SMPT: A Testbed for Reachability Methods in Generalized Petri Nets

Nicolas Amat, **Silvano Dal Zilio**

LAAS-CNRS

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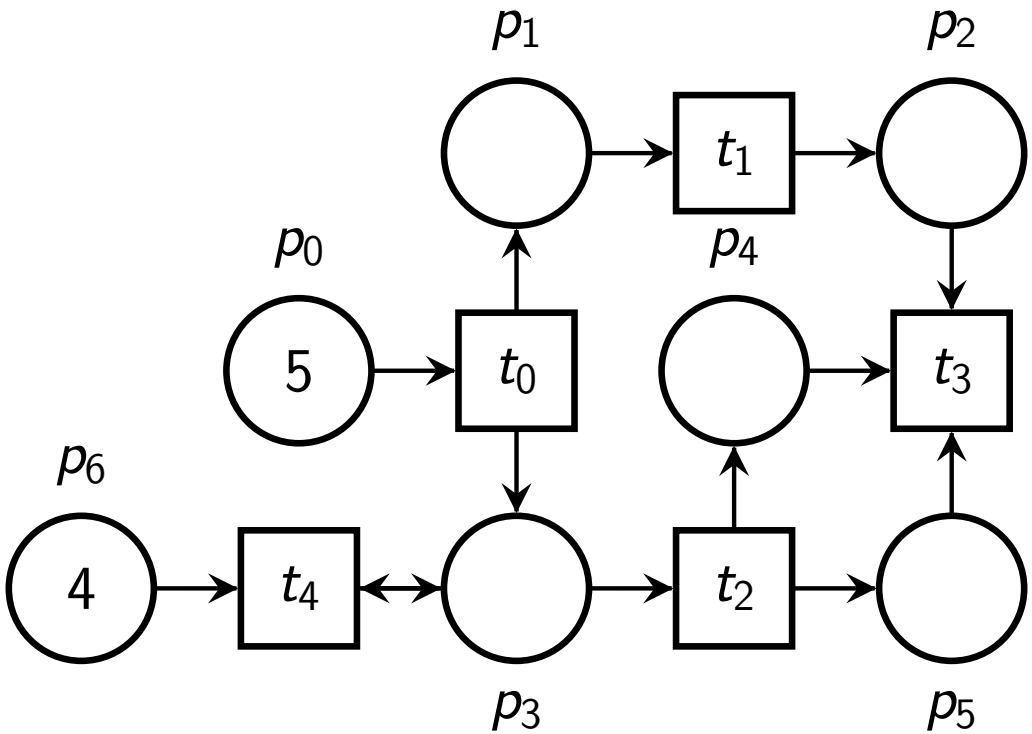
