Mopsa at the Software Verification Competition

Raphaël Monat

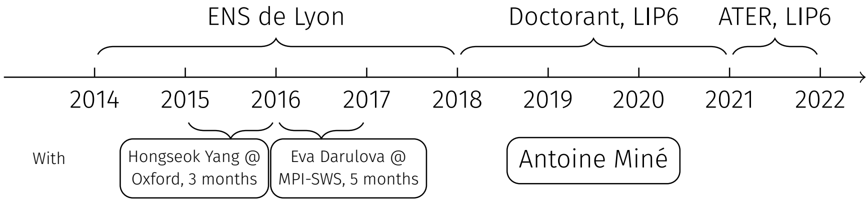
SyCoMoRES team

`rmonat.fr`

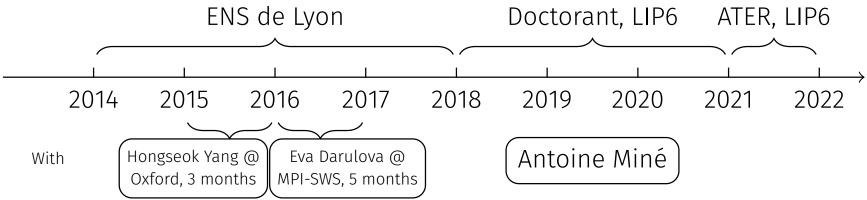
30 minutes of Science
10 March 2023

Introduction

whoami


ENS de Lyon
Doctorant, LIP6
ATER, LIP6
2014
2015
2016
2017
2018
2019
2020
2021
2022
With
Hongseok Yang @ Oxford, 3 months
Eva Darulova @ MPI-SWS, 5 months
Antoine Miné

whoami



Research area: formal methods

Goal: improve confidence in software

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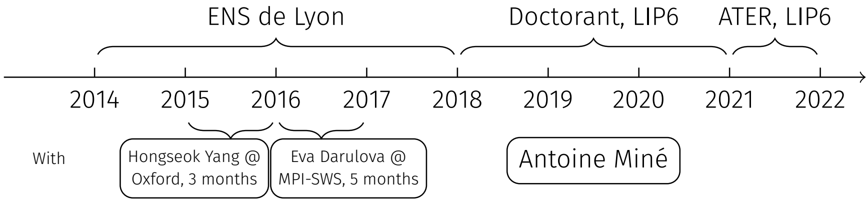

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Worked on two real-world systems

- Analysis of Python programs, and interoperability with C (LIP6)
- French income tax code (Inria Paris & MSR)

SyCoMoRES team

Youngest team, hosted in ESPRIT.

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Component-based design of real-time embedded systems

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- Programming language design
- Static analysis
- Real-time scheduling
- Computer-assisted formal proofs

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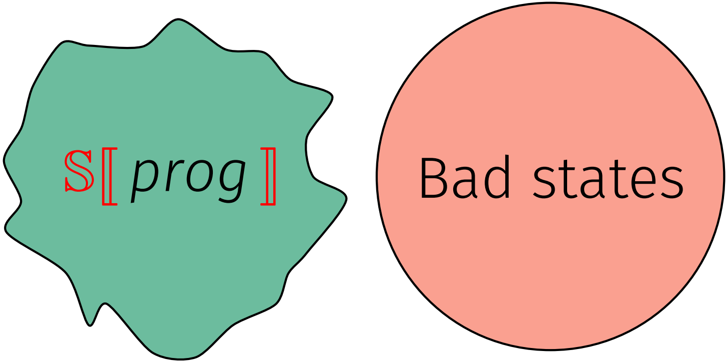
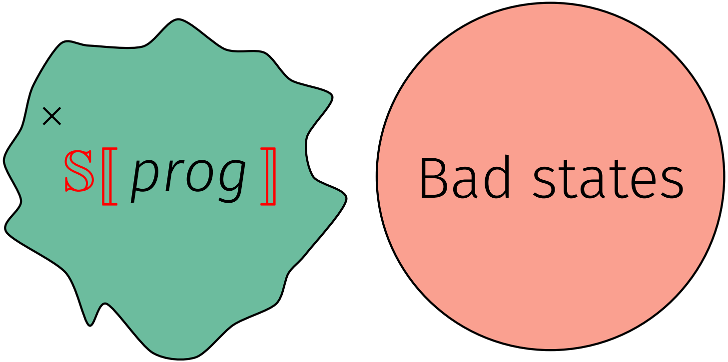
Members

