Coverage-Based Testing with Symbolic Transition Systems

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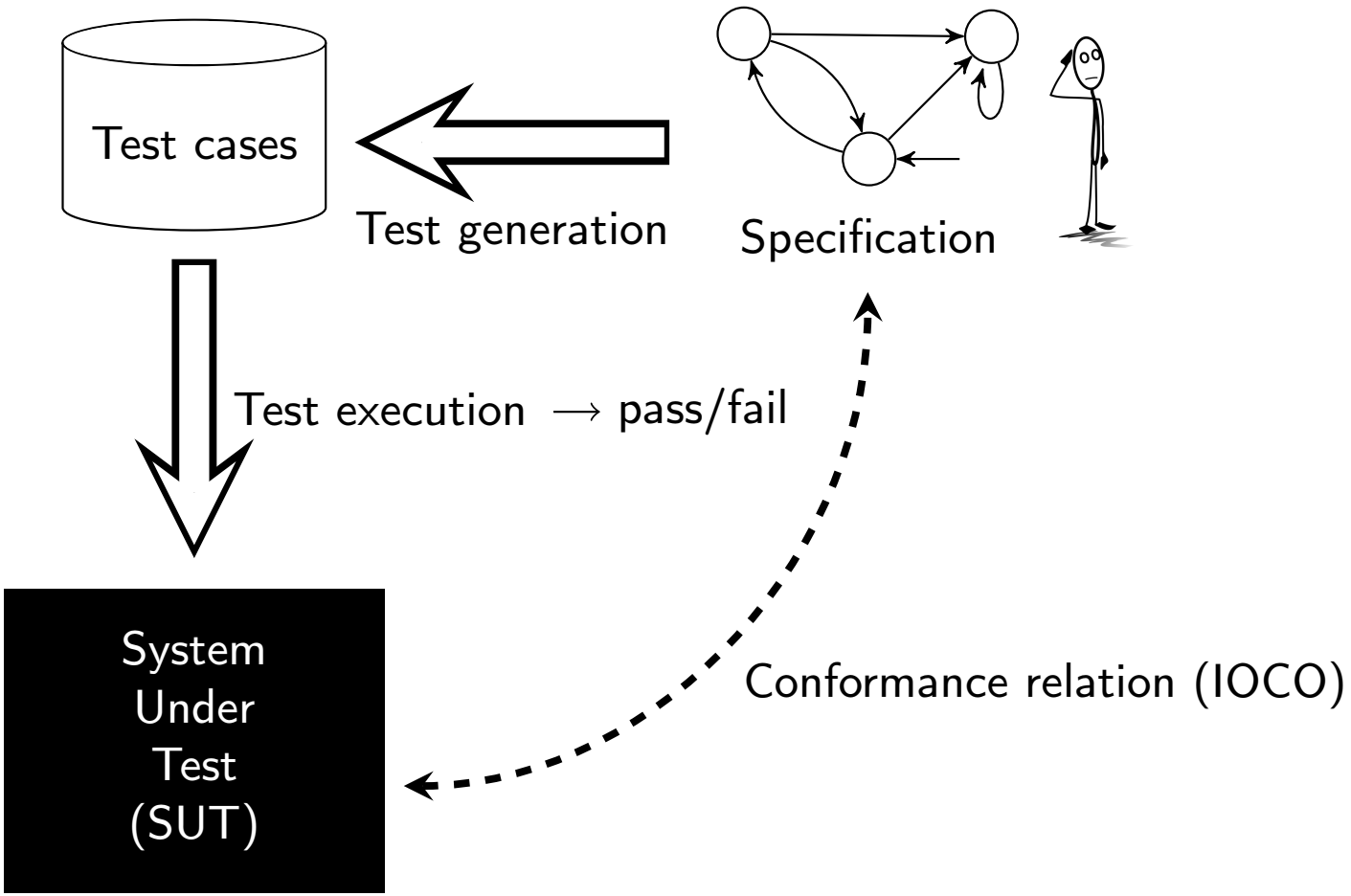
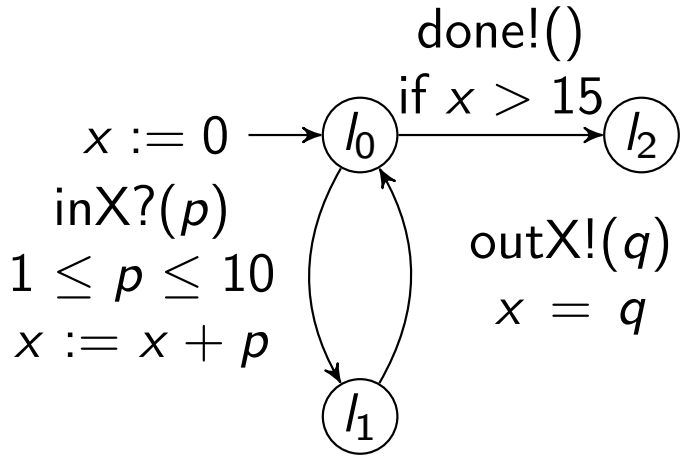
Model-Based Testing