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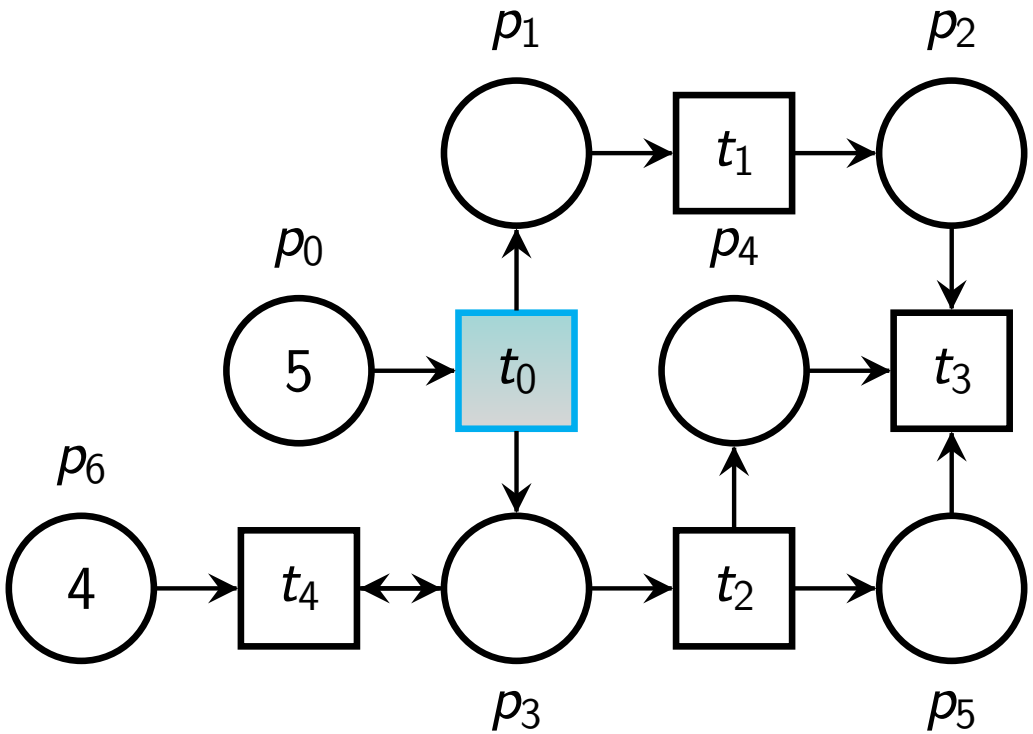
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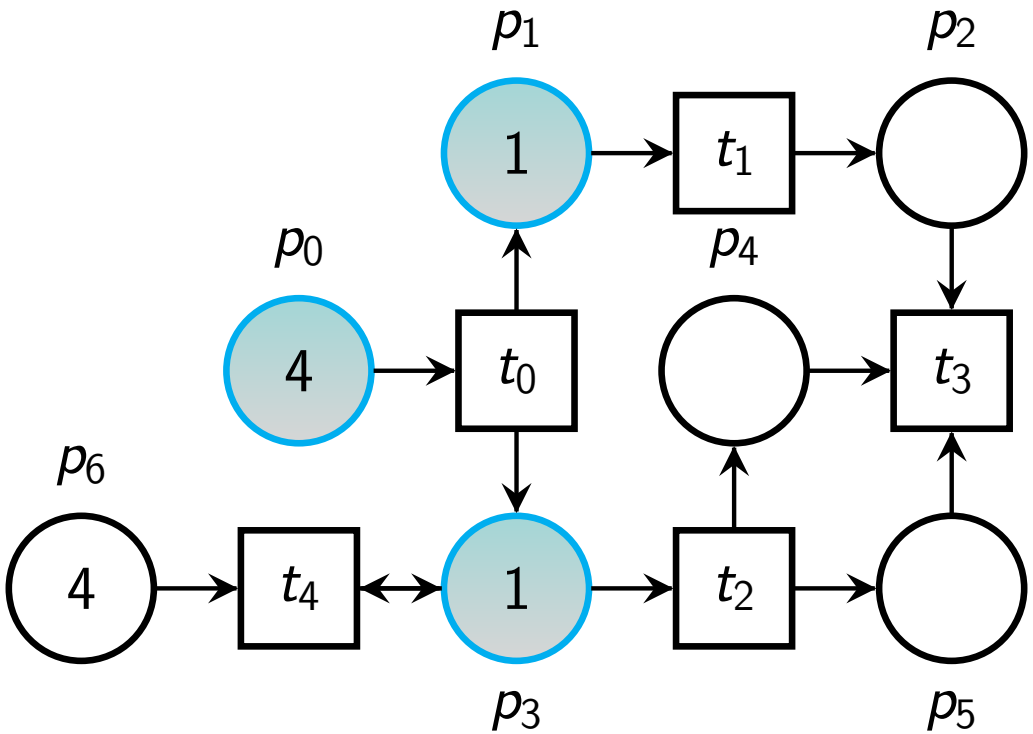