- Patrick Baillot
- Clément Ballabriga
- Julien Forget
- Giuseppe Lipari
- Vlad Rusu
- Nordine Feddal
- Andrei Florea
- Sandro Grebant
- Leandro Gomes
- Ikram Senoussaoui

Software verification

Software verification





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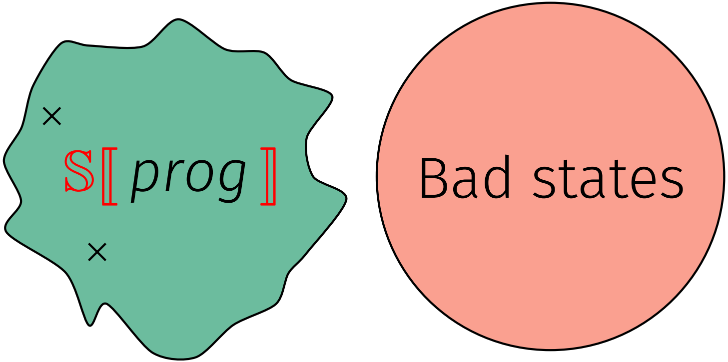

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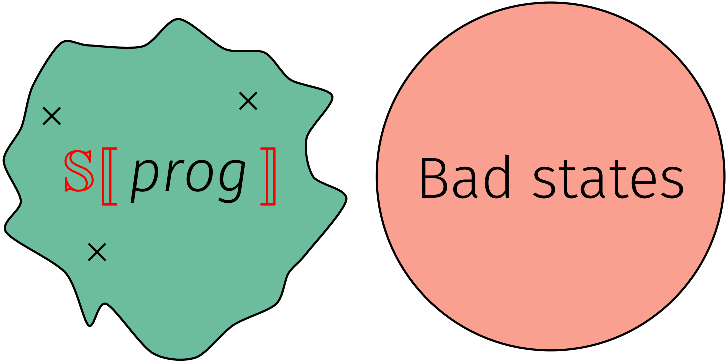

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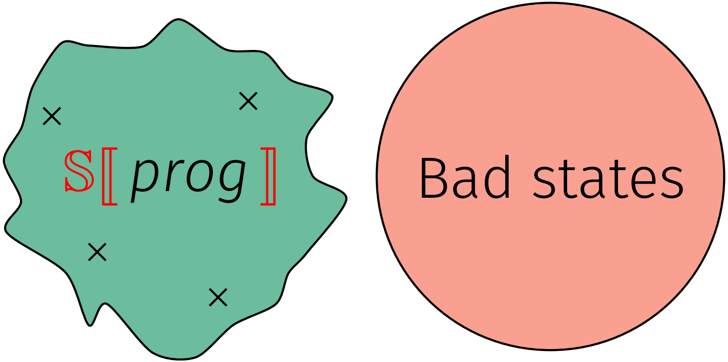

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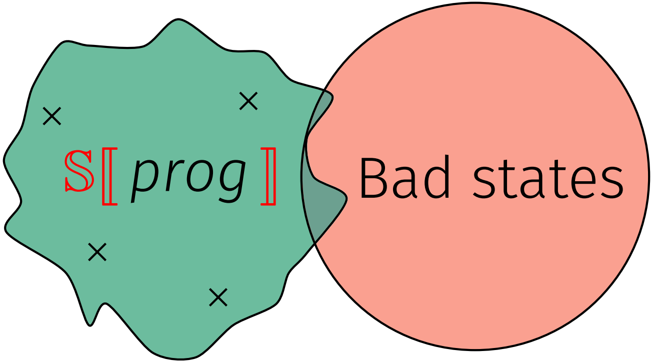