Testing Systems with Control Flow and Data

- Present-day systems use both:
  - control flow: states, actions
  - data: variables, parameters, conditions ...



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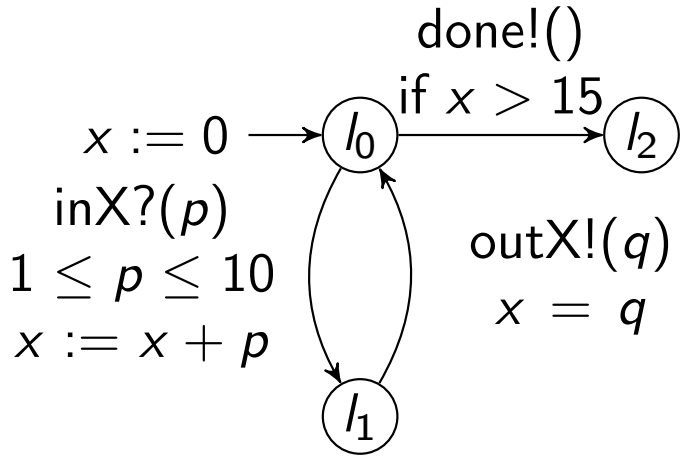

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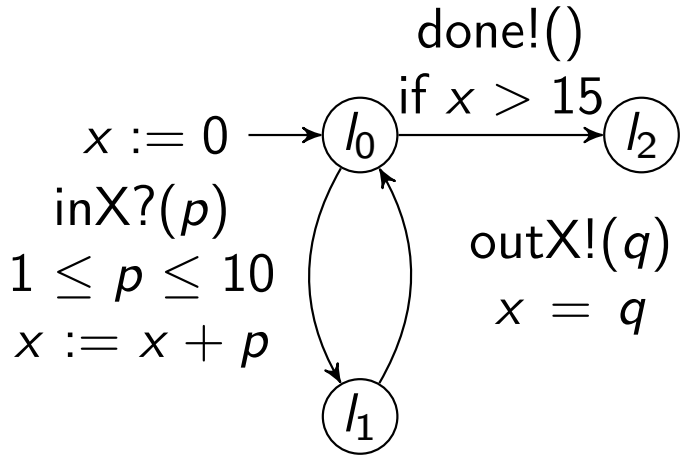
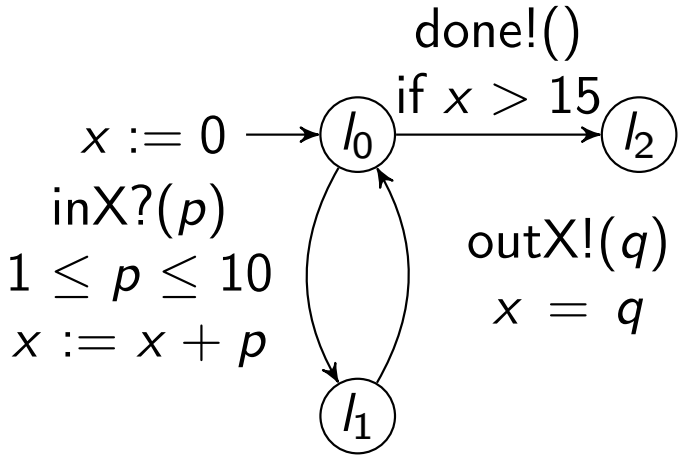
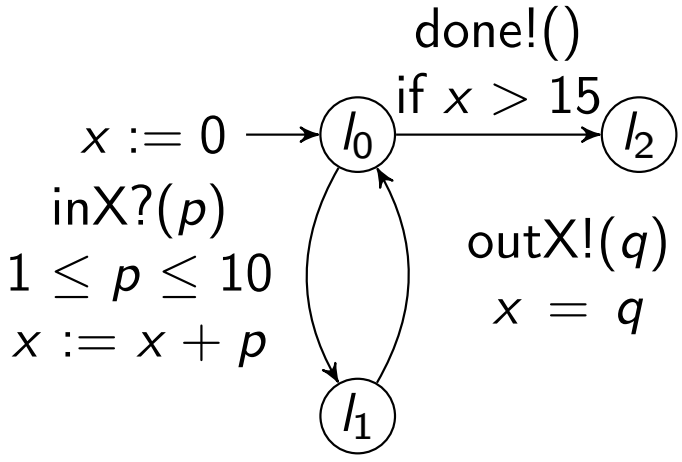