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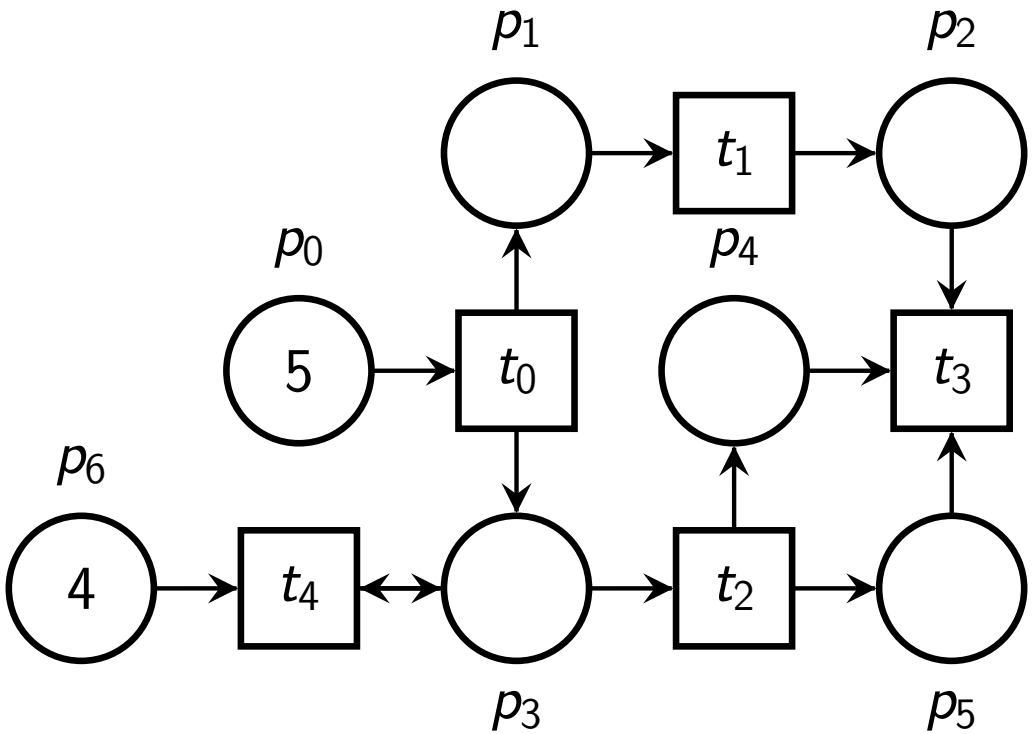
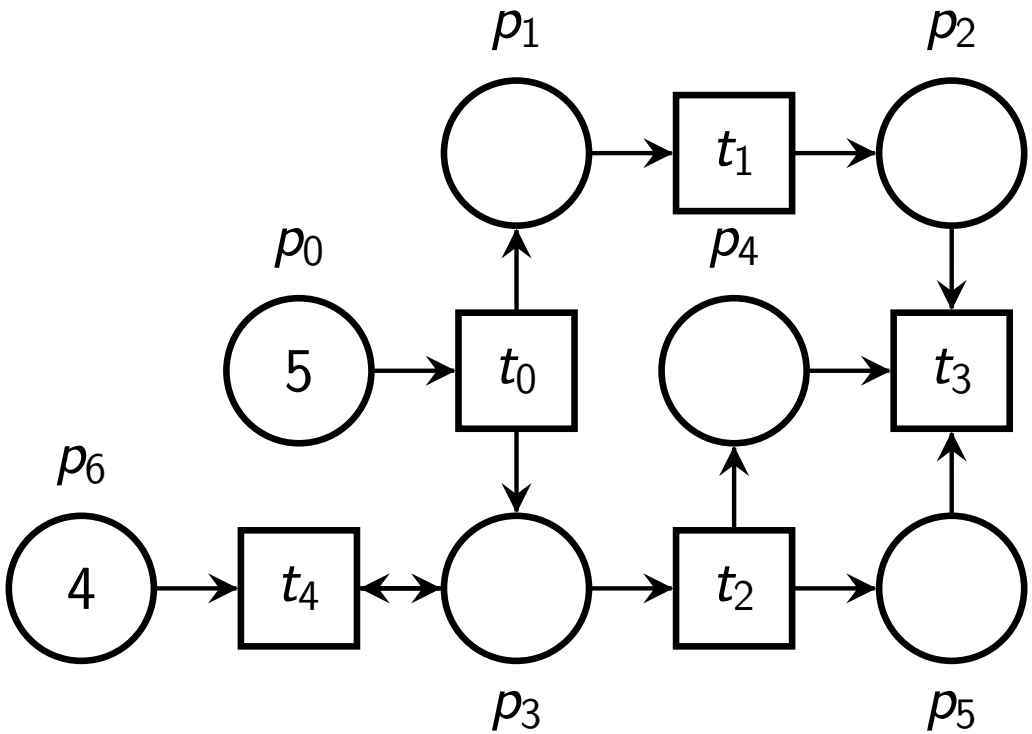
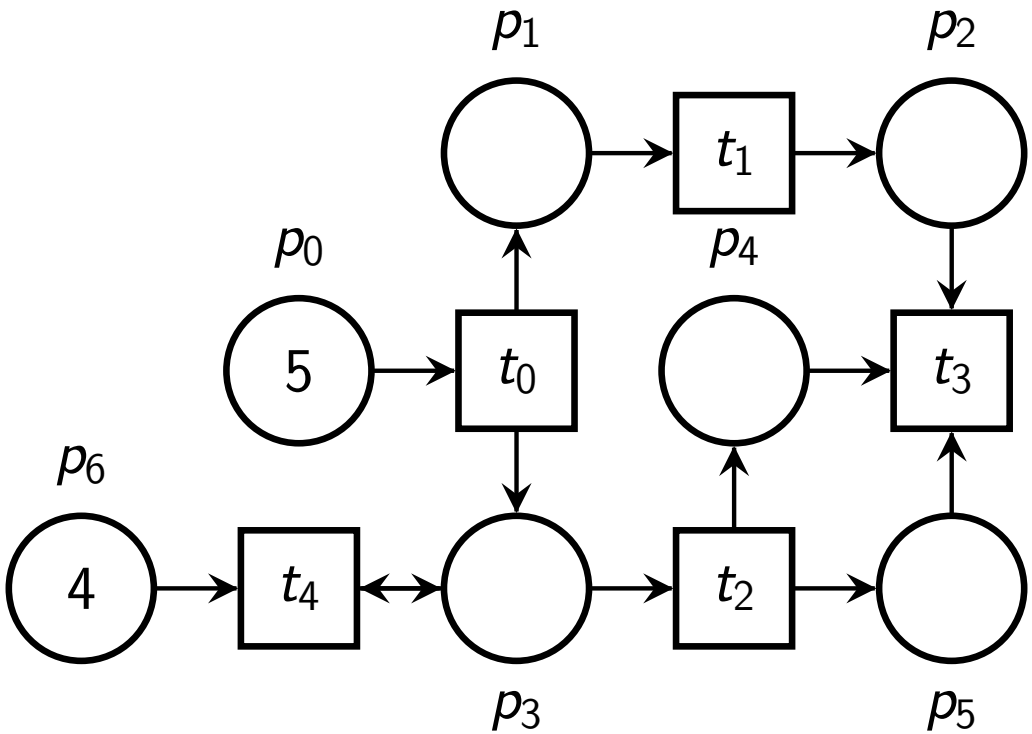


