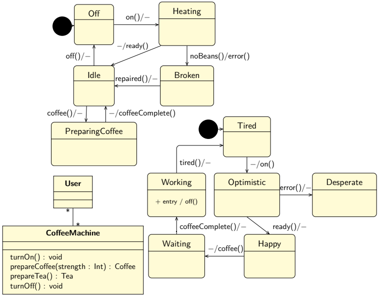
Towards Scenario-Based Testing of UML Diagrams

Magdalena Widl

Knowledge-Based Systems Group
Vienna University of Technology

Model-Driven Engineering

Model-Driven Engineering



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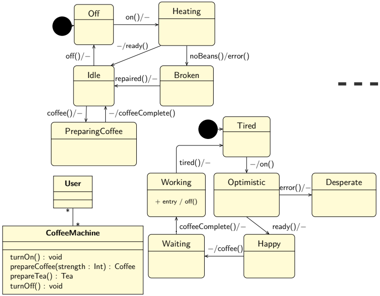


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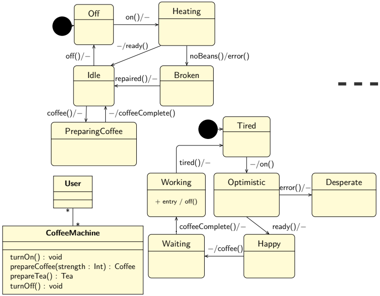

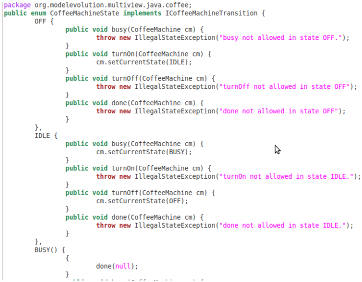

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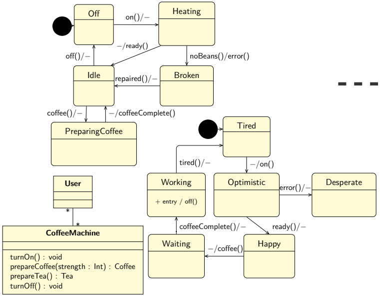
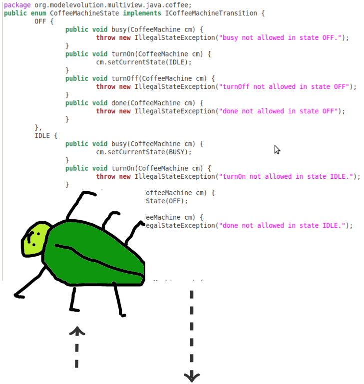
Software verification, testing

Model-Driven Engineering





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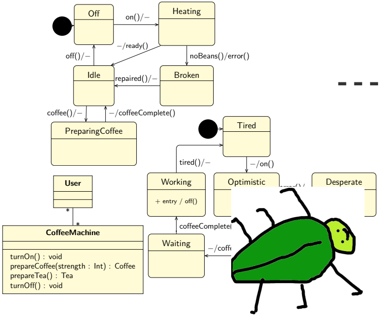

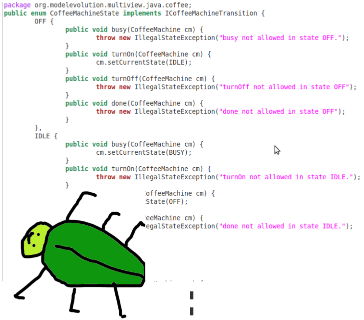

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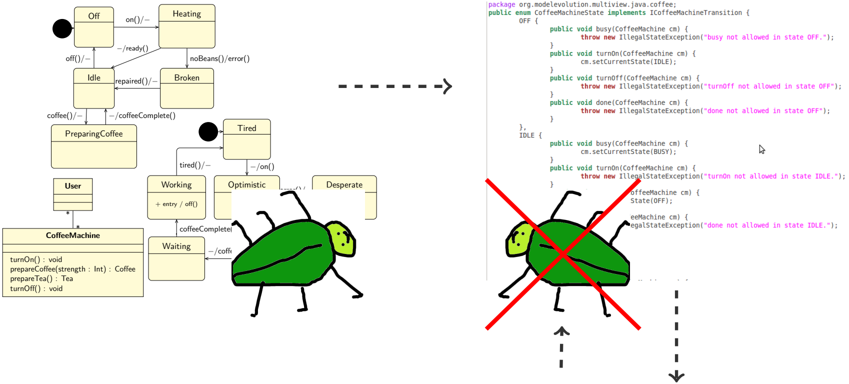