- How to deal with state space explosion
- ... and bound test execution time?
- Use switch coverage for test selection!

Model: Symbolic Transition System



Switch coverage in STS: Reachability & Data



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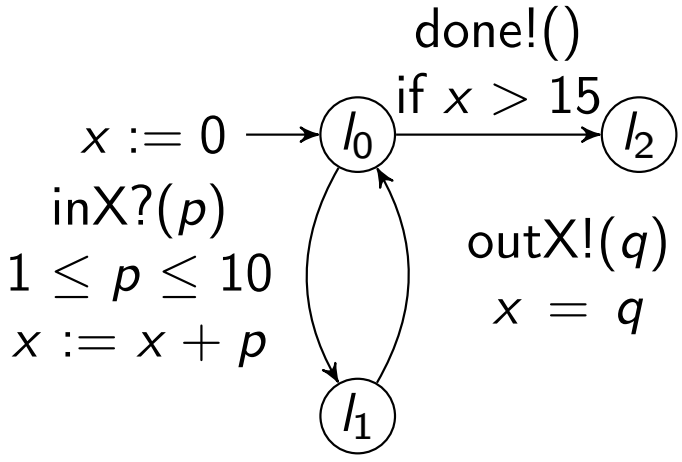

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- inX?(6)
- outX!(6)

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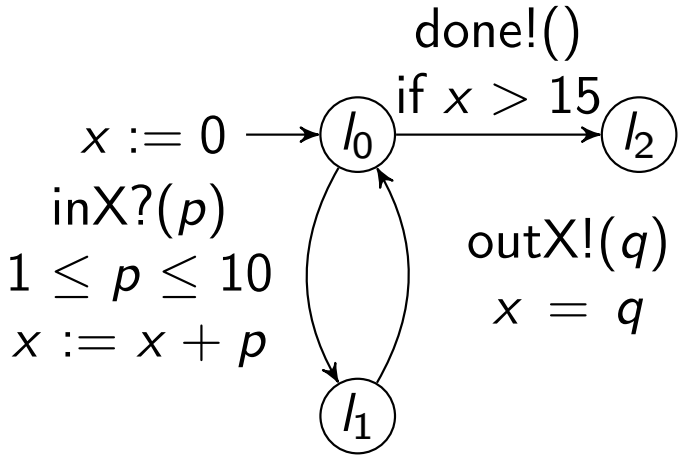