Is $(p_1 \geqslant 1) \wedge (p_6 \leqslant 2)$ **reachable** from the initial marking?



Is $(p_1 \geqslant 1) \wedge (p_6 \leqslant 2)$ **reachable** from the initial marking?

Is $(p_1 + p_2 \leqslant 5) \wedge (p_4 = p_5)$ an **invariant** for all the reachable markings?



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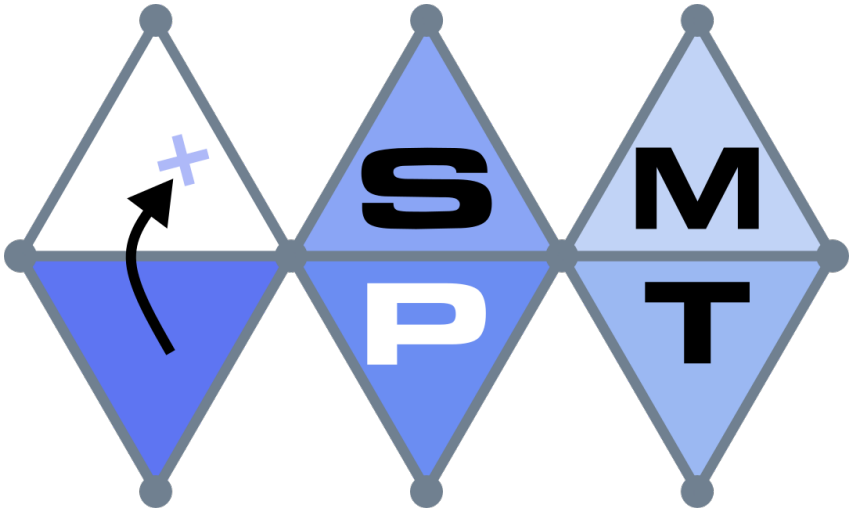
Good fit with Quantifier-Free Linear Integer Arithmetic!
(and more generally Presburger arithmetic)

What is SMPT?

