Statistical Model Checking of Approximate Circuits: Challenges and Opportunities

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It is about a cost/quality trade-off

Many researchers have proposed approaches for finding a **trade-off** between the approximation error and resource savings **for predefined applications** of approximate circuits.

Some approximation domains are neglected

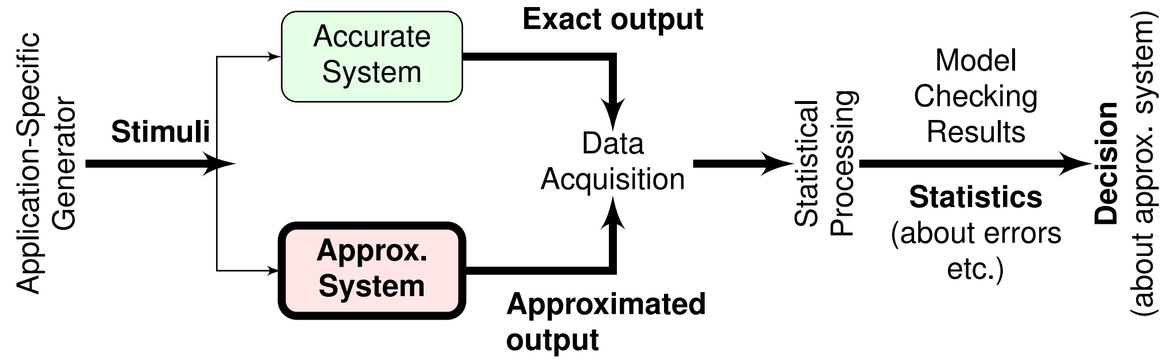
Generally, an approximation can be done in the two domains:

- **Logical** – most of the approaches, however, approximate data (e.g., the static function/structure of a combinational circuit) rather than sequential behavior and/or control flow (e.g., power/load management in a CPU),
- **Temporal** – approximations in this domain seem untouched by existing approaches.

We are building a framework to handle ...

... approximations related to dynamic aspects of systems and adverse phenomena such as jitters, aging/stress, faults etc.