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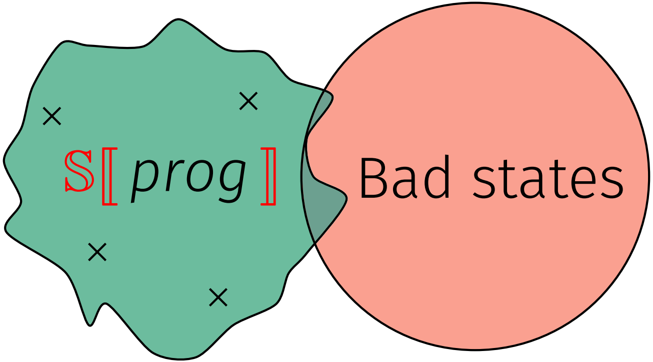

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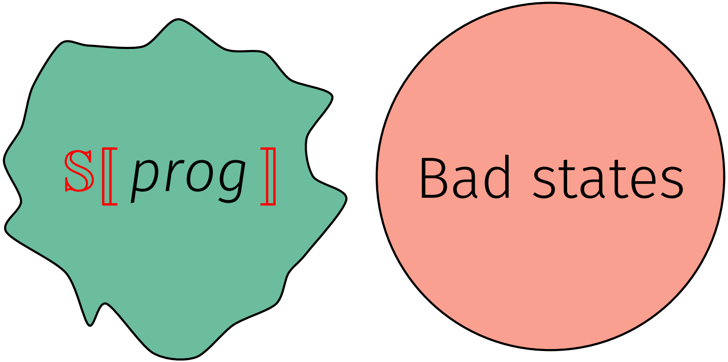

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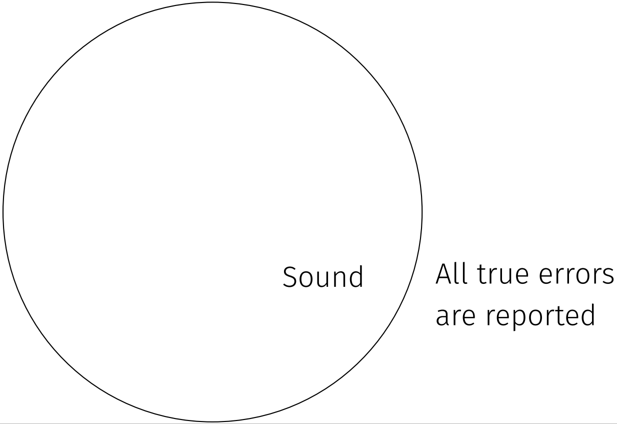
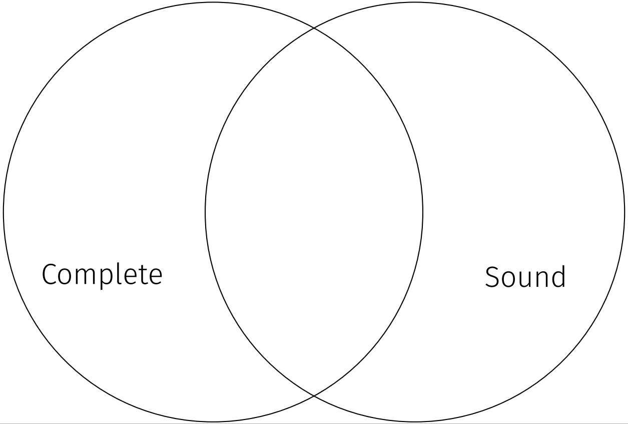
Would there be a way to automatically prove programs correct?