Introduction



- A Petri nets model-checker for **reachability problems**

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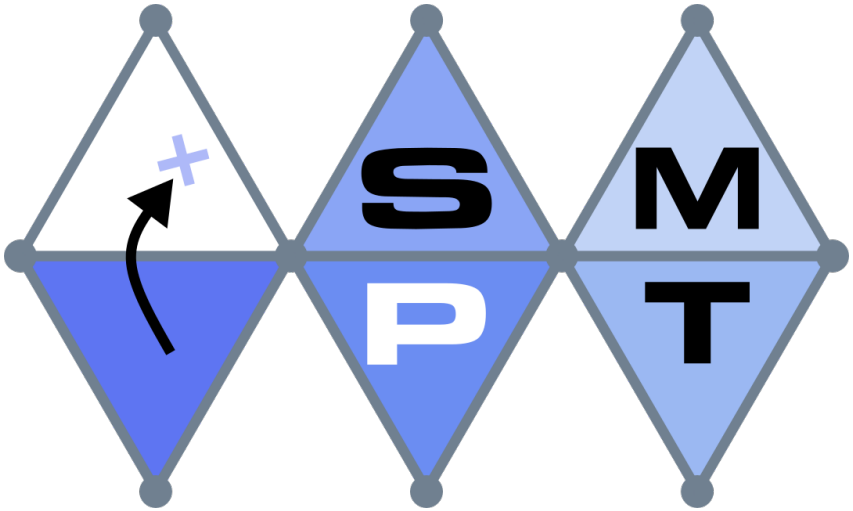

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  Can handle **unbounded nets**!

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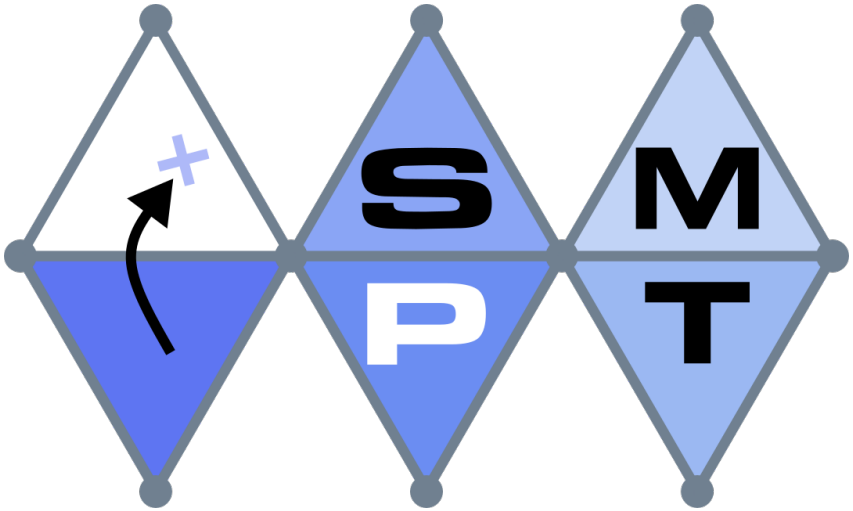

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- Support a generalized notion of **reachability properties** (boolean combination of linear constraints between place)

  Includes deadlock detection, quasi-liveness, reachability, etc.

Why the tool can interest you?

- Lots of use-cases ("assembly" of concurrent systems):

  Verification of **concurrent** systems: biological, business processes, ..