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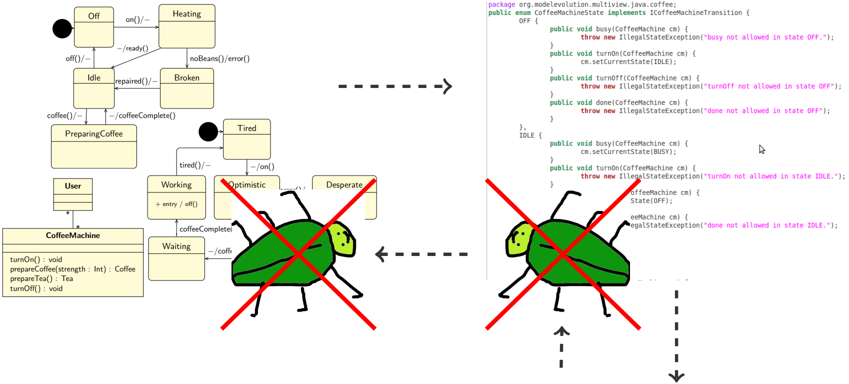

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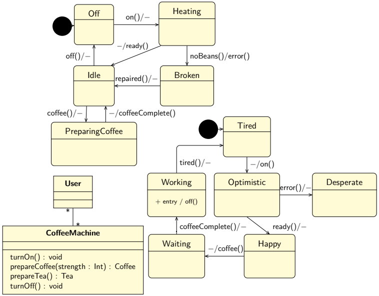

Model verification!

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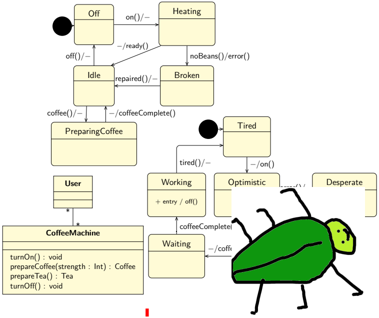

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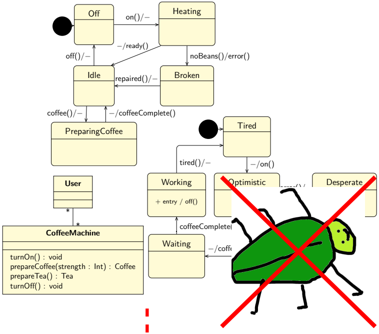

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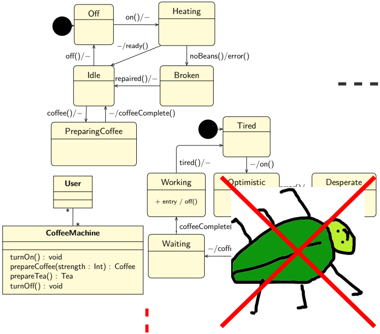


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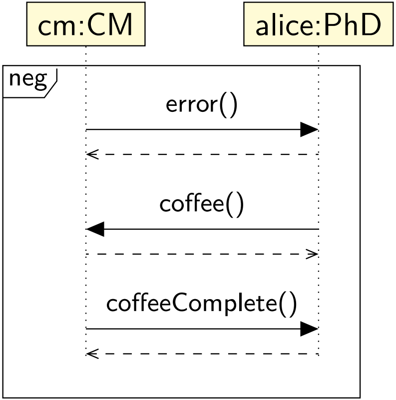
Model verification!

Scenario-based Testing

Scenarios can be represented by models



The Big Picture

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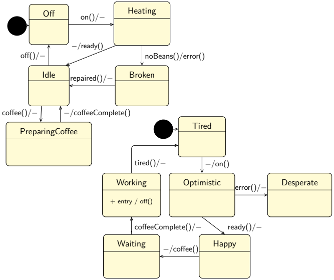
Model to generate code
(e.g. state machines)



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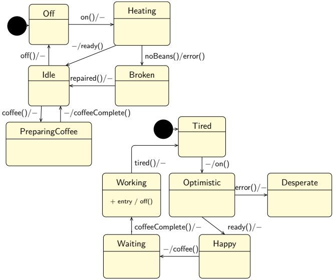
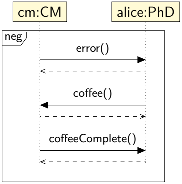


