A Monitoring Tool for Linear-Time μ-HML

L. Aceto *et al.* · Monday, September 12th 2022
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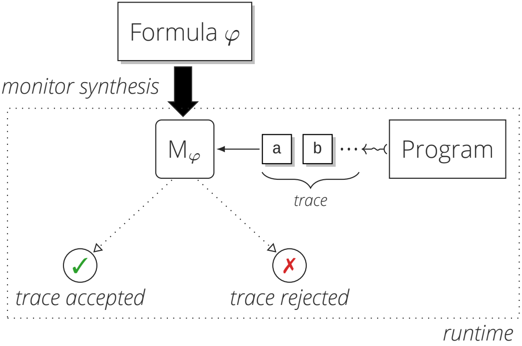
Overview: Runtime verification (RV)

> *RV = property as formula φ + current program trace*



Our monitor verdicts **cannot be changed** once given

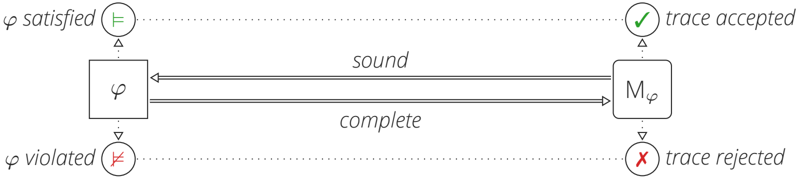
The aspects of modular RV

Monitorability of the logic

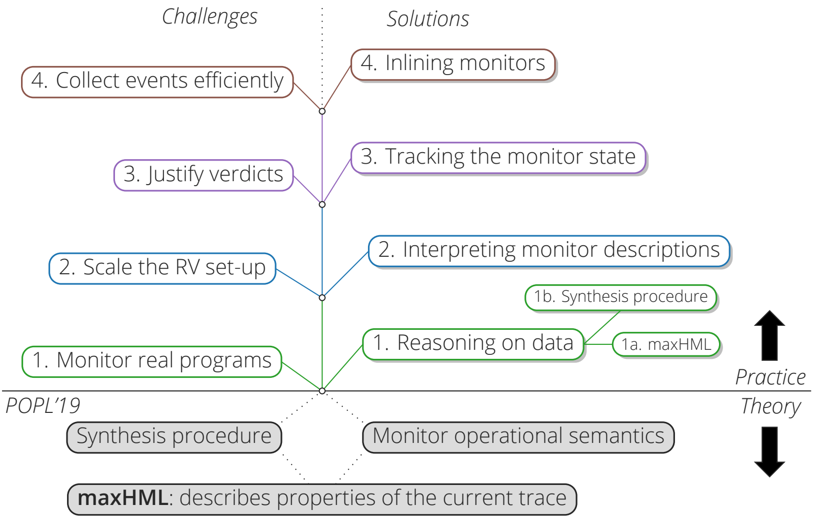
Establishing the set of properties that can be runtime checked

Correctness of monitors

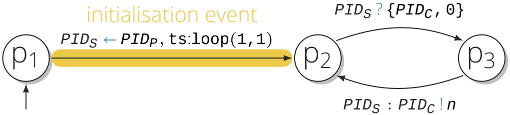
Ensuring that the monitor represents the specified property φ



