Bridging the Gap: Consistent SystemC Code Generation for Multi-Abstraction-Level State Charts

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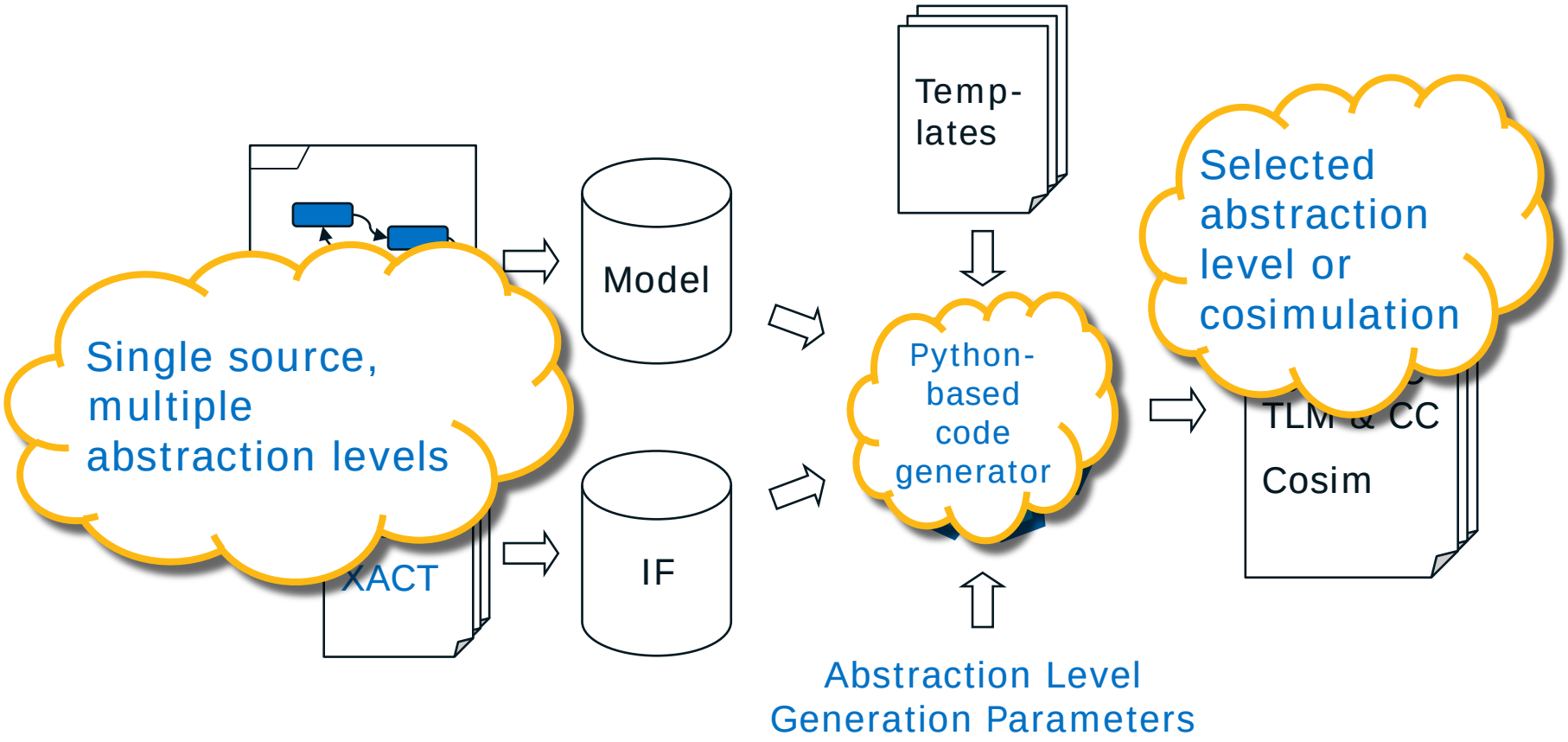
Agenda