An impossibility theorem



An impossibility theorem

All reported errors are true errors



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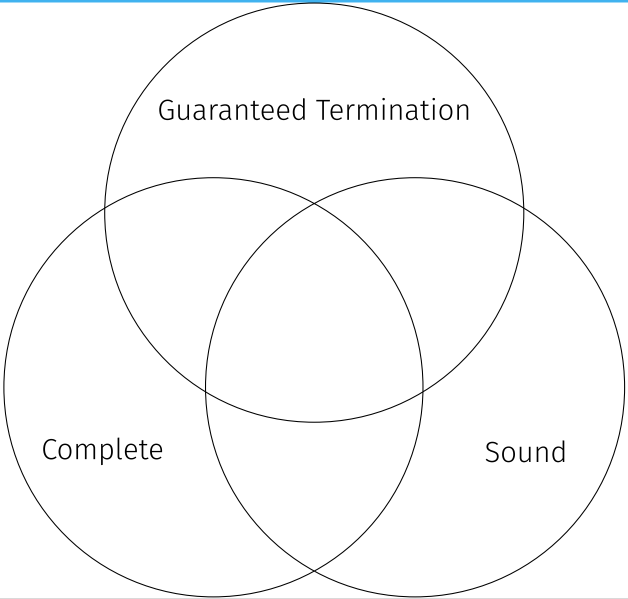

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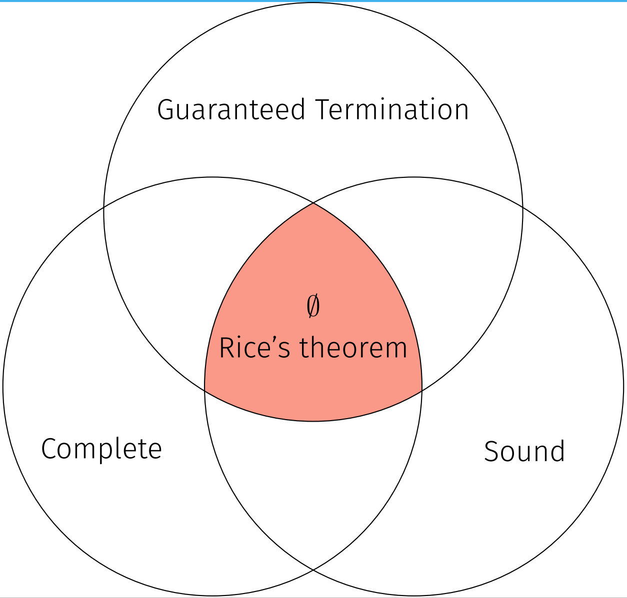

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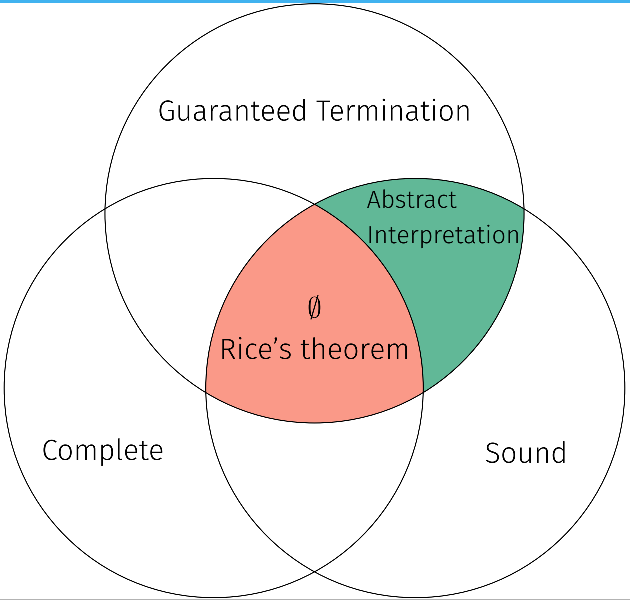

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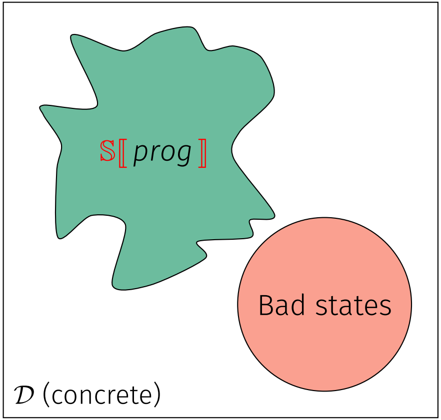
Abstract interpretation – the big picture