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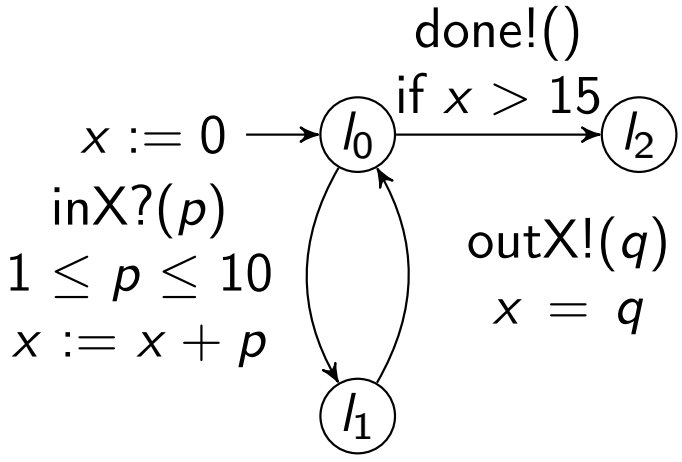

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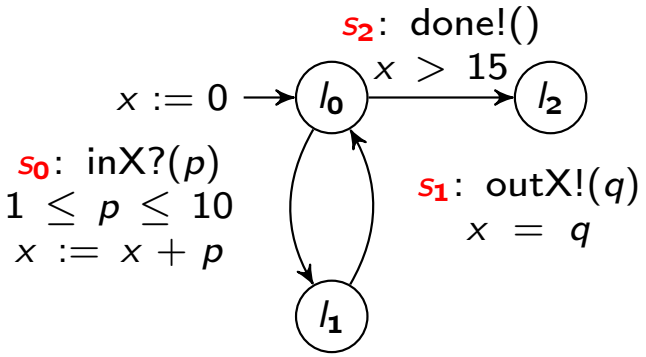
- done!()

Contributions

- Switch coverage test selection
- On-the-fly parameter value generation
- Deal with SMT solvers returning Unknown

Switch coverage test generation

- Obtain test purposes using Symbolic Execution



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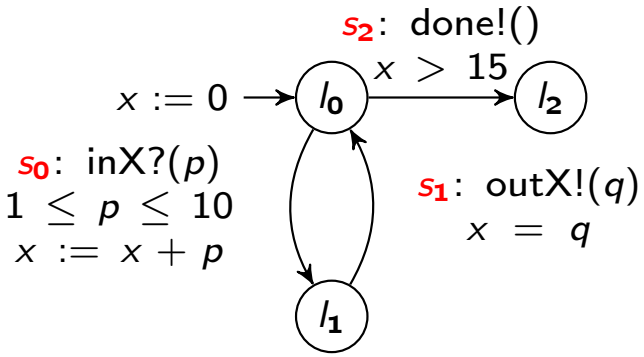

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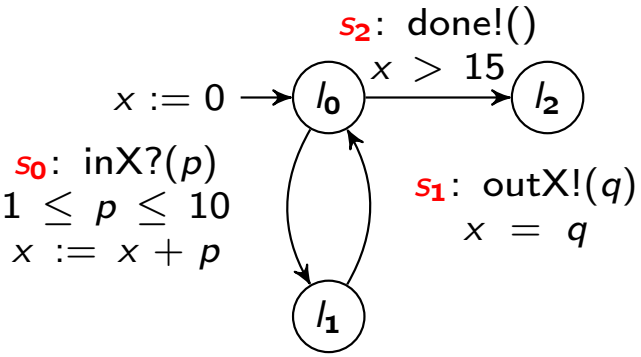