1. **Single Source Modeling and Code Generation**
2. Ensuring Consistency
3. Results
4. Summary

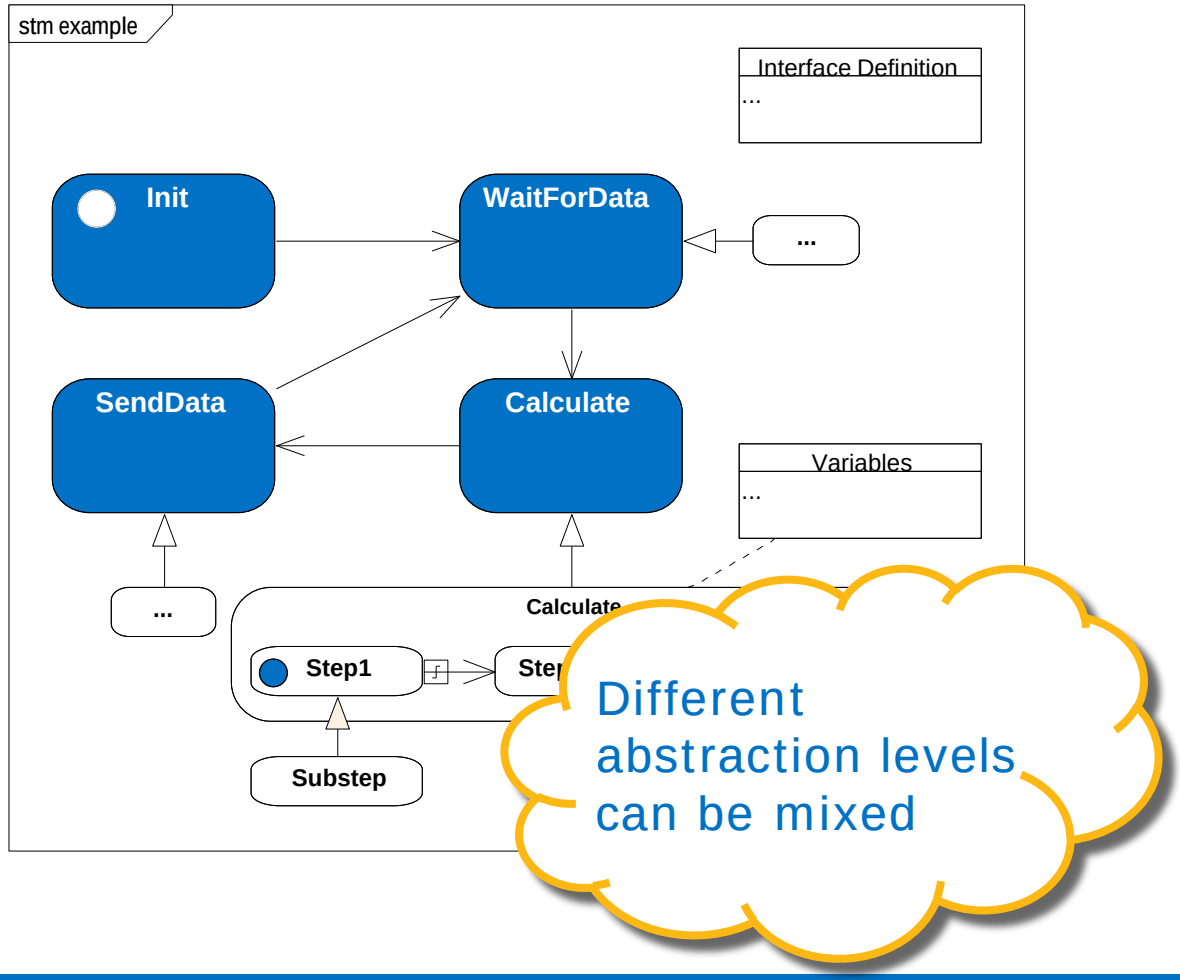
Code Generation



Single Source, Multiple Abstraction Levels

User View: UML profile

- Integrate with standard UML
- Support multiple abstraction levels for behavior and interface
- Allow consistent modeling style
- Reference interface definition



