A Monitoring Tool for a Branching-Time Logic

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Outline

Property Specification and Monitor Synthesis

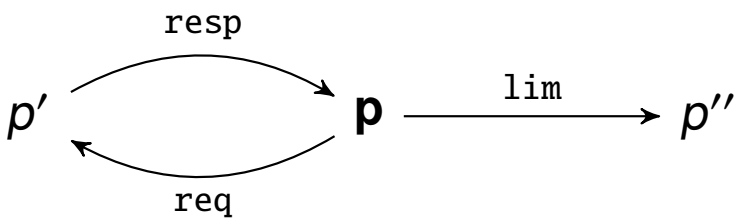
Implementation of a Tool in Erlang

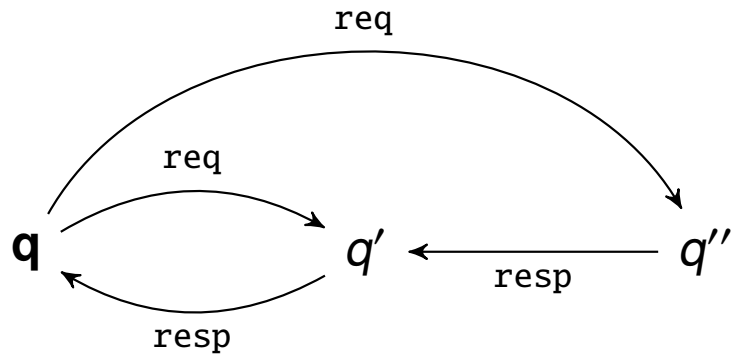
Demo

Modelling Process Behaviour

The behaviour of systems can described using LTSes that model process execution graphs

Example (Two simple servers)





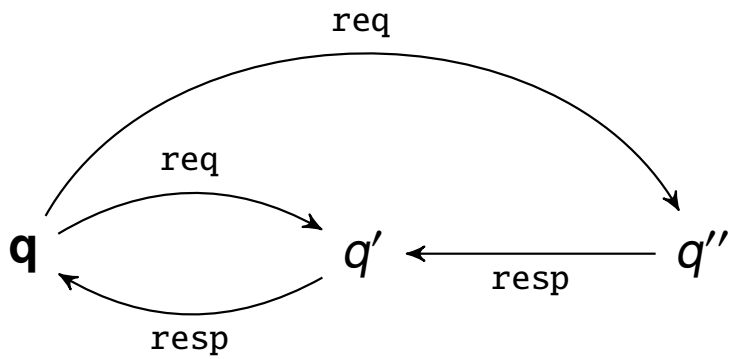
The Branching-Time Logic μHML

Syntax

$$\varphi, \phi \in \mu\text{HML} ::= \mathbf{tt} \mid [\alpha]\varphi \mid \varphi \wedge \phi \mid \mathbf{max}\, X.\varphi \mid X$$
$$\mid \mathbf{ff} \mid \langle\alpha\rangle\varphi \mid \varphi \vee \phi \mid \mathbf{min}\, X.\varphi$$

Example (A liveness property)

$$[\texttt{req}]\langle\texttt{resp}\rangle\mathbf{tt}$$



Cheat sheet

$[\alpha]\mathbf{ff}$ "*cannot* do event α"

$\langle\alpha\rangle\mathbf{tt}$ "*can* do event α"

A Monitorable Subset

The Syntax

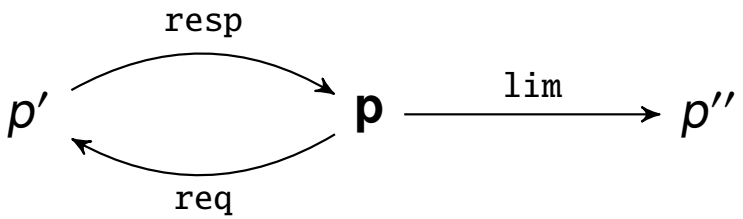
$$\psi \in \text{MHML} \stackrel{\text{def}}{=} \text{sHML} \cup \text{cHML}$$

$$\theta, \vartheta \in \text{sHML} ::= \mathbf{tt} \mid \mathbf{ff} \mid [\alpha]\theta \mid \theta \wedge \vartheta \mid \mathbf{max}\, X.\theta \mid X$$

$$\pi, \varpi \in \text{cHML} ::= \mathbf{tt} \mid \mathbf{ff} \mid \langle\alpha\rangle\pi \mid \pi \vee \varpi \mid \mathbf{min}\, X.\pi \mid X$$