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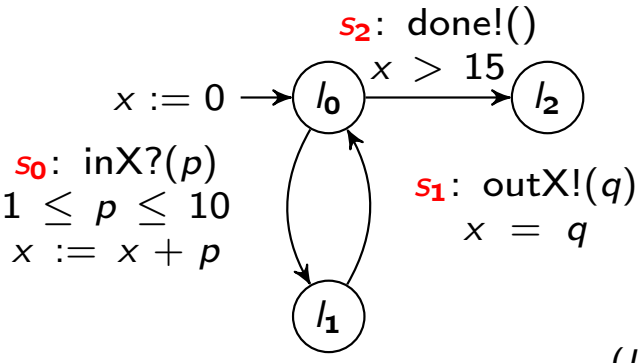

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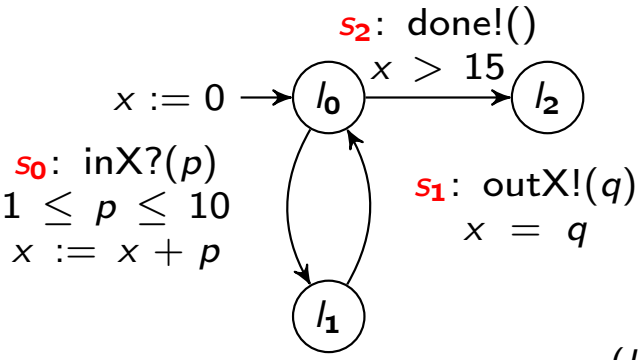

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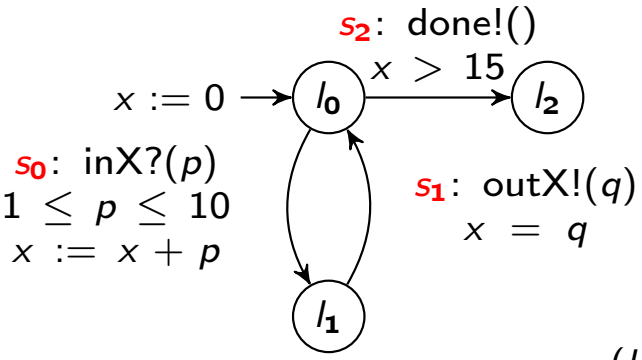

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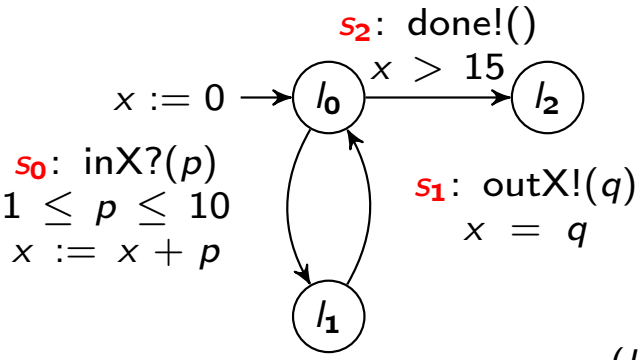

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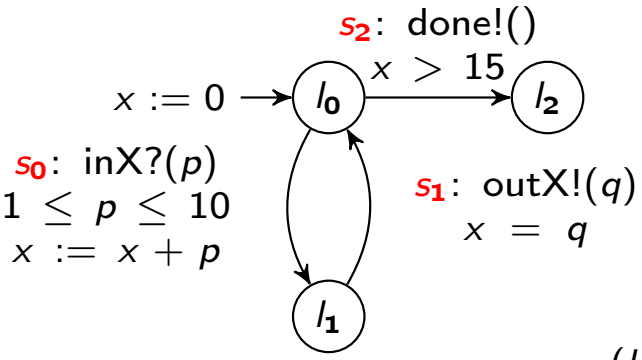

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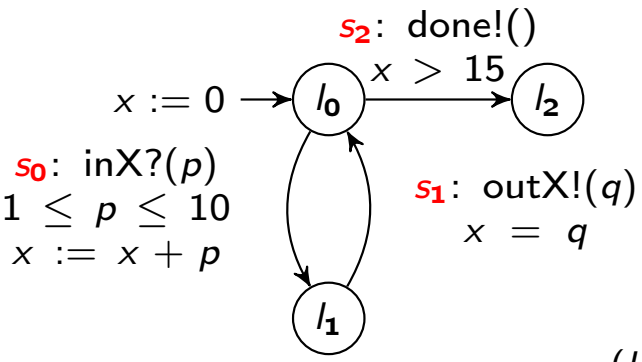