Advantages

1 Model Reuse

- Don‘t throw away high-level models
- Reuse and refine

2 Consistent Changes

- Minimize need to modify several models
- Make corresponding parts visible

3 Mix and Match

- Different applications have different requirements
- Allow mixing different abstraction levels in a single model

4 Verification Support

- Ease verification of refinement
- Localize errors easier and earlier

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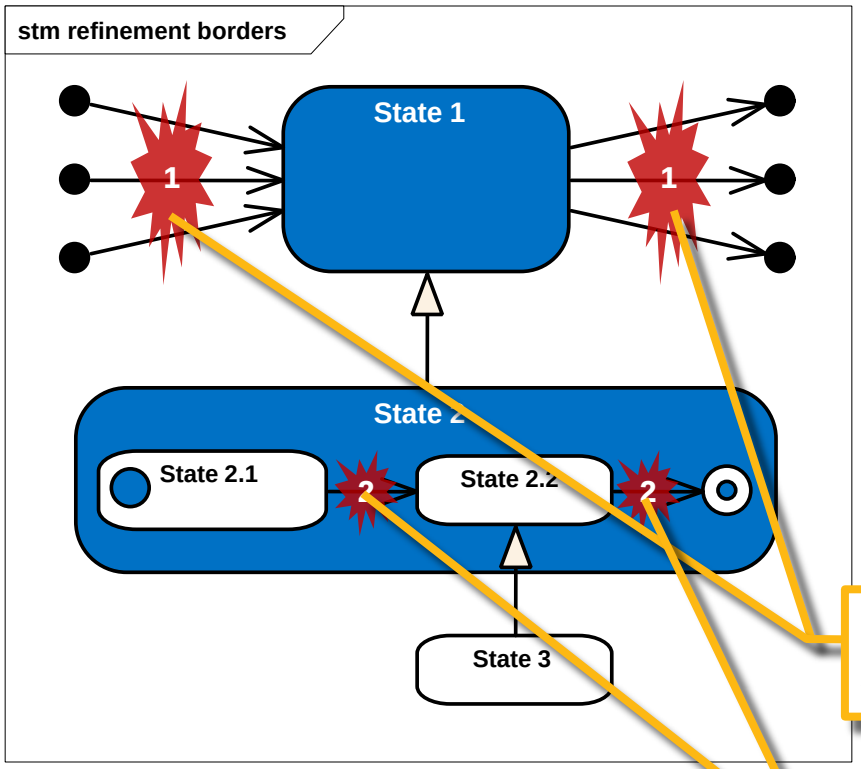
Consistency under Refinement

- Approach allows arbitrary code in the State Chart
  - Rules out existing static consistency approaches

- Cosimulation to check two abstraction levels:
  - Compare refinement to original
  - Use scoreboards to keep track of consistency
  - Currently no automation of testbench

Consistency under Refinement: States



State Refinement

- Liskov Substitution Principle
- Undecidable in general
- Cosimulation based on refinement borders
- Automatic scoreboard generation allows tests during cosimulation

