

Universality for Timed Automata with Minimal Resources

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Joint work with Joël Ouaknine and James Worrell

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Overview

- 1 Motivation
- 2 Timed Automata
- 3 Universality Problem
 - Known results
 - Our main result
 - Structure of the proof

Motivation

Verification of real-time systems

Essential role of language inclusion
e.g. “Implementation \subseteq Specification”

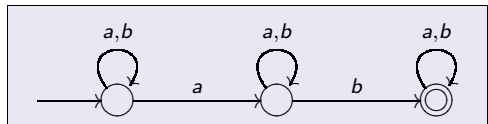
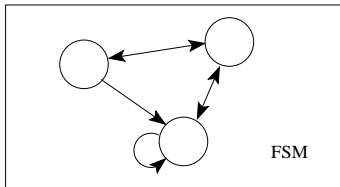
Special case of language inclusion

U : set of all timed words

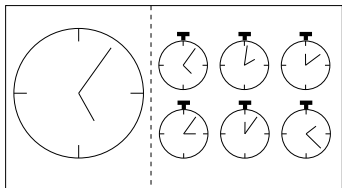
$U \subseteq L \Rightarrow U = L$ and L is universal

Universality undecidable \Rightarrow language inclusion undecidable

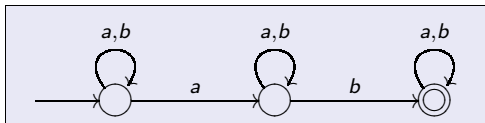
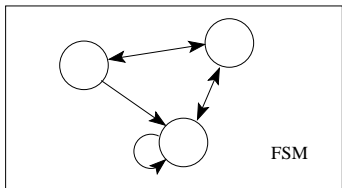
Concept of a timed automaton



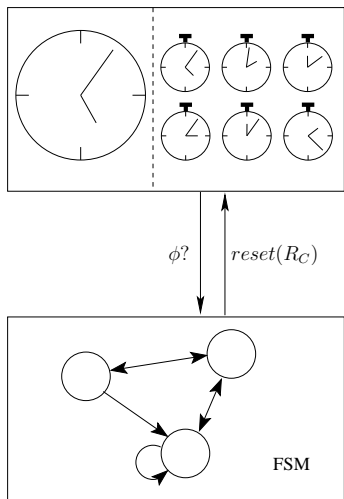
Concept of a timed automaton



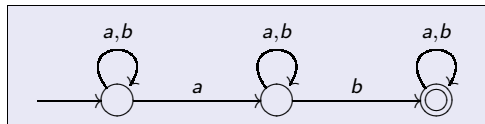
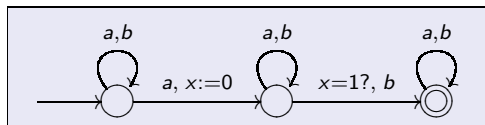
Clock x



Concept of a timed automaton



Clock x



Universality Problem

Does a given automaton accept every timed word?

Alur and Dill, 1994 [1]

Universality is undecidable for timed automata with two clocks.

Ouaknine and Worrell, 2004 [2]

Universality is decidable for:

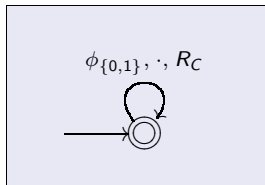
timed automata with one clock;

timed automata with comparisons to 0 only.

Main result

Adams, Ouaknine, Worrell, 2006

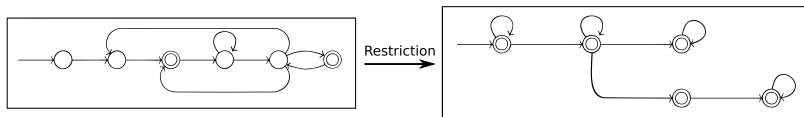
Universality is undecidable for timed automata
with one state, one event and comparisons to 0 and 1 only.



No restriction on the number of clocks

Else: only finitely many timed automata left - trivially decidable

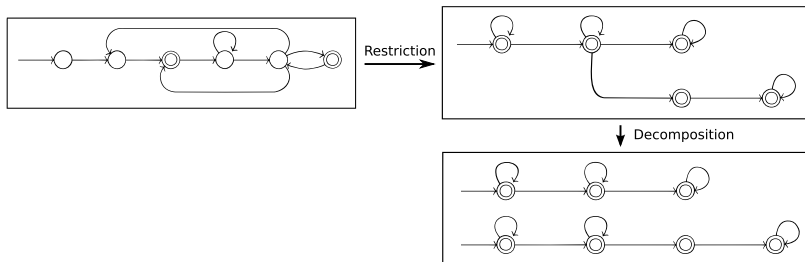
Structure of the proof



Basic steps

1. Universality for Flat Timed Automata

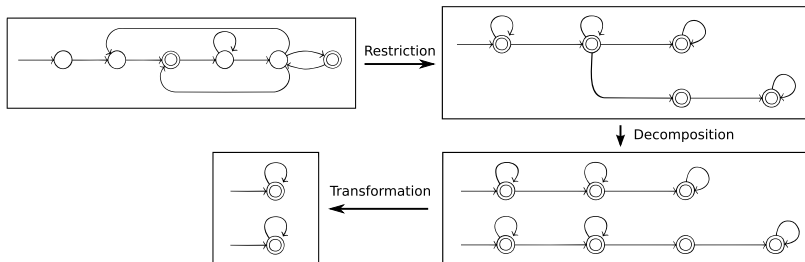
Structure of the proof



Basic steps

1. Universality for Flat Timed Automata
2. Decomposition of Flat Timed Automata

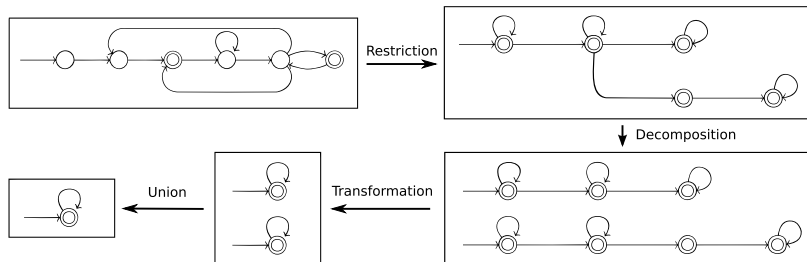
Structure of the proof



Basic steps

1. Universality for Flat Timed Automata
2. Decomposition of Flat Timed Automata
3. Transformation of Linear Flat Timed Automata

Structure of the proof



Basic steps

1. Universality for Flat Timed Automata
2. Decomposition of Flat Timed Automata
3. Transformation of Linear Flat Timed Automata
4. Union of transformed automata

Details

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- [1] Rajeev Alur and David L. Dill, *A Theory of Timed Automata*, Theoretical Computer Science 126-2, 1994
- [2] Joël Ouaknine and James Worrell, *On the Language Inclusion Problem for Timed Automata: Closing a Decidability Gap*, Logic in Computer Science, 2004