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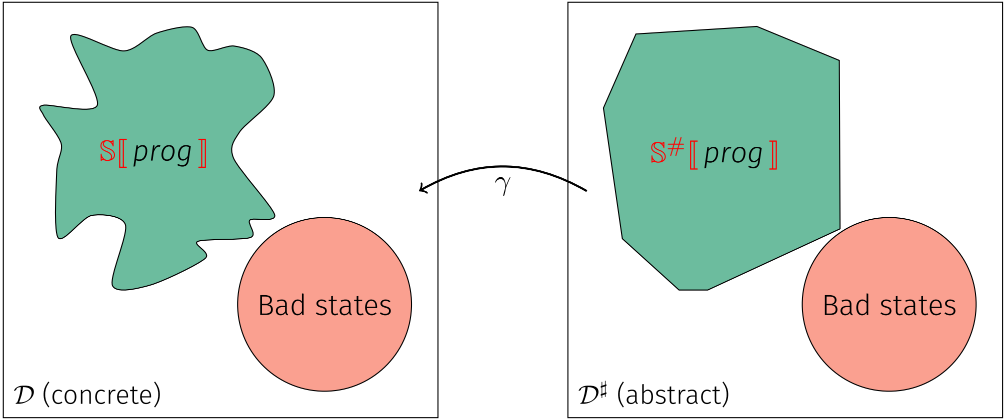

Program proved safe

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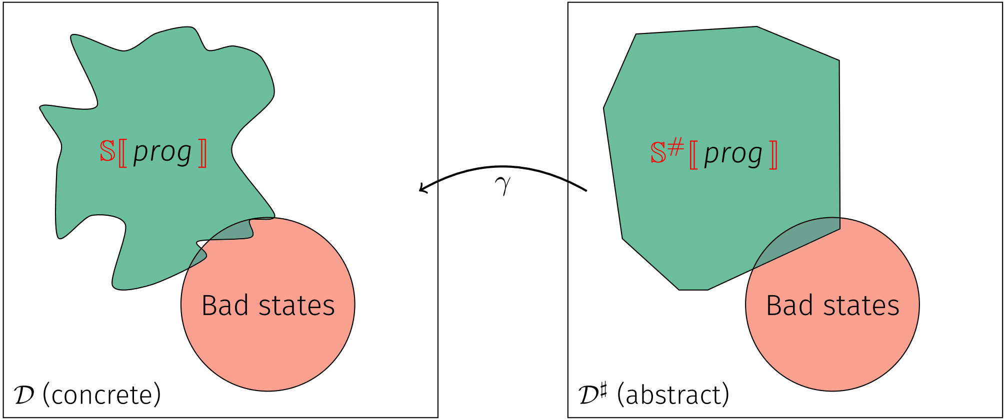

True alarm

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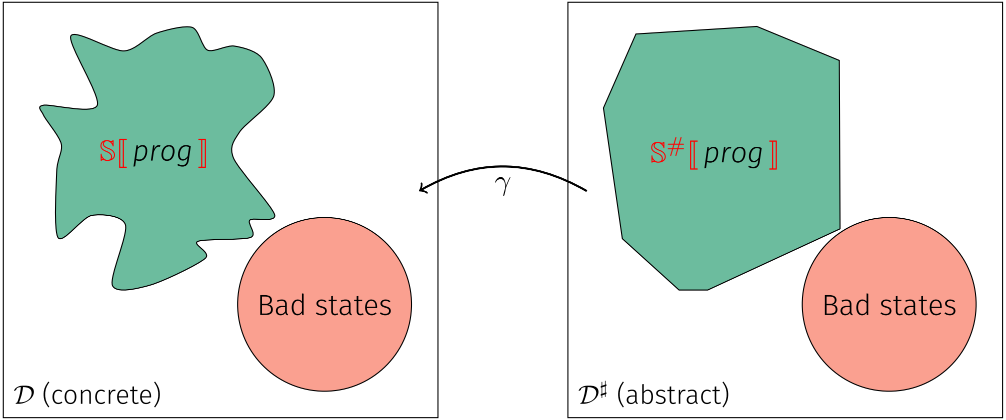