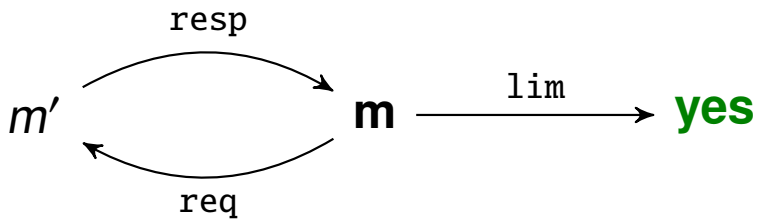
Example (A co-safety property)

$\mathbf{min}\, X.(\langle req\rangle\langle resp\rangle X \vee \langle lim\rangle \mathbf{tt})$



Monitors as LTSes

Example (A monitor for process p)

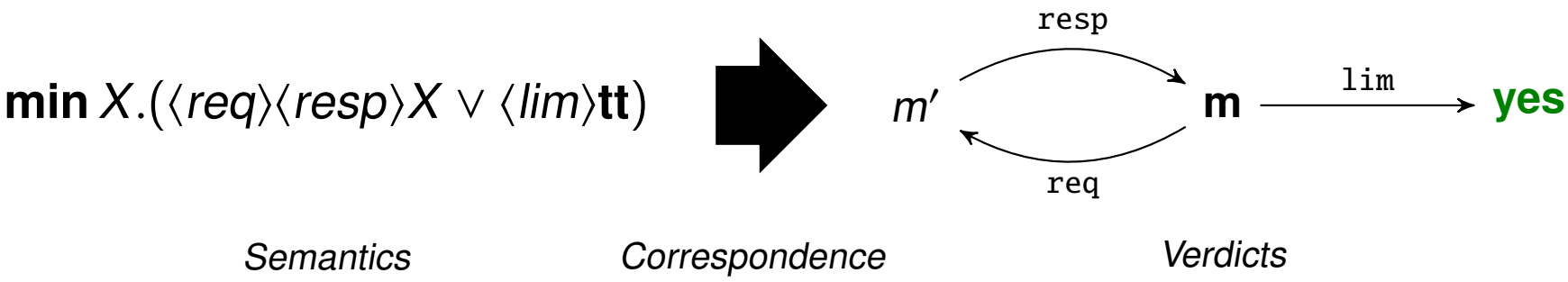


- A **subtle** difference: processes *generate* actions, monitors *analyse* these actions, and yield verdicts
- Conclusive verdicts: **no**, **yes**
- Inconclusive verdict: **end**

Monitor Synthesis

From μHML to Monitors

Correct Synthesis (Compositional)



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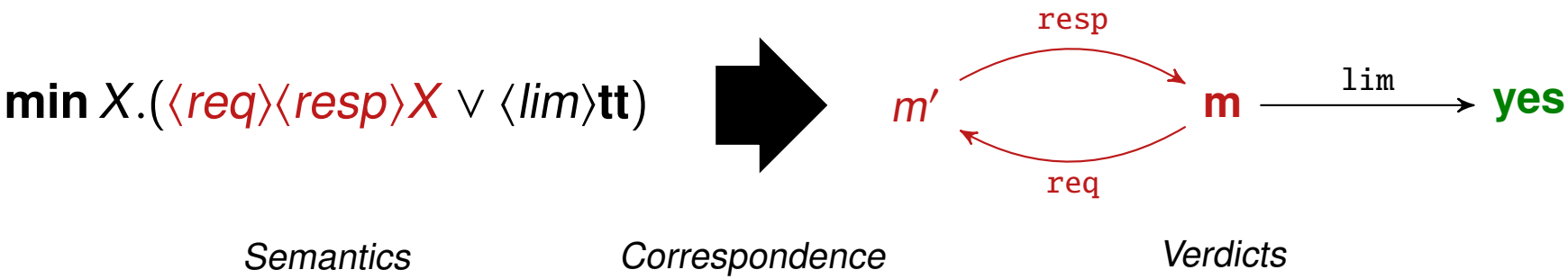

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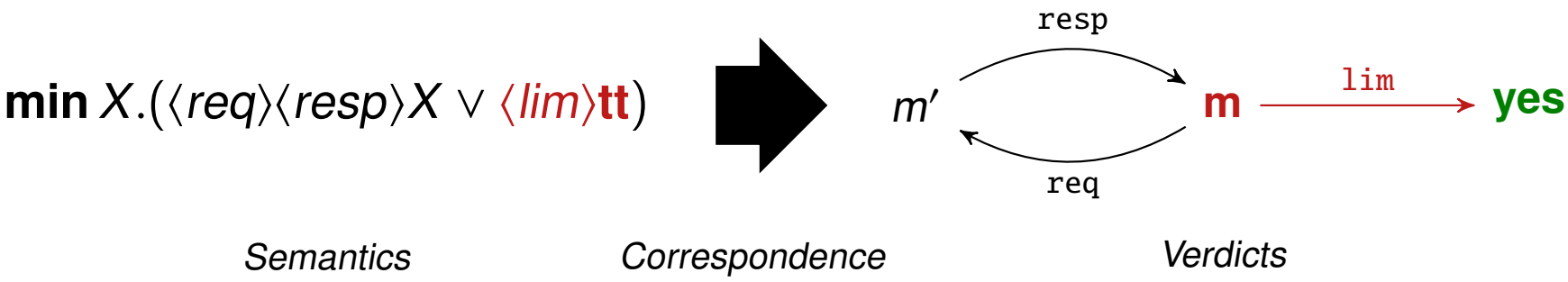