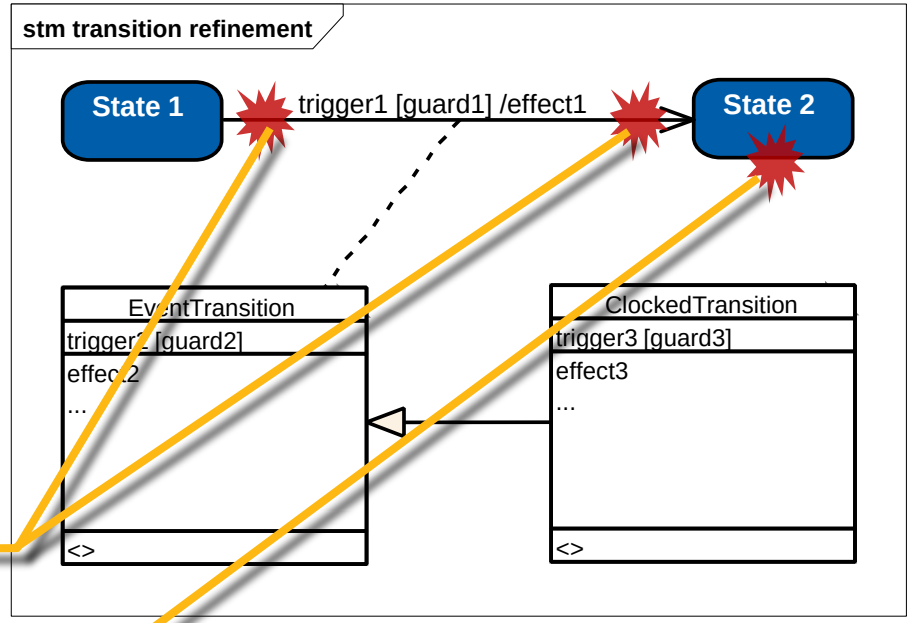
Scoreboard for refining state 1 by state 2

Scoreboard for refining state 2.2 by state 3

Consistency under Refinement: Transitions

Transition Refinement

- Behavior: Liskov Substitution Principle