Scenario



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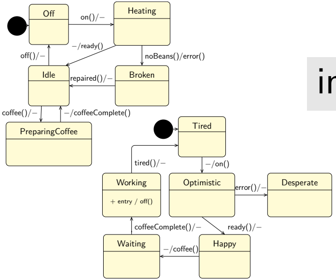

implements

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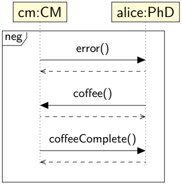

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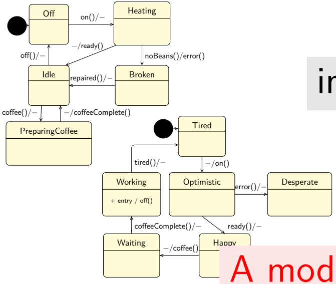

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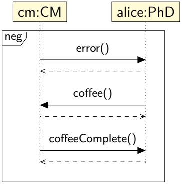

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A model checking problem!

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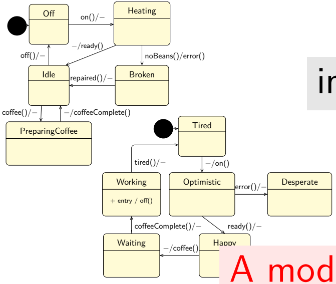

$\mathcal{K}$

Kripke structure

implements

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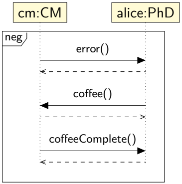
Scenario



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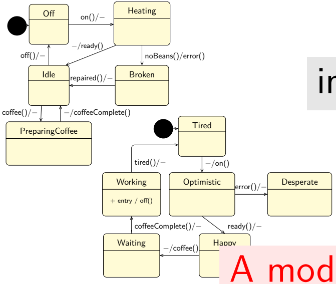

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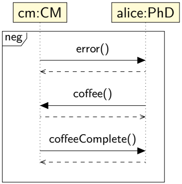

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Temporal logic

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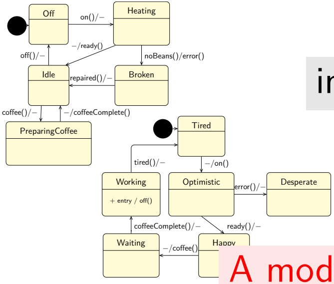

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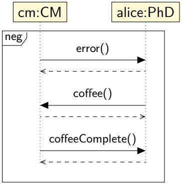

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Idea & Challenges

Use model checking to verify a set of state machines against a set of sequence diagrams.

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1. **Formal problem definition, formal semantics of models**
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Problem Instance

A triple $(\mathcal{A}, \mathcal{M}, \mathcal{S})$, where

- $\mathcal{A}$ a set of actions (vocabulary)
- $\mathcal{M}$ a set of state machines, and
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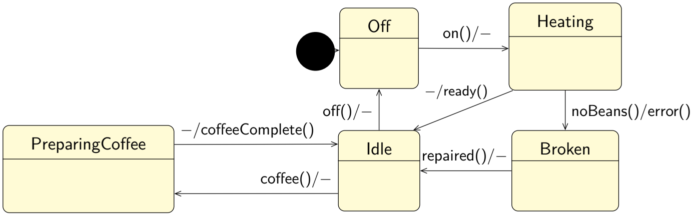

A quintuple $(S, \iota, A^{tr}, A^{eff}, T)$, where

- S is a set of states
- $\iota \in S$ is an initial state
- $A^{tr} \in \mathcal{A}$ is a set of triggers
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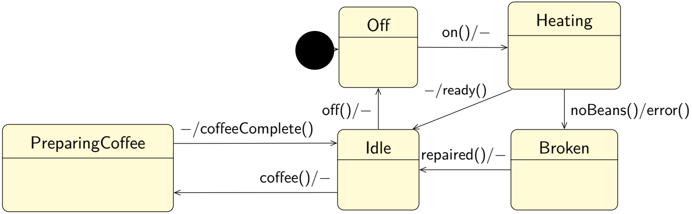
- $T \subseteq S \times A^{tr} \times P(A^{eff}) \times S$ is a set of transitions

