Two-Automaton Accepting Run Search in Spot

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Introduction

The model checking toolchain

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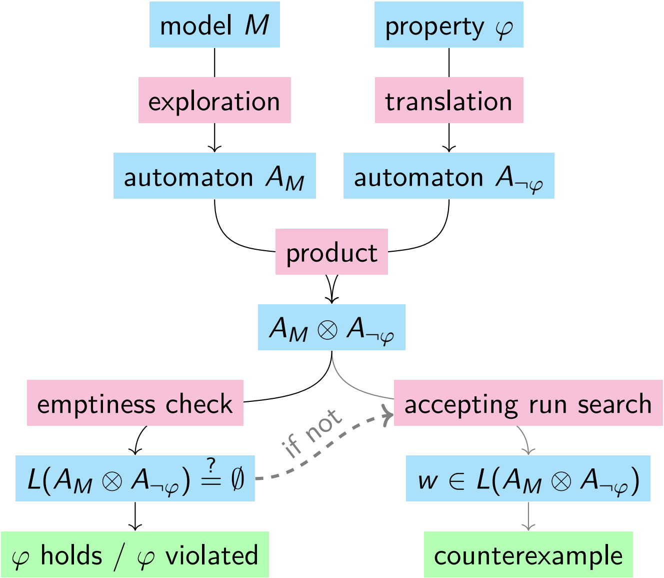
The Model Checking Toolchain



The Spot library

Spot 2

- "Spot 2.0 — a framework for LTL and ω-automata manipulation" [4]
- C++ library
- algorithms, bridges for model checking
- executables for testing and comparing
  - `ltlcross`, `autcross`: language equivalence

The problem

The Problem

```
info: check_empty P1*N0
info: check_empty P1*N1
info: building Comp(N1)*Comp(P1) requires more acceptance sets than supported
info: building state-space #0/1 of 200 states with seed 0
info: state-space has 4225 edges
```

- ω-automata in Spot cannot have more than fixed number of acceptance sets (32 by default)
- acceptance sets sizes add-up during product

Operands may be expressed but not the product

Last Year's Work

Two-automaton emptiness check:

- Two-automaton emptiness check in Spot [5]
- Simulate a product on-the-fly
- Based on Couvreur's on-the-fly emptiness check algorithm [2]
- Optimisations on automata strength and API

No accepting run search, we cannot use it to look for a counterexample.

What we need to build

What We Need To Build

Pumping lemma: infinite word, but finite automata

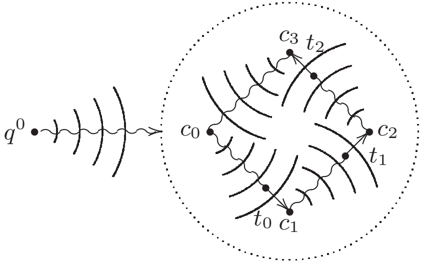
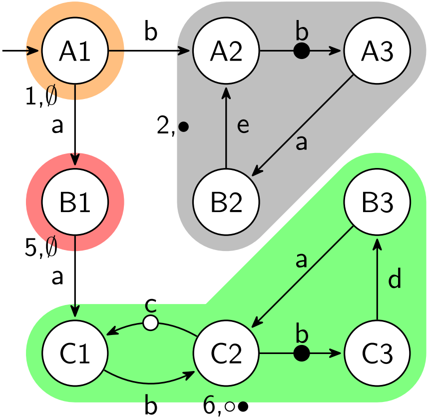


Fig. 5. Computing an accepting run for a TGBA.