- State trajectory: additional scoreboard required



Scoreboard for effect

Scoreboard for state trajectory

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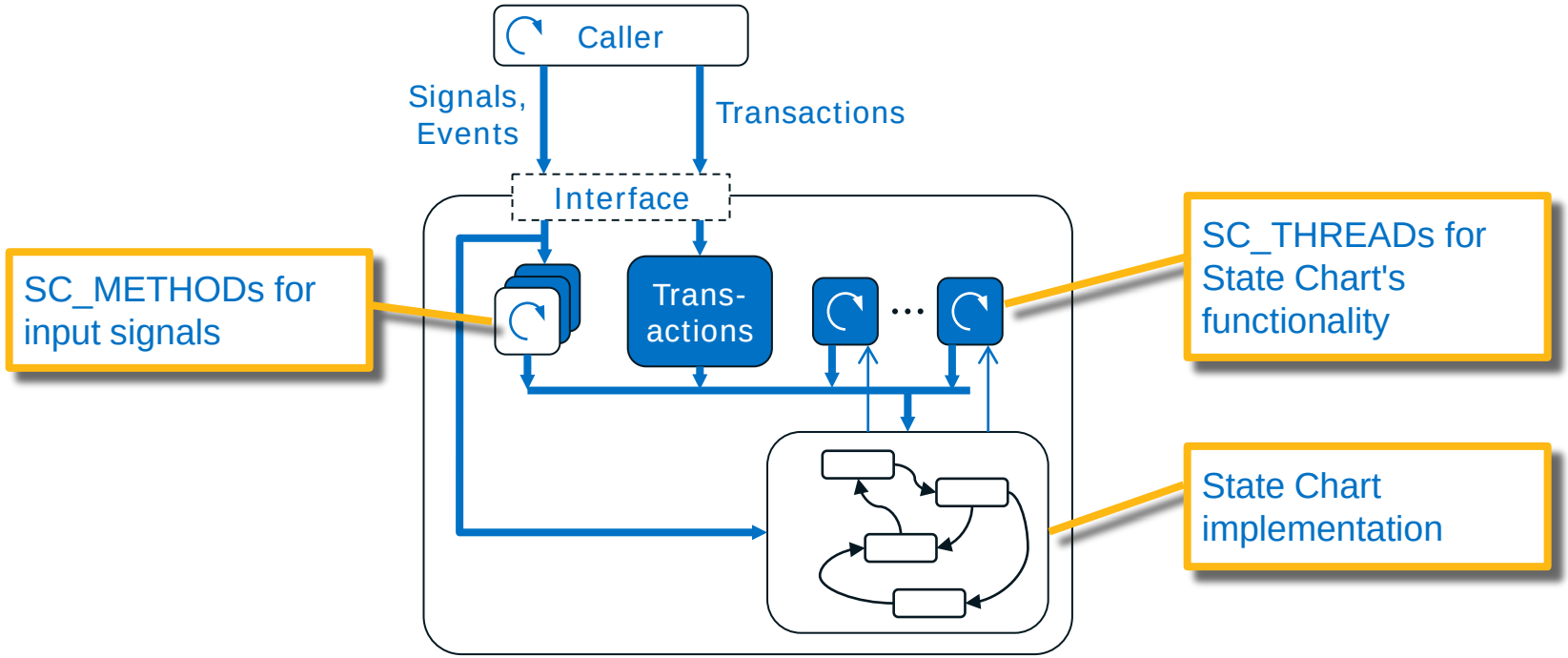
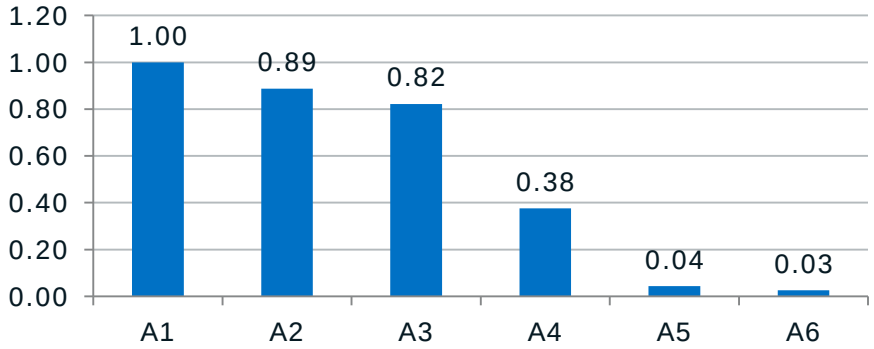
Code Generation: Module Structure