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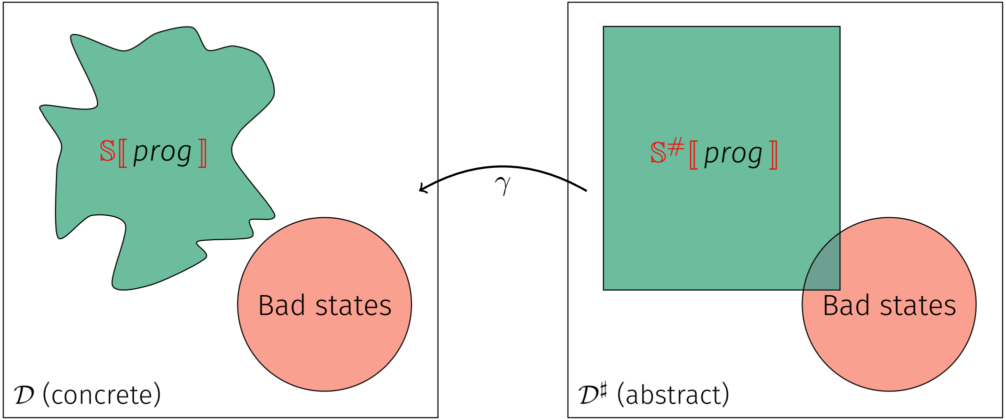

False alarm (Abstraction too coarse)

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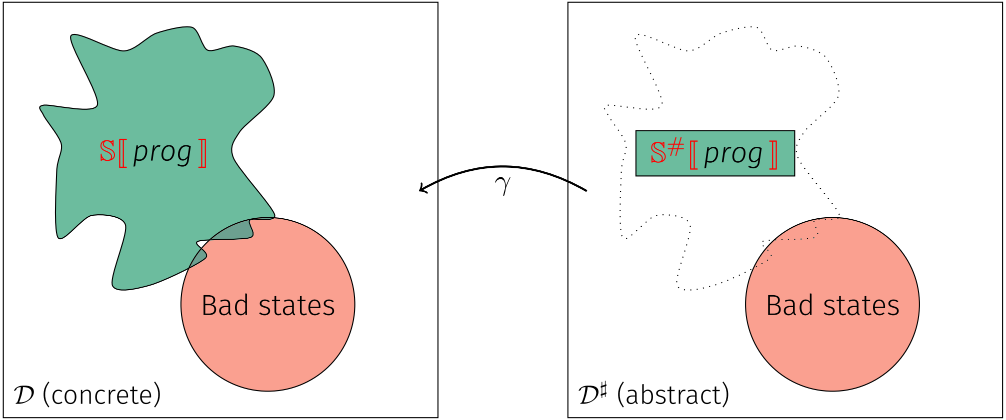

Unsound analysis
(shouldn't happen)

P. Cousot and R. Cousot. "Abstract Interpretation: A Unified Lattice Model for Static Analysis of Programs by Construction or Approximation of Fixpoints". POPL 1977

Conservative static program analysis

average.py

```python
def average(l):
  m = 0
  for i in range(len(l)):
    m = m + l[i]
  m = m // (i + 1)
  return s

r1 = average([1, 2, 3])
r2 = average(['a', 'b', 'c'])
```

TypeError: unsupported operand type(s) for '+': 'int' and 'str'

argslen.c

```c
#include <string.h>

int main(int argc, char *argv[]) {
  int i = 0;
  for (char **p = argv; *p; p++) {
    strlen(*p); // valid string
    i++; // no overflow
  }
  return 0;
}
```

No alarm

Specifications of the analyzer

Inference of program properties such as the absence of run-time errors.

Semantic based on a formal modelization of the language.

Automatic no expert knowledge required.

Sound covers all possible executions.

Critical software certification through static analysis

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Embedded C

- Generated code
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Democratizing static analysis?

- Multiple langages?
- Precision and configurability?

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Outline

Mopsa

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`gitlab.com/mopsa/mopsa-analyzer`

2016-2021: ERC Consolidator Grant, awarded to Antoine Miné.

