Matrices of Multiple Weights for Test Response Compaction with Unknown Values

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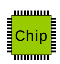
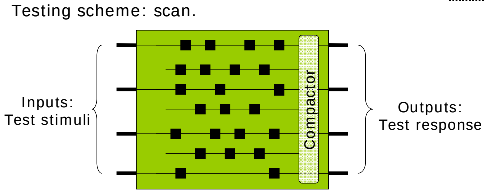
Overview

- Introduction to test response compaction.
  - Motivation.
  - Compaction technique.
- Problem caused by unknown values.
  - Impact on current compaction technique.
  - New scheme:
    - Main idea.
    - Properties and evaluation.
- Conclusion and Future work.

Need for compaction

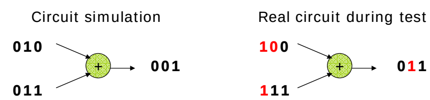
- Ubiquitous Networked Media Computing: need for circuits for intensive computation and with high reliability.
- Our focus: test VLSI circuits (processor, ASIC…)
  - Complexity, desired reliability.
  - Economics: fast test required (cost=1yen/sec).
- Testing scheme: scan.





Compaction technique

- Example: parity check.



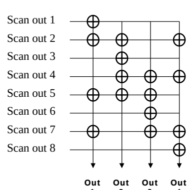
- In general, compactor characteristics are:
  - Compaction ratio.
  - Error detection capabilities.

Linear compactors

- Compactors implemented with xor trees and represented by matrices.

$$n \text{ inputs} \quad \begin{pmatrix} 1 & 0 & 0 & 0 \\ 1 & 1 & 0 & 1 \\ 0 & 1 & 0 & 0 \\ 0 & 1 & 1 & 1 \\ 1 & 1 & 1 & 0 \\ 0 & 0 & 1 & 0 \\ 1 & 0 & 1 & 1 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

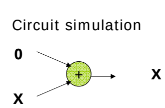
m outputs



- Matrices correspond to check matrices of error correcting codes.

Unknown values

- Unknown values (X) are circuit responses that cannot be determined during simulation.
  - Sources: bus contention, unmodeled memory…
- Impact on compactor:



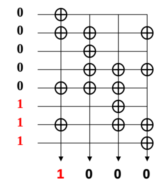
  - Masking of values from other cells.
  - In practice, 1% of scan cells with Xs can mask remaining 99% of scan cells for compaction ratio of 100.

Main idea

- Goal: reduce X-masking.
- Scheme: modify the compactor matrix.
  - Previously proposed matrices: single weight, i.e. every row has same number of ones.
  - Observations:
    - A row with small weight propagates to few outputs.
    - Some scan chains produce more Xs than others.
  - Idea: use multiple weights to build the compactor matrix.

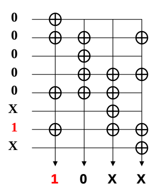
Properties of multiple weight matrices.

- In absence of Xs: same property as single weight matrices.
  - If all the rows are nonzero, different and all the weights are odd, then there is guarantee of detection of 1,2,3 or any odd number of errors.



Properties of multiple weight matrices.

- In presence of Xs: different properties from single weight matrices.
  - In presence of one X occurring at a row with small weight, it is guaranteed to detect one error anywhere.
  - Also, if 2*weight_low < weight_high: in presence of 2 Xs occurring at rows of small weight, it is guaranteed to detect one error occurring at row of high weight.



Evaluation

- Percentage of scan cells masked
  - Compactor with 1600 inputs, 16 outputs.
  - 90% of Xs are produced by 10% of scan chains.

	% of scan cells producing X values						
	0.01	0.02	0.05	0.1	0.25	0.50	1.00
Single weight (7)	0.067	0.26	1.9	7.9	42	83	99
Multiple weight (3,7)	0.027	0.066	0.29	1.1	8.6	36	82

Compaction ratio

- Using multiple weights can also increase the compaction ratio.
- Maximum number of inputs for a given number of outputs:

	Number of outputs					
	4	6	8	10	12	14
Single weight	4	20	56	252	792	3432
Multiple weight	8	32	128	512	2048	8192

Conclusion and future work

- Multiple weight matrices can:
  - Reduce X-masking.
  - Increase the compaction ratio.
- Future work:
  - Evaluate the error-masking performance of multiple weight matrices.
  - Evaluate the combination of error and X-masking with industrial circuits.