State Machine



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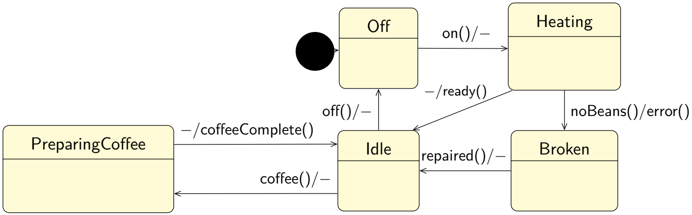

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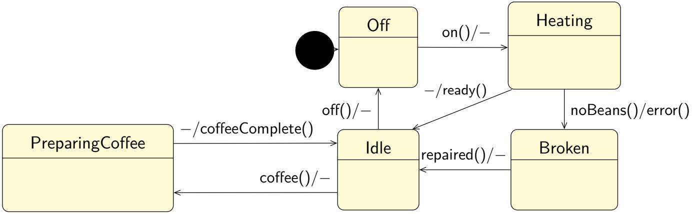

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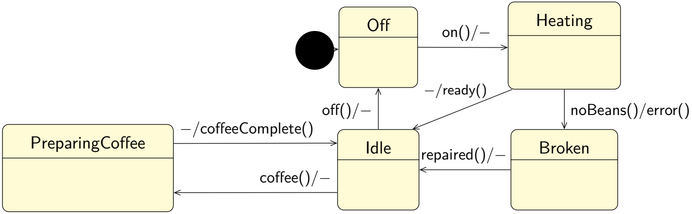

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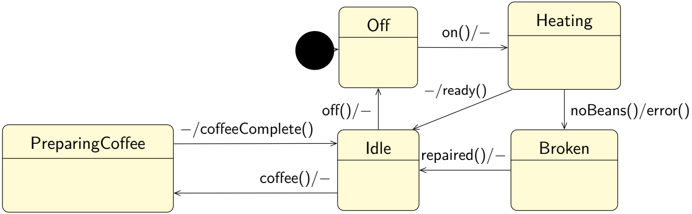

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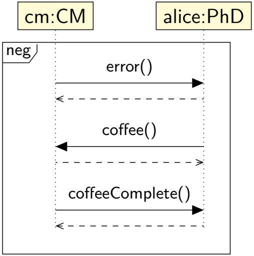
Sequence Diagram

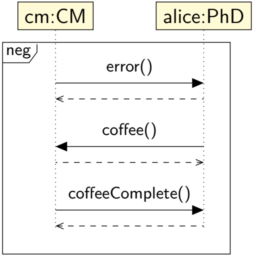


A triple (L, m, N), where

- L a set of lifelines
- $m : L \to \mathcal{M}$ a function assigning a state machine to each lifeline
- N a sequence of elements in $L \times \mathcal{A} \times L$

Only *neg* fragments.

Sequence Diagram



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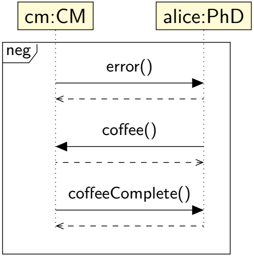

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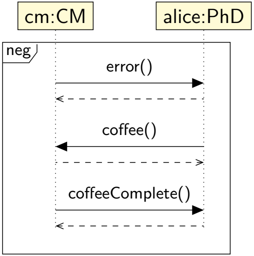

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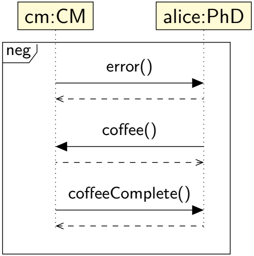

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Problem Definition

Given a set $\mathcal{M}$ of state machines

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Given a set $\mathcal{M}$ of state machines and a set $\mathcal{S}$ of *neg* sequences (scenarios),

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Given a set $\mathcal{M}$ of state machines and a set $\mathcal{S}$ of *neg* sequences (scenarios), does any $S \in \mathcal{S}$ occur on any path of the *composition* of $\mathcal{M}$?

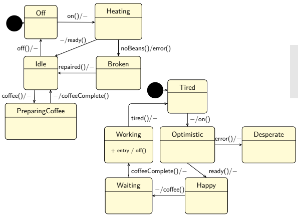
Idea & Challenges

Use model checking to verify a set of state machines against a set of sequence diagrams.

1. Formal problem definition, formal semantics of models
2. **Translation to model checker**
3. Presentation of result (counterexample)

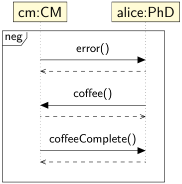
Model Checking with SPIN

State machines



implements

Scenario



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$\mathcal{K}$ $\models$ ϕ ?