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s_0 ↙ $\quad$ s_2 ↘

$$(l_0, \{x \mapsto 0 + p'''' + p'' + p\}, 1 \leq p \leq 10 \wedge q' = 0 + p'''' + p'' \wedge 1 \leq p'' \leq 10 \wedge q''' = 0 + p'''' \wedge 1 \leq p'''' \leq 10)$$

$$(l_2, \{x \mapsto 0 + p'''' + p''\}, 0 + p'''' + p'' > 15 \wedge q' = 0 + p'''' + p'' \wedge 1 \leq p'' \leq 10 \wedge q''' = 0 + p'''' \wedge 1 \leq p'''' \leq 10)$$

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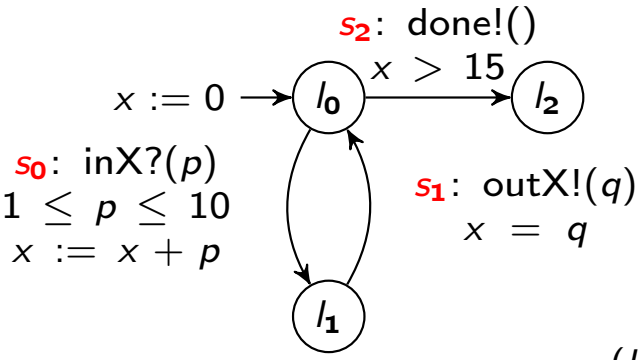

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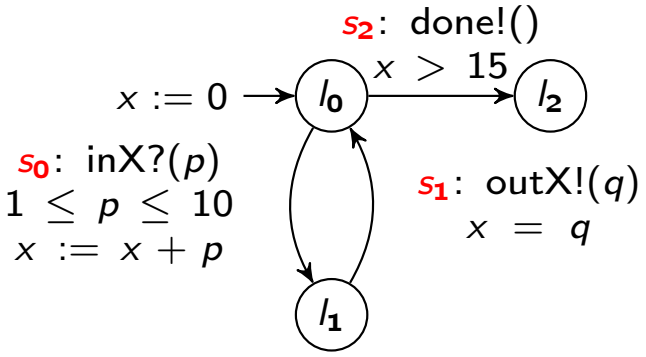

- A test purpose consists of
  - Sequence of swiches: $s_0 s_1 s_0 s_1 s_2$
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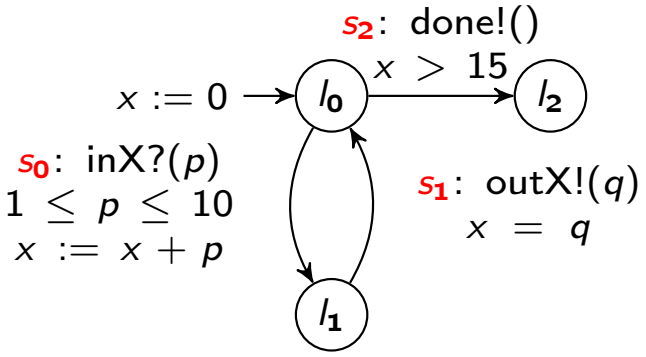

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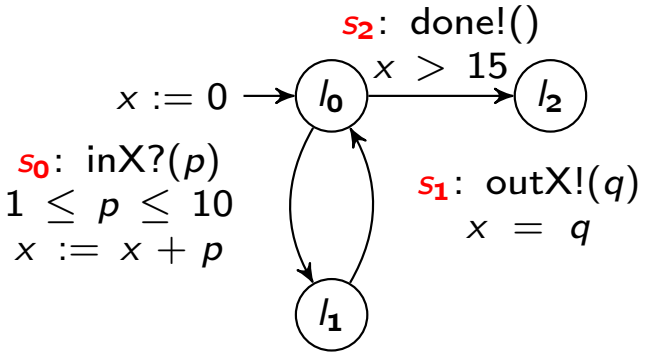