  Verification of **software** systems

  Analysis of **infinite state** systems

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- Timely subject

  Recent **tools** [Dixon et al.'2020] [Blondin et al.'2021]
  Ackermann-complete [Czerwiński et al.'2021] [Leroux'2021]

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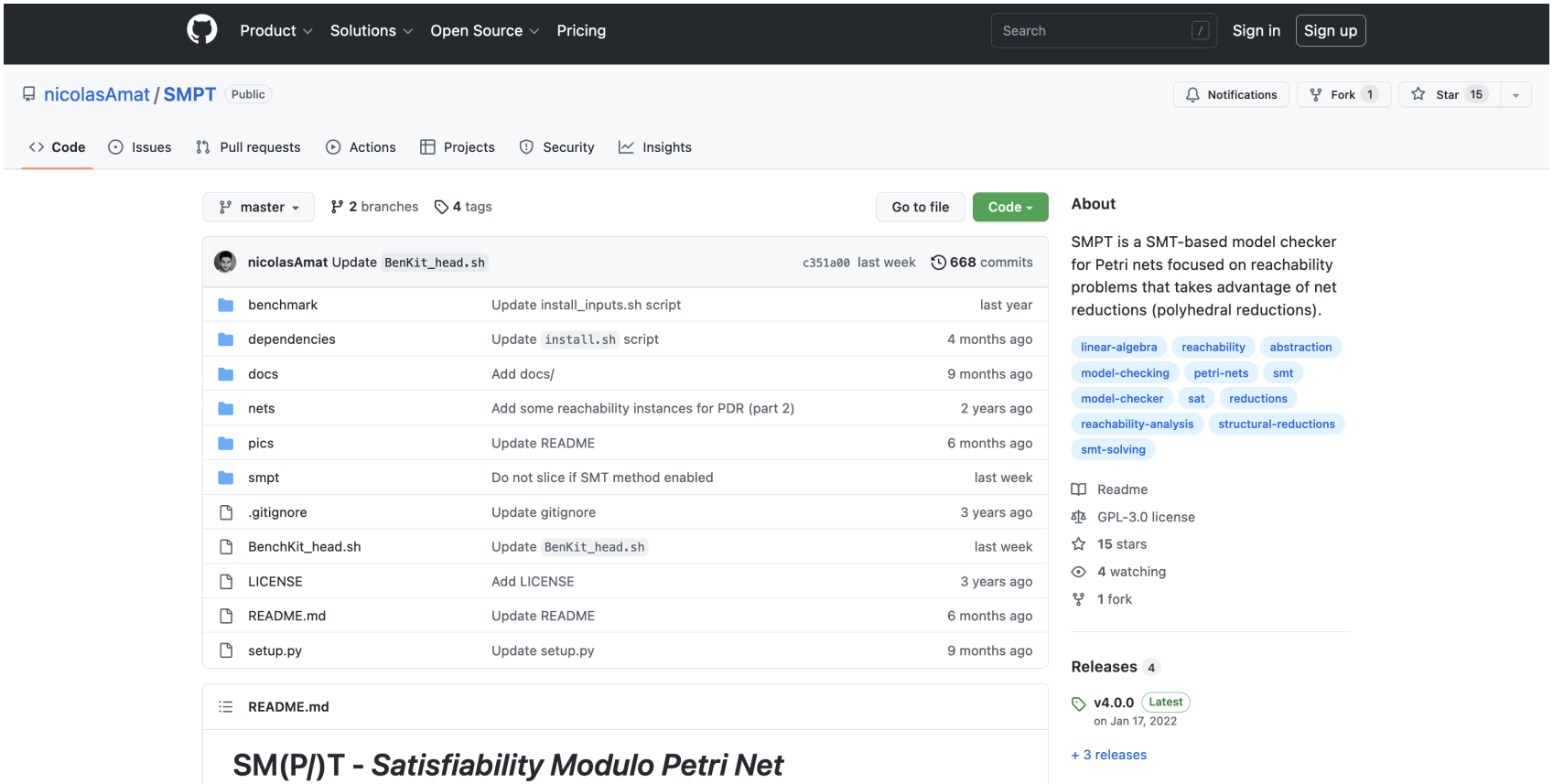
- **Portfolio** tool participating in the Model Checking Contest

Where can I find the tool?