Making the theory come alive



Token Server: An example in Erlang



Erlang token server (ts.erl)

```
start(Tok) -> spawn(ts, loop, [Tok, Tok]).

loop(OwnTok, NextTok) ->
    receive
      {Clt, 0} ->
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    end.
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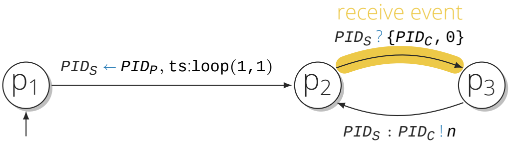

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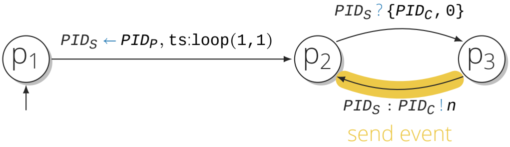

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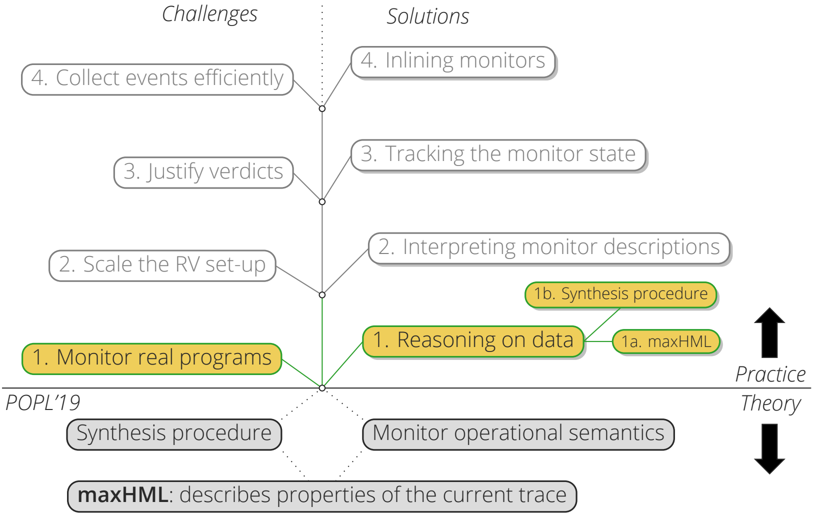

1. Reasoning on data

Formulae $[\{P \texttt{ when } C\}]\varphi$ in the logic use **symbolic actions**

$$[\{\underbrace{P}\ \texttt{when}\ C\}]\varphi$$

pattern P **matches** the shape of a trace event:

- $\leftarrow$ initialisation event pattern
- ! send event pattern
- ? receive event pattern

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Formulae $[\{P \texttt{ when } C\}]\varphi$ in the logic use **symbolic actions**

$$[\{P \texttt{ when } \underbrace{\boxed{C}}\}]\varphi$$

C is a **decidable** Boolean constraint expression:

- `Var1`, `Var2`, *etc.* — data variables
- `1`, `{1,b}`, *etc.* — data values
- `==`, `/=`, `>`, *etc.* — Boolean and relational operators

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Formulae $[\{P \texttt{ when } C\}]\varphi$ in the logic use **symbolic actions**

binds the free variables

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$$\underbrace{[\{P \texttt{ when } C\}]}_{\textbf{necessity}\ \text{modality}}\varphi$$

{*P* when *C*} defines a set of concrete of program events

An event is in this set when:

1. *P* matches the event, instantiating the variables in *C*, **and**
2. *C* is satisfied

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$$[\{P \texttt{ when } C\}]\underbrace{\varphi}_{\text{formula continuation}}$$

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$$\underbrace{[\{P \text{ when } C\}]\,\mathbf{ff}}$$

event does not match P or if it does, C is not satisfied

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1. P matches the event, instantiating the variables in C, **and**
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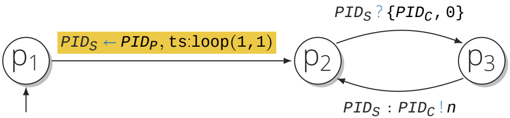
1a. maxHML: an example trace property



The server private token is not leaked in client replies

```
[{_ ← _, ts:loop(OwnTok, _)}]
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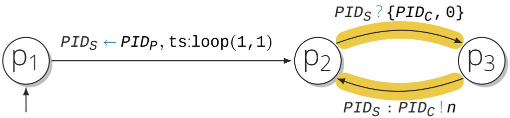

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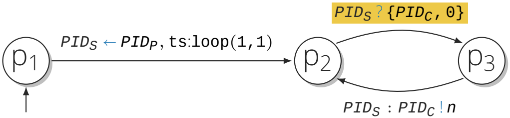

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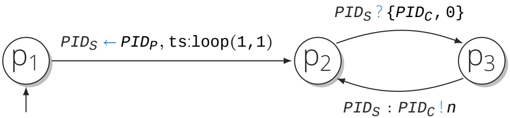

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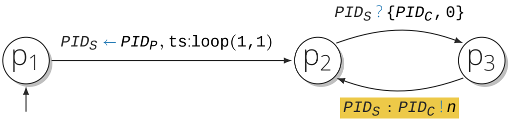

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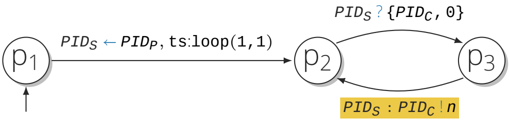

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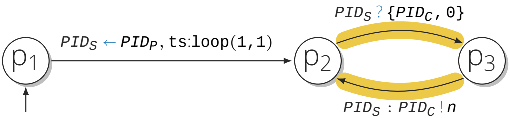

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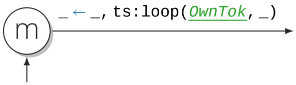

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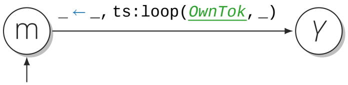

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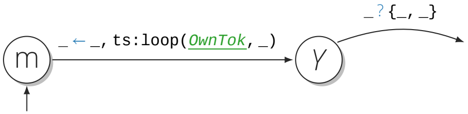

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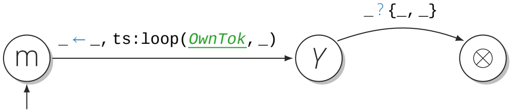