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Actions = Events with Data

- Why? Because we want to look at the *data* inside actions
- Events with structure permit us to use pattern matching
- Output events: $\alpha = \texttt{client}\ \mathbf{!}\ \{\texttt{resp}, 5\}$
- Input events: $\alpha = \text{server}\ \mathbf{?}\ \{\texttt{req}, \texttt{client}, 5\}$

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Example (Pattern variable binding)

A successor server *Srv* adds one to any numeric payload it receives from clients *Clt*

$$[\mathit{Srv}\ \mathbf{?}\ \{\texttt{req},\ \mathit{Clt},\ \mathit{Num}\}][\mathit{Clt}\ \mathbf{!}\ \{\texttt{resp},\ \mathit{Num}\}]\mathbf{ff}$$

Safety formula ensures that clients *do not* receive the same value *Num* sent by them to the server

The Tool Synthesis

Example (Non-recursive formula)

$[Srv\ \mathbf{?}\ \{\texttt{req}, Clt, Num\}][Clt\ \mathbf{!}\ \{\texttt{resp}, Num\}]\mathbf{ff}$

- Non-recursive formulae can only observe one interaction before terminating

The Tool Synthesis

Example (Recursive formula)

max X.(

$[Srv$ **?** $\{\texttt{req}, Clt, Num\}][Clt$ **!** $\{\texttt{resp}, Num\}]$**ff**

$\wedge$

$[Srv$ **?** $\{\texttt{req}, Clt, Num\}][Clt$ **!** $\{\texttt{resp}, Succ\}]X$

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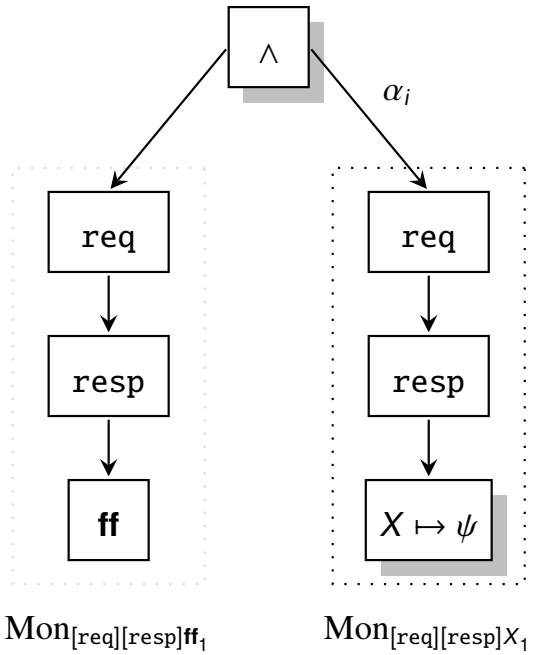

- Recursive formulae allow continuous monitoring
- The verdict branch matches events that lead to a detection
- The recursive branch permits the monitor to unfold *lazily*

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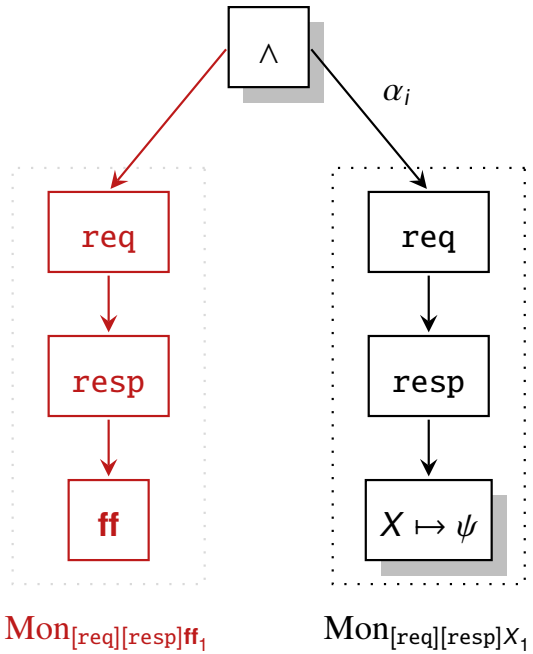