Kripke structure

Temporal logic

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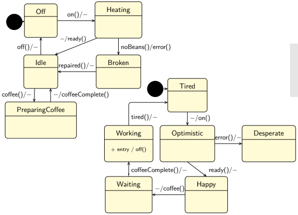

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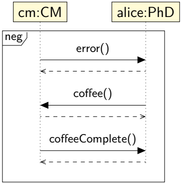

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Temporal logic

PROMELA processes

Never claims (Buchi Automata)
or (no)trace assertions

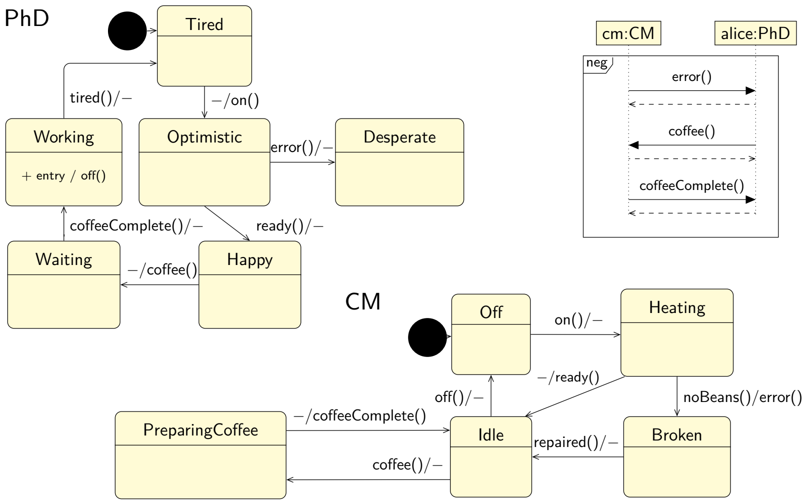
Encoding

Model Checker SPIN

- Each state machine a process
- Communication over synchronous channels
- Each sequence diagram a (no)trace assertion

Automatic code generation

Example


PhD
Tired
tired()/−
−/on()
Working
+ entry / off()
Optimistic
error()/−
Desperate
coffeeComplete()/−
ready()/−
Waiting
−/coffee()
Happy
cm:CM
alice:PhD
neg
error()
coffee()
coffeeComplete()
CM
Off
on()/−
Heating
−/ready()
off()/−
noBeans()/error()
PreparingCoffee
−/coffeeComplete()
Idle
repaired()/−
Broken
coffee()/−

Encoding

```
mtype = {on,off,ready,error,
coffee,complete};

chan phd = [0] of {mtype};
chan cm = [0] of {mtype};

active proctype PhD() {
mtype x;

Tired: atomic{cm!on;goto Optimistic;}

Optimistic: atomic{ phd?x;
    if :: x == error; goto Desperate;
       :: x == ready; goto Happy; fi;}

Desperate: goto Tired;

Happy: atomic{cm!coffee;goto Waiting;}

Waiting:
    atomic{phd?complete;goto Working;}

Working: atomic{ cm!off; goto Tired; }
}
```

```
active proctype CM() {
mtype x;

Off: atomic{ cm?on; goto Heating; }

Heating: atomic{
     if :: phd!error; goto Broken;
        :: phd!ready; goto Idle; fi;}

Broken: goto Off;

Idle: atomic{cm?x;
      if :: x == off; goto Off;
         :: x == coffee;
            goto PreparingCoffee; fi;}

PreparingCoffee:
     atomic{ phd!complete; goto Idle;}
}

notrace {    if ::    phd?error;
             cm?coffee;
             phd?complete; fi;
}
```

Challenges

1. Formal problem definition, formal semantics of models

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    - ✓ Definition of restricted state machine

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   - ✓ Prototype in SPIN

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   - ✗ Better encodings in other model checkers

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3. Presentation of result (counterexample)
   - ✗ Concrete syntax

Related Work

- Cimatti et al.: Hybrid Automata and Message Sequence Charts
- Li et al.: Petri nets and Message Sequence Charts
- CHARMY tool suite: Software Architecture with componen, state transition and sequence diagrams
- HUGO: State machines and collaboration diagrams with SPIN
- Other works in the area of synthesis (e.g. Uchitel et al.)