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Contributors

- Antoine Miné
- Abdelraouf Ouadjaout
- Raphaël Monat
- *David Delmas*
- *Guillaume Bau*
- *Milla Valnet*
- Matthieu Journault

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Current public analyses in Mopsa

Semantic property
Runtime error detection

$\simeq$ 50,000 lines of OCaml code

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	bitarray	5,700	4.6m	94.6%

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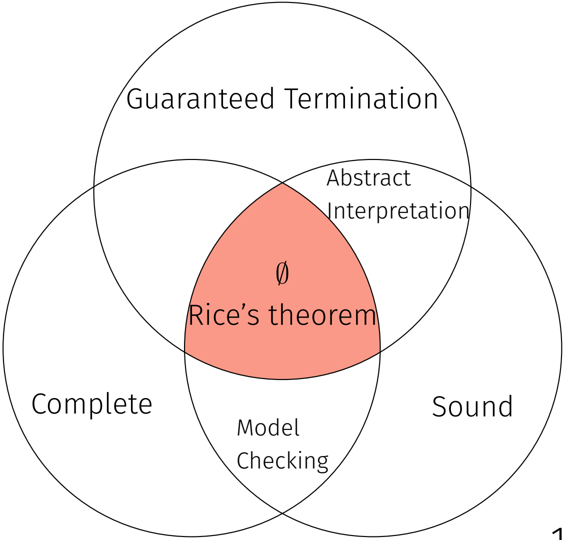

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Properties

- Reachability
- Memory safety

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- Data race

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Category	# tasks	Median loc.
ReachSafety	6282	1267
MemSafety	6280	86
ConcurrencySafety	2370	127
NoOverflows	6539	49
Termination	3324	901
SoftwareSystems	5825	6655

Subcategories in SoftwareSystems

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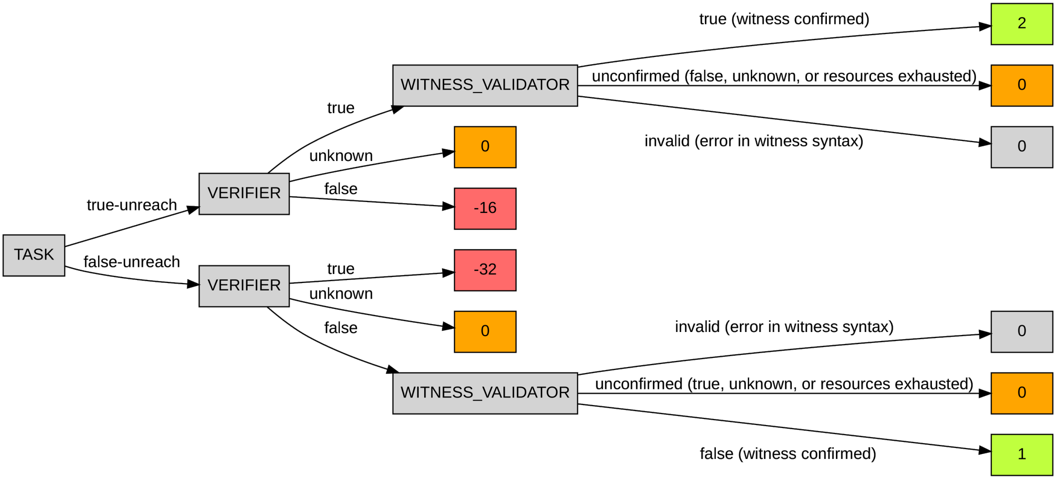
SV-Comp's Scoring System