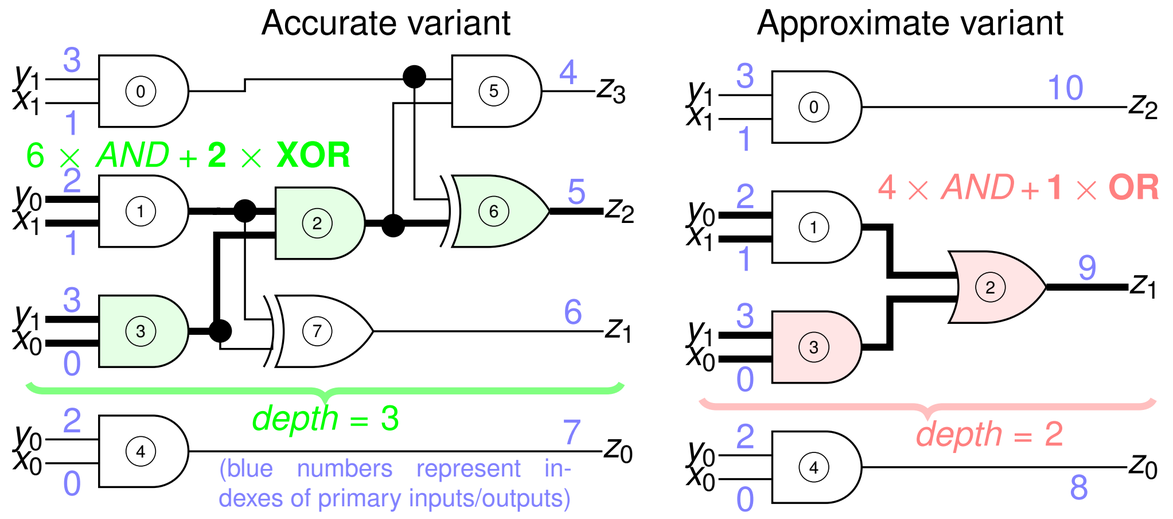
Block schema of our framework



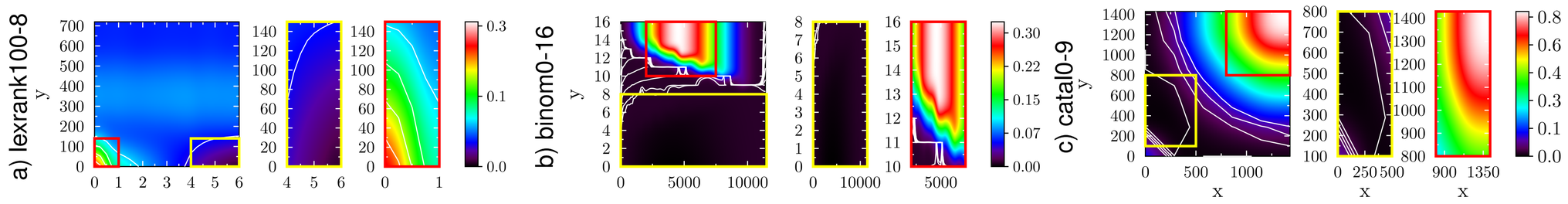
Example: An approximation in the logical domain (2-bit multiplier based on [1])

Truth table for the accurate and approximate variants of the multiplier

$x_1 x_0$ \ $y_1 y_0$	00	01	10	11
00	0000	0000	0000	0000
01	0000	0001	0010	0011
10	0000	0010	0100	0110
11	0000	0011	0110	**1001** **0111**
	$z_3 z_2 z_1 z_0$			



Heat maps of probability density functions (PDFs) for (x,y) pairs in selected applications

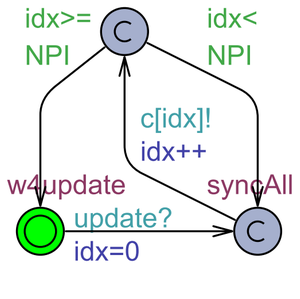


Key components of our model

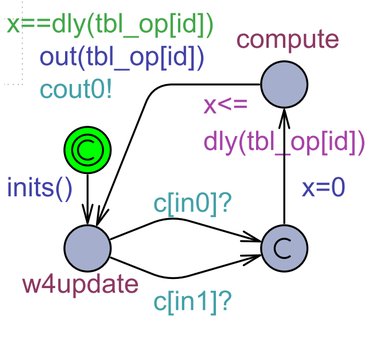
Generator of stimuli:

Equivalence checker:

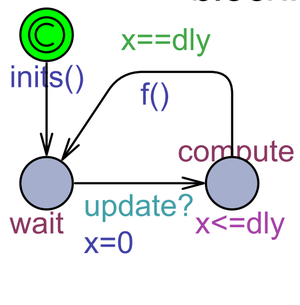
Primary input synchronization:



2-input logical gate:



Higher-level block:



Example: Queries and results

(Q1) `simulate [<=`t_{max}`;n] {`ϕ`}`

(Q2) `Pr[<=`t_{max}`] (<>coveR>87.5%)`
(Q3) `E[<=`t_{max}`; n] (max:tcover)`
(Q4) `E[<=`t_{max}`; n] (max:sumDiff)`
(Q5) `Pr[<=`t_{max}`] (<>errR > 5%)`

Probability density functions (PDFs)

References

[1] P. Kulkarni, P. Gupta, and M. Ercegovac, "Trading Accuracy for Power with an Underdesigned Multiplier Architecture," in *24th Internatioal Conference on VLSI Design*. Los Alamitos: IEEE, 2011, pp. 346–351, DOI 10.1109/VLSID.2011.51.

[2] A. David, K. Larsen, A. Legay, M. Mikucionis, and D. Poulsen, "Uppaal SMC Tutorial," *International Journal on Software Tools for Technology Transfer*, vol. 17, no. 4, pp. 397–415, 2015. DOI 10.1007/s10009-014-0361-y.

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