Introduction

Freely available under the GPLv3 license

`github.com/nicolasAmat/SMPT`



Outline

1. Overview
2. Distinctive features
3. Live demonstration
4. Model Checking Contest retrospective
5. What's next?

Overview

- **Python** project, **fully typed** using `mypy`
- Mainly based on **SMT methods** (SMT-LIB format)
- Many **tracing** and **debugging** options
- Packaged into libraries, and provide abstract classes to help with future **extensions**

Portfolio of methods

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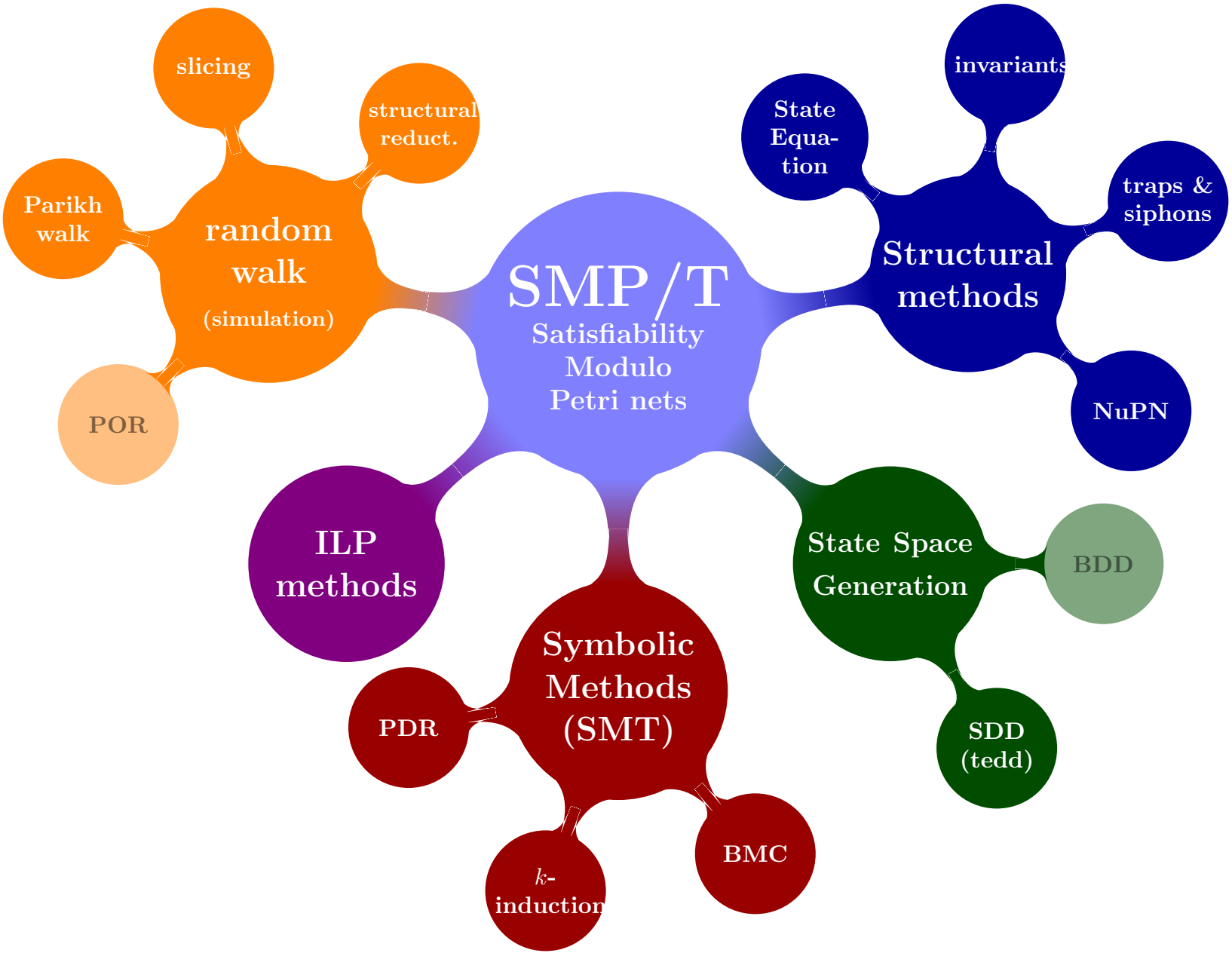

Input and output formats

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Nets:

- Petri Net Markup Language (**PNML**) for nets
- Support **colored** Petri nets (high-level nets)

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- **MCC** property language (XML format encoding)
- Textual format
- Some specific options (deadlock, quasi-liveness, etc.)