Excerpt from “On-the-Fly Emptiness Checks for Generalized Büchi Automata” [3]

Example

Example



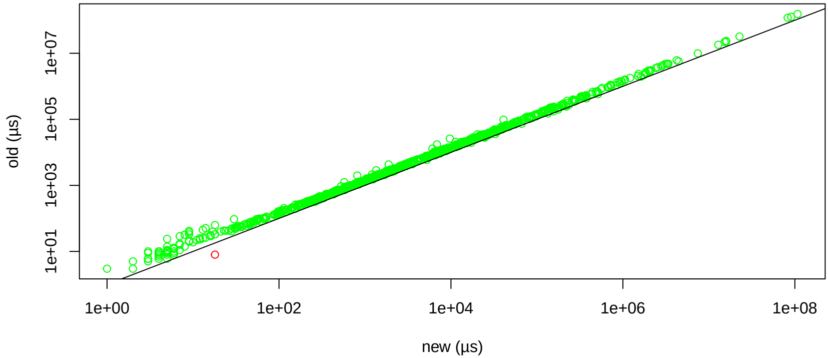
$$Inf(\bullet) \wedge Inf(\circ)$$

Results

Speed up

Speed Up

Comparison of old vs. new emptiness check in `ltlcross`



- 100 formulae[1] × 3 tools[2] ⇒ 849 emptiness checks (all empty, no accepting run search) + 27 timeouts
- outlier: "`(!(X(p11))) -> (!(p0))`" through `ltl3ba`

[1] `randltl --tree-size=30 30`

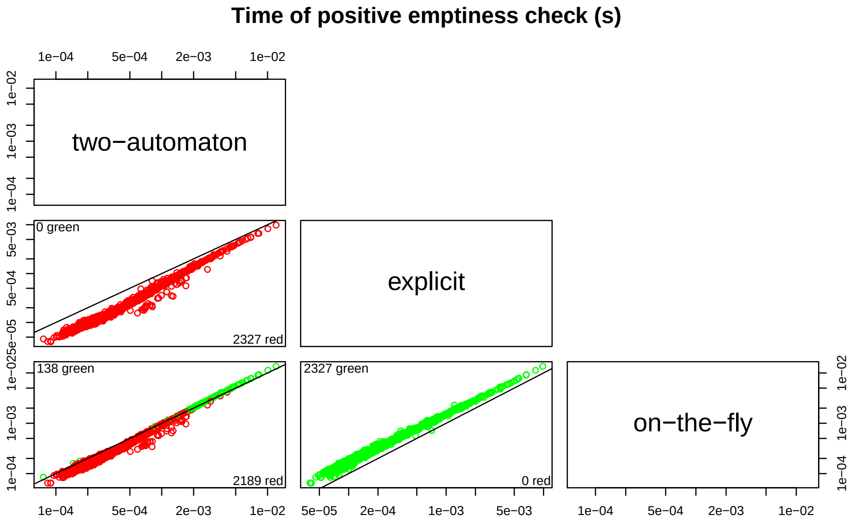
[2] `ltlcross -T 60 ltl2ba ltl3ba ltl2tgba`