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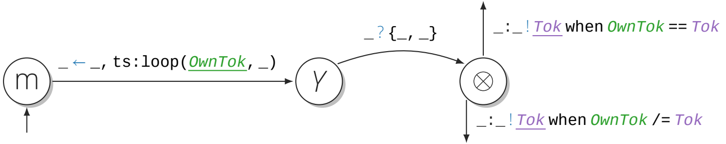

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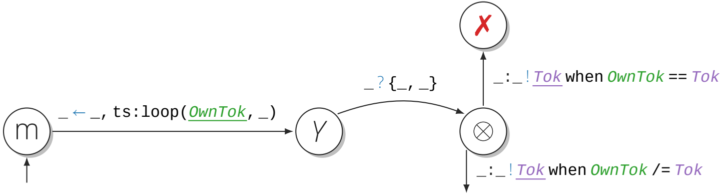

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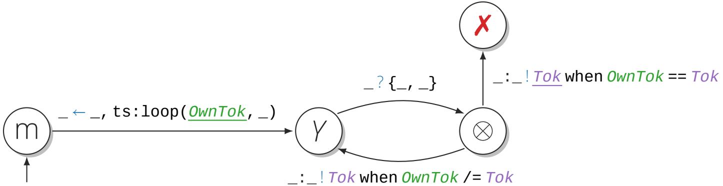

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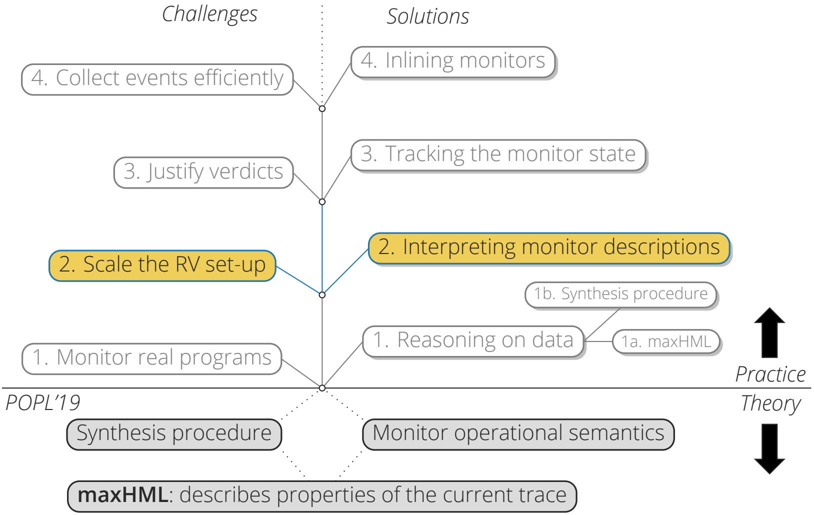
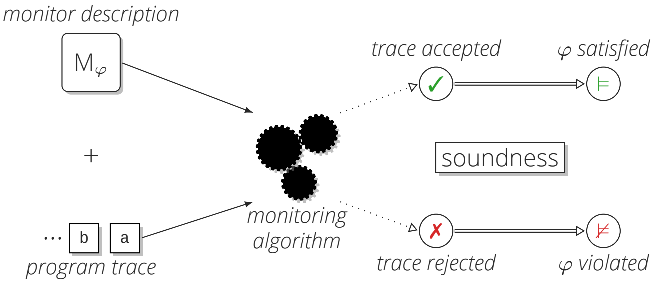


