical results in real-time model checking.

References

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DOI 10.1109/TIME.2008.30