- Module is generated automatically
- Only transactions are defined externally (by deriving)
- Blue elements: Not used in cycle callable model

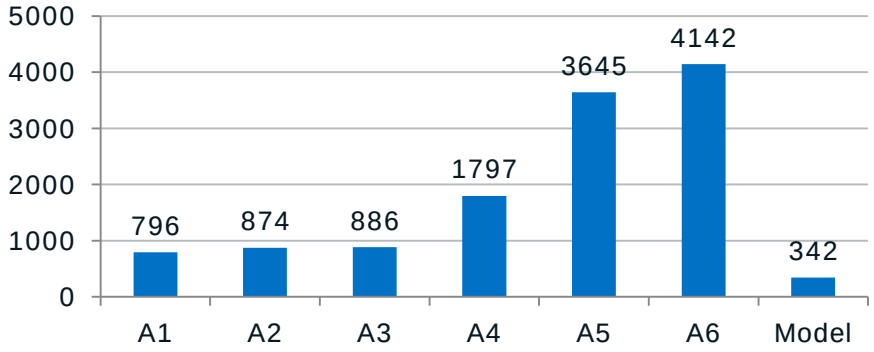


Results: AES Encryption Core

- Performance, normalized to highest



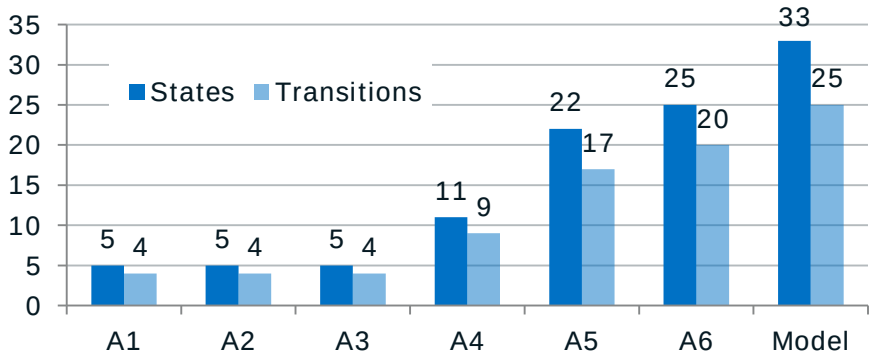
- Generated lines of code for model



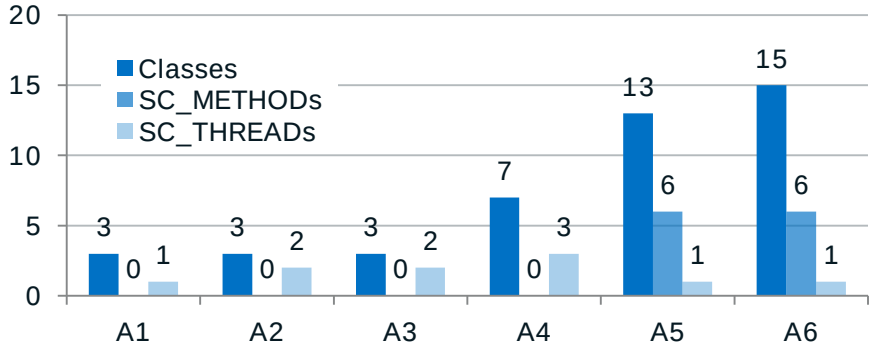
Abstraction Levels
A1 OpenSSL (3rd party library)
A2 A1 with timing
A3 Software model, timed
A4 A3, AT
A5 partly CC
A6 CC
A1-4 Transaction IF
A5-6 Pin-true IF

Results: AES Encryption Core

- Elements on the different abstraction levels



- Structure of the generated code



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Results: AES Encryption Core

- Number of scoreboards generated for checking consistency in cosimulation

Refined Model	Original Model: A1 S	A1 T	A1 R	A1 Σ	A2 S	A2 T	A2 R	A2 Σ	A3 S	A3 T	A3 R	A3 Σ	A4 S	A4 T	A4 R	A4 Σ
A2	1	0	0	*1*	-	-	-	-	-	-	-	-	-	-	-	-
A3	1	0	0	*1*	1	0	0	*1*	-	-	-	-	-	-	-	-
A4	1	2	1	*4*	1	2	1	*4*	3	3	2	*8*	-	-	-	-
A5	1	2	1	*4*	1	2	1	*4*	3	3	2	*8*	1	0	0	*1*

S, T, R, Σ: # of Scoreboards for States, Transitions, Regions, and total

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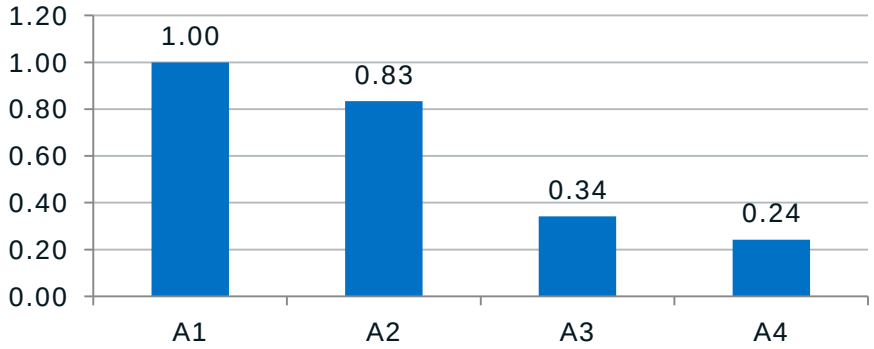
Results: MIPS Core