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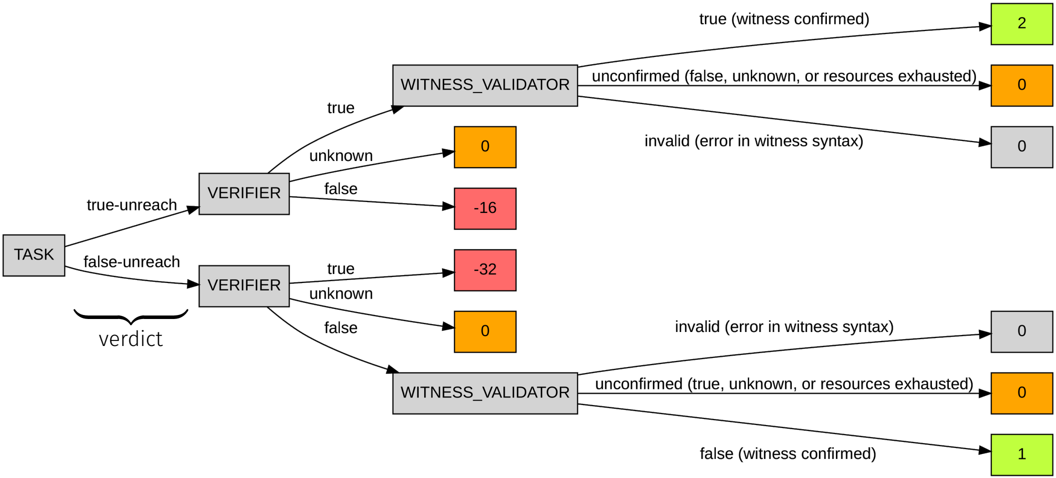
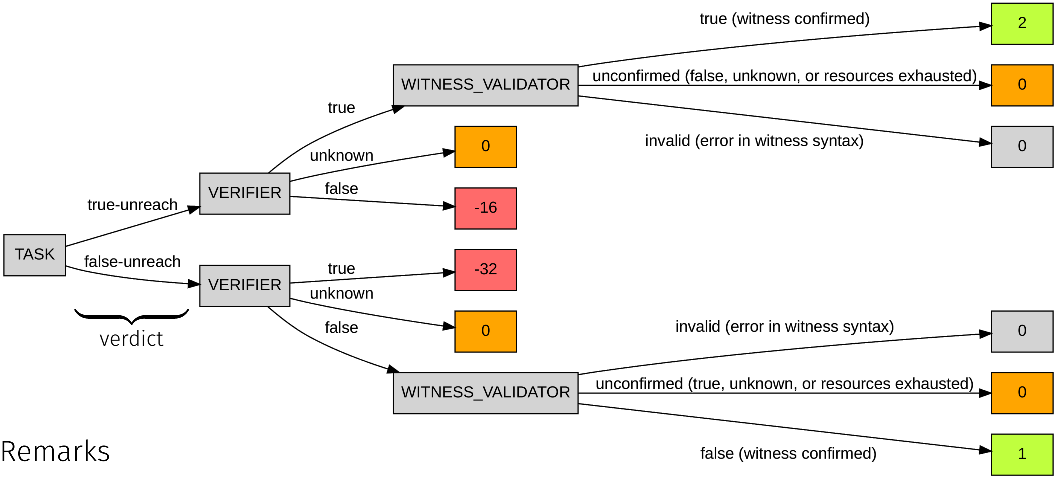


SV-Comp's Scoring System



Remarks

- community-based curation of verdicts
- 187 manual fixes on my end

SV-Comp's Scoring System (II)

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You may have a high raw score but not so good overall score.

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Mopsa at SV-Comp

Our approach

1. Analyze the target program with Mopsa

Adapting Mopsa to SV-Comp's Framework

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- New analyses restart from scratch

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21220 tasks in total, 12636 correctness tasks

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Mopsa validates 54% of correct tasks (61% for overall winner, UAutomizer).

Mopsa’s Results

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Overflow

Ranks 6th/19, before Frama-C and Goblint.

Mopsa is on par with the winner for the number of programs proved correct!

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Proved correct	291	**1,651**	1,256	1,610	942	1,423
Proved incorrect	143	59	0	0	84	2
CPU Time (s)	2,000,000	730,000	800,000	580,000	**400,000**	1,400,000
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Mopsa ranks second on raw scores.

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Some SV-Comp related research questions

- Best configuration to analyze a given program under resource constraints
- Synergy with symbolic execution tools

Mopsa at the Software Verification Competition Questions

Raphaël Monat

SyCoMoRES team

`rmonat.fr`

30 minutes of Science
10 March 2023