2. Interpreting monitor descriptions

Our algorithm determinises monitors **on-the-fly**

Monitor descriptions are **instantiated** with trace event data

Scalability: we **emulate** disjunctive and conjunctive parallelism



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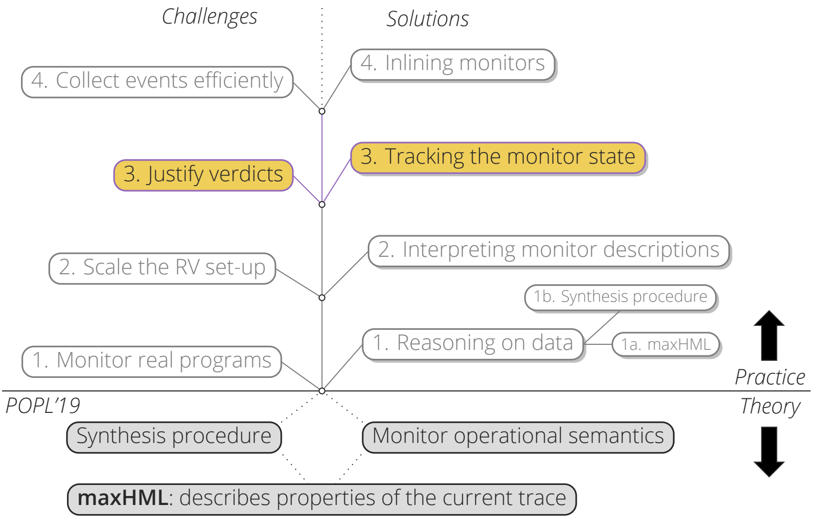
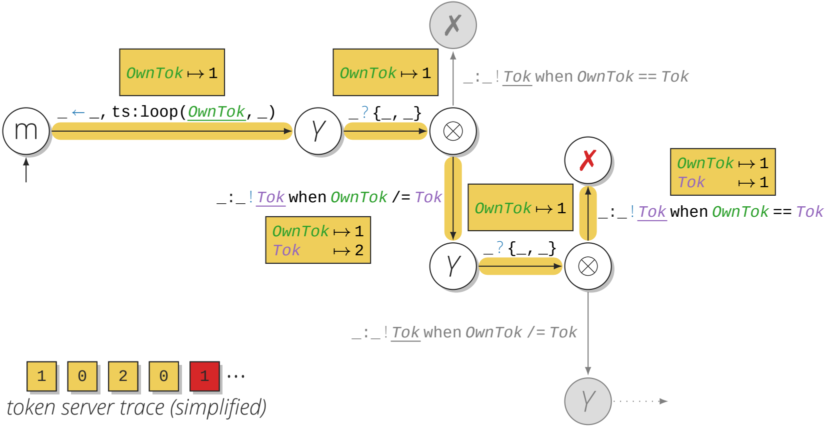


3. Tracking the monitor state

❝ *Explainability = tracking monitor state + applied rules* ❞



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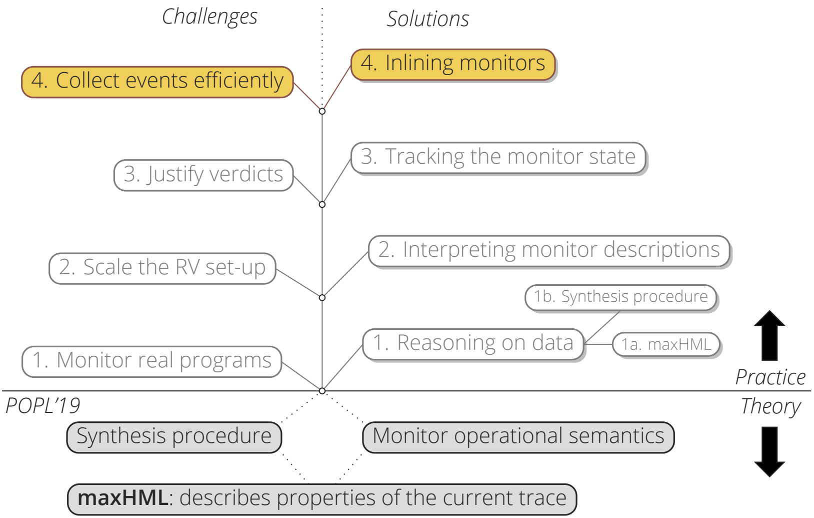
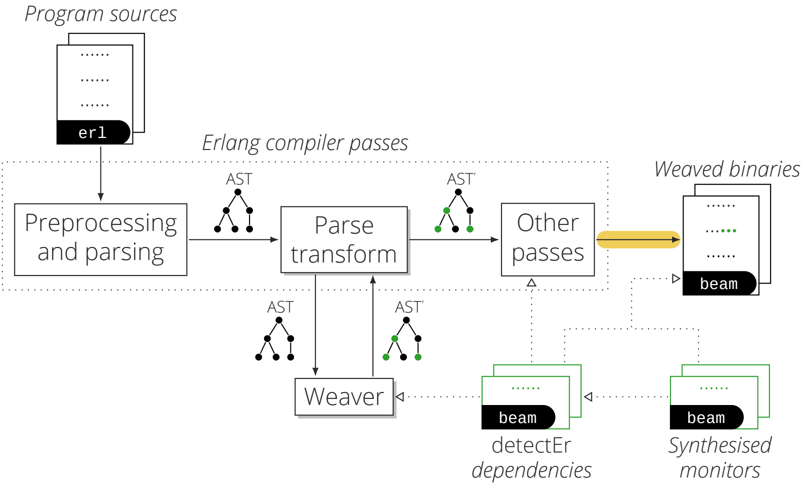


4. Inlining monitors



Contributions and summary

An extended monitorable logic and monitors that handle **data**

An algorithm that follows the monitor **operational semantics**

Verdict **explainability** based on monitor reductions

One tool to monitor linear- and branching-time specifications

Future directions and improvements

- Bound on the number of states managed by the algorithm
- Leverage the outline instrumentation provided by detectEr
- Empirical study of runtime overhead

GitHub link

https://duncanatt.github.io/detecter

Thank you