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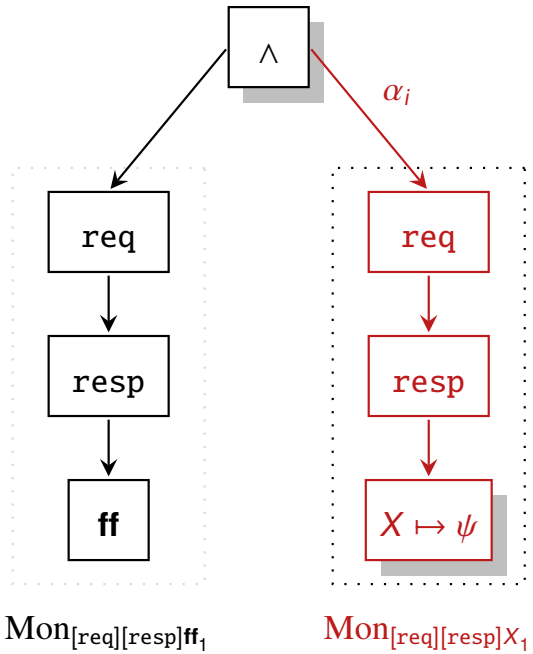

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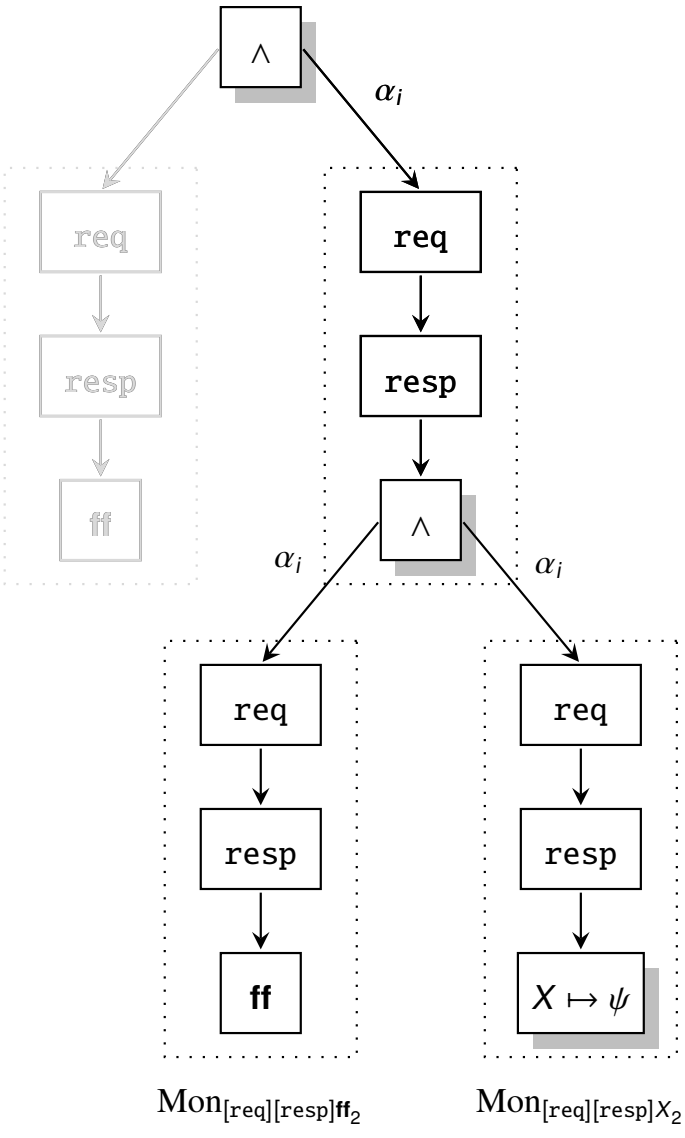

Formal *vs.* Tool Synthesis

$$[Srv\ \mathbf{?}\ \{\texttt{req}, Clt, Num\}][Clt\ \mathbf{!}\ \{\texttt{resp}, Num\}]\mathbf{ff}$$

```
formula:mon_nec(
  fun(Action) ->
    case Action of
      {recv, Srv, {req, Clt, Num}} ->
        formula:mon_nec(
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              _ -> formula:mon_id()
            end
          end);
      _ -> formula:mon_id()
    end
  end)
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Outline

Thank You!

Resources

The tool can be downloaded from:
`https://bitbucket.org/duncanatt/detecter-lite`

Information and publications from:
`http://www.cs.um.edu.mt/svrg/Tools/detectEr`

Questions?