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- Guard x = 6 holds; state: $(l_0, x := 6)$

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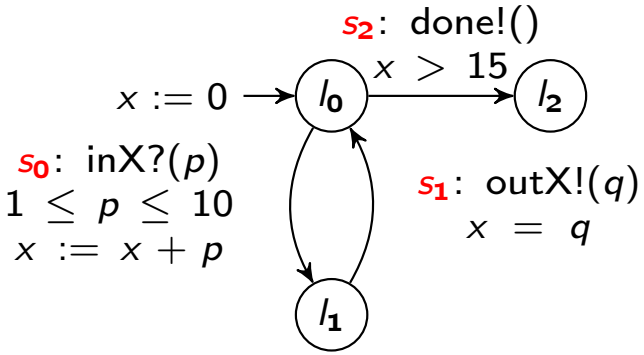

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- Substitute values: $0 + 6 + p'' > 15 \wedge q' = 0 + 6 + p'' \wedge 1 \leq p'' \leq 10 \wedge 6 = 0 + 6 \wedge 1 \leq 6 \leq 10$

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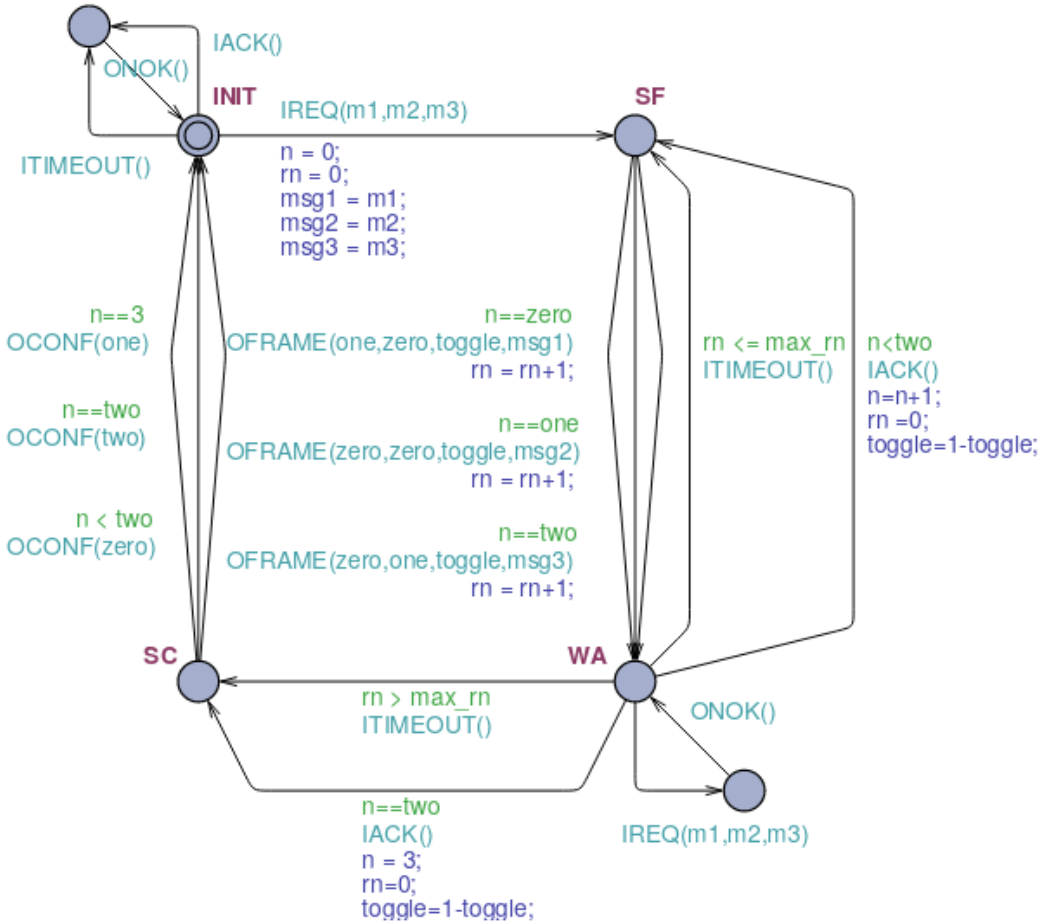
- After execution: a-posteriori coverage