Comparison with other implementations

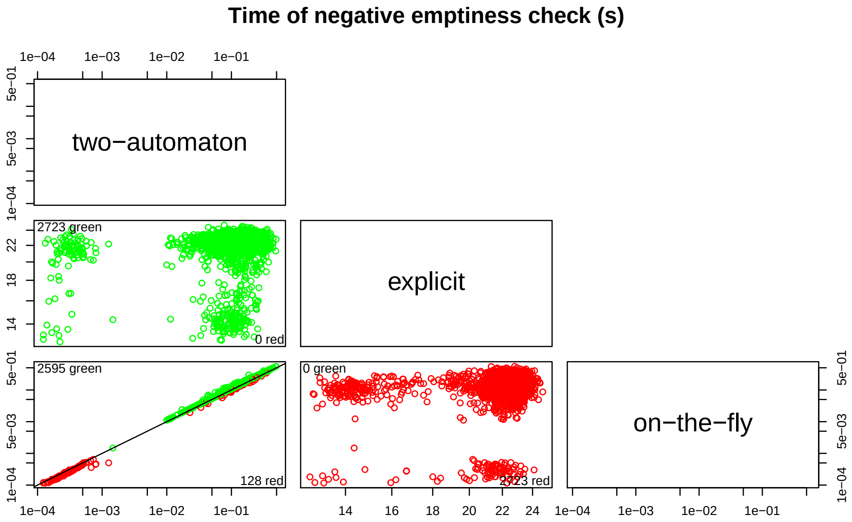
Bench Setup

1. We measure the time spent in:
   - two-automaton emptiness check
   - explicit product + emptiness check
   - on-the-fly product + emptiness check
   - + accepting run search when not empty
2. Data set:
   - 100 random automata: 200 states, 16 acceptance sets, 10 condition variables
   - 5050 combinations, 2668 empty, 2382 non-empty
3. In parallel over 24 cores of the same machine

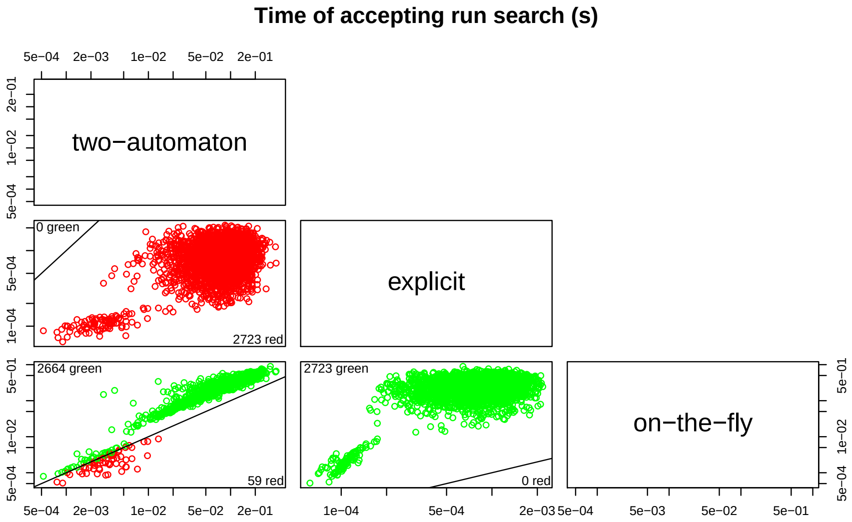
Case of Emptiness



Case of Non-Emptiness



Case of Non-Emptiness



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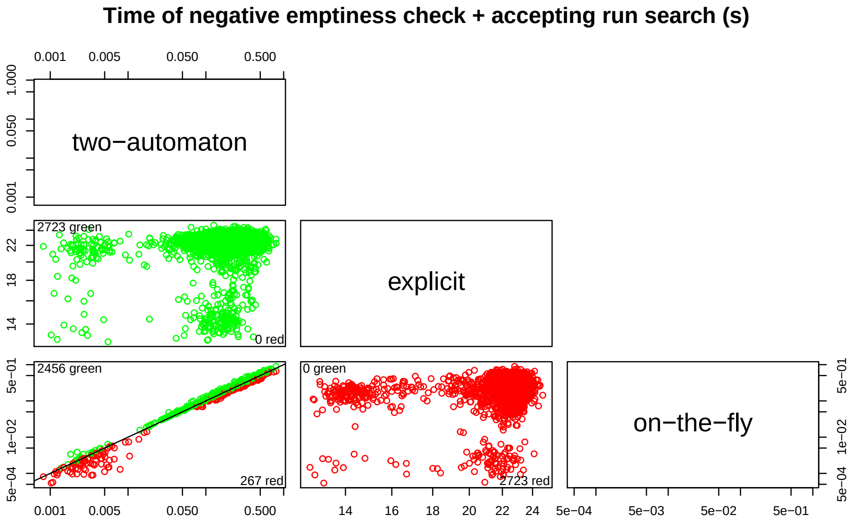

Conclusion

Conclusion

What has been done:

- Make the two-automaton emptiness check fully usable
- Test it on a broader range

What remains to be done:

- Investigate on performances
- From generalised Büchi to Rabin: “Explicit State Model Checking with Generalized Büchi and Rabin Automata” [1]

Questions?

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