- Performance, normalized to highest



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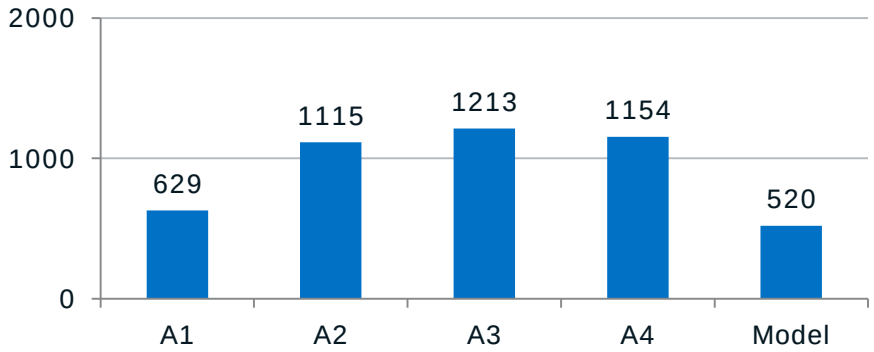

Abstraction Levels
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A2 Untimed with hierarchy
A3 AT
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A1-3 Transaction IF
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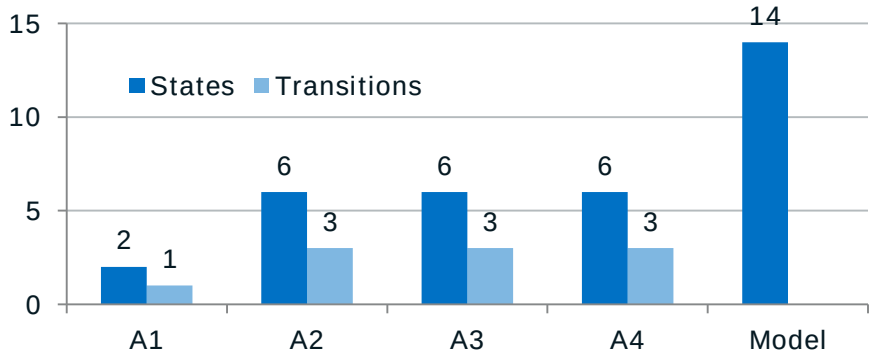
Results: MIPS Core

- Elements on the different abstraction levels



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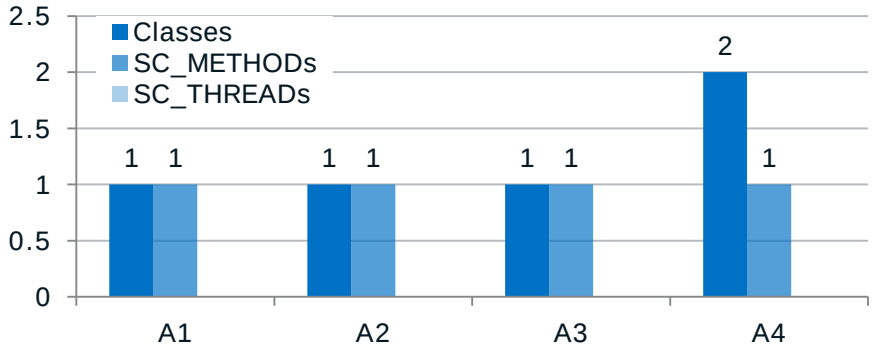

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A3	1	0	0	*1*	0	4	1	*5*	-	-	-	-
A4	1	0	0	*1*	0	4	1	*5*	0	4	1	*5*

S, T, R, Σ: # of Scoreboards for States, Transitions, Regions, and total

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Summary

- We presented
  - a single-source modeling approach
  - based on UML for behavior specification
  - and a code generation framework that allows
  - generating a required abstraction level or
  - generating a cosimulation framework for
  - consistency checking.

- Further work:
  - More static code checking
  - Model optimizations to further improve performance


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Thank you!