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Output is MCC compliant.

SMPT can be interchanged with other participating tools `ITS-Tools`, `Tapaal`, `LoLA`, `GreatSPN`, ...

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"There exist checkable certificates of non-reachability in the Presburger arithmetic" [Leroux, 2009]

Definition (Certificate of Invariance)

A predicate R is a Certificate of Invariance (CI) for F if:

- R inductive
- R entails F: $R(\boldsymbol{p}) \wedge \neg F(\boldsymbol{p})$ unsatisfiable

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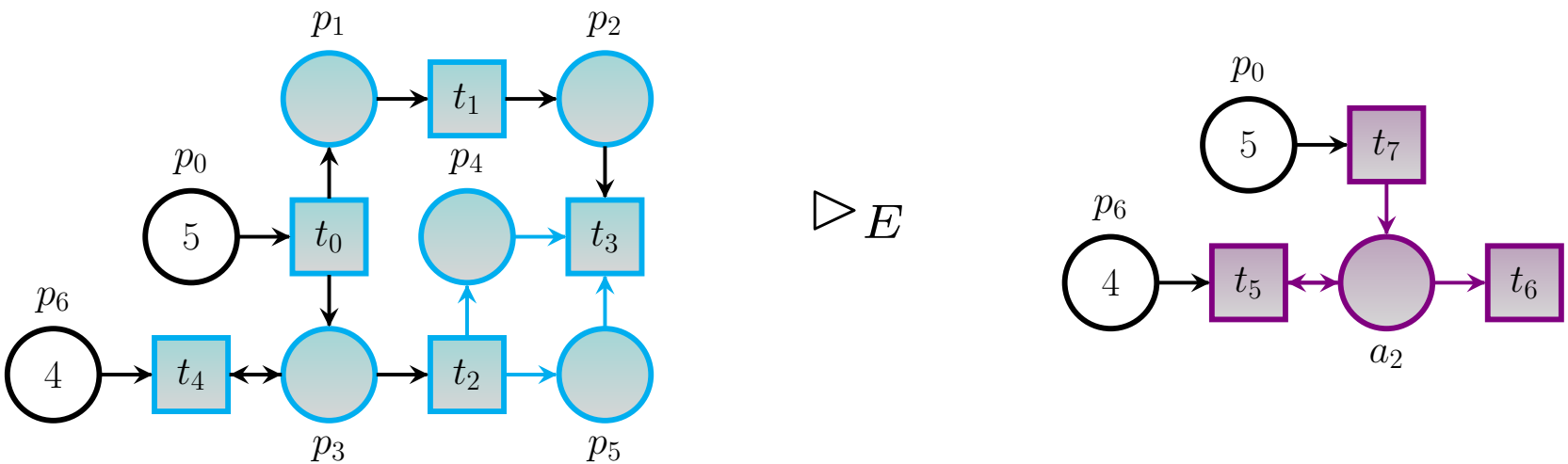

$$E = (p_5 = p_4) \wedge (a_1 = p_2 + p_1) \wedge (a_2 = p_4 + p_3) \wedge (a_1 = a_2)$$

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Model Checking Contest retrospective

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- Annual **competition** for model-checking tools
- Huge **benchmark** (1 618 models and 51 744 queries)
- Compare approaches and improve **reliability**!

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Bronze medal and 100% confidence award! (high reliability)

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What's next?

Continue to explore the relation of Petri nets with **Presburger arithmetic**:

- **Quantifier elimination** in a specific fragment of Presburger (make better use of polyhedral reductions)

- Extract part of nets that are **Presburger-definable** (*flattable*)

  Automated procedure to prove polyhedral reductions

  Improve our use of the "state equation" method (identifying new classes of Petri nets for which all **potentially reachable markings** are indeed **reachable**)

Thank you for your attention!

Have a look at the GitHub repository :)

Any questions?