Implementation

- Obtaining test purposes: Maude & Z3
- Test execution: Python & Z3

Case study: Bounded Retransmission Protocol

- BRP: benchmark from the Automata Wiki (`http://automata.cs.ru.nl/`)



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	Switch coverage	TorXakis
Mutant 1	44	12
Mutant 2	16	234
Mutant 3	8	12
Mutant 4	6	18
Mutant 5	18	1620
Mutant 6	164	76
Sum	256	1972
Geometric mean	21.5	64.9

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Sum	256	1972	8 times more!
Geometric mean	21.5	64.9	3 times more!

Conclusions

- Switch coverage test selection
- On-the-fly parameter value generation
- Deal with SMT solvers returning Unknown

Future work

- Add data-coverage techniques to switch coverage

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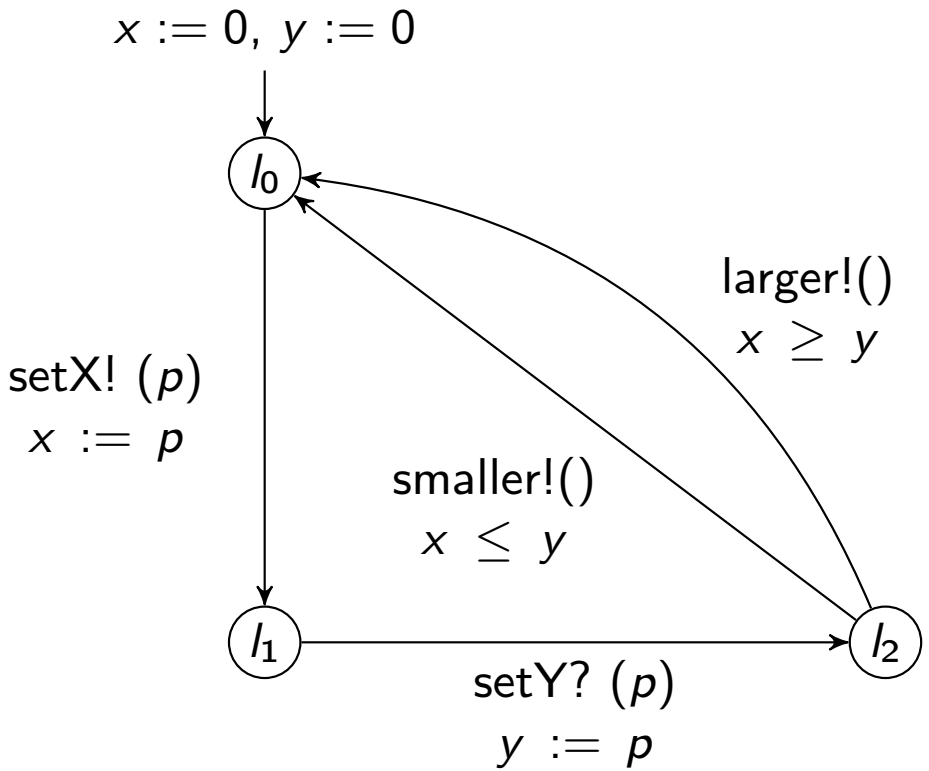
- More case studies

Thank you for listening!

Questions?

Generate inputs at latest moment



Cannot choose inputs parameters that always work