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TAM design and Test Data Compression for SoC Test Cost Reduction

Julien DALMASSO, Marie-Lise FLOTTES, Bruno ROUZEYRE

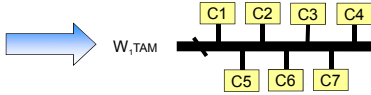
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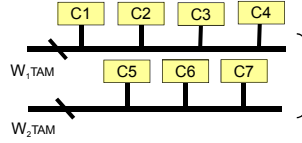
Framework

Motivations

- > Number of Cores \uparrow
- > Complexity of cores \uparrow
- \Rightarrow Test Time of SoCs \uparrow
- > **Goal: Test Time reduction**
- > **How: Test Parallelism \uparrow**
- Standard Solution: ATE costs \uparrow
- With Compression: ATE costs constant

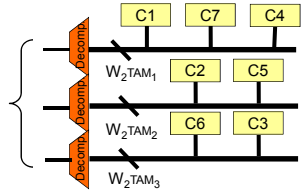


Standard Solution



$$W_{1,TAM} + W_{2,TAM} = W_{ATE}$$

With Compression



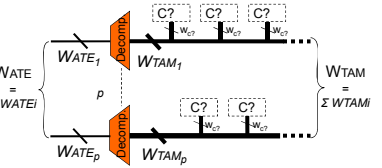
$$W_{ATE} < \sum W_{i,TAM} \Rightarrow \text{Test Parallelism } \uparrow$$

Remarks on compression

- > Must follow SoC test paradigm:
 - > Circuit netlist independent
 - > Test data independent
 - > No Specific tool
 - > Low hardware decompressor
 - > No Impact on fault Coverage
 - > Allow Sharing of decompressor among cores
 - > May increase individual cores test time

Compression Technique

- > Compression Technique used here:
 - > [1] Julien Dalmasso, Marie-Lise Flottes, Bruno Rouzeyre: Fitting ATE Channels with Scan Chains: a Comparison between a Test Data Compression Technique and Serial Loading of Scan Chains - DELTA 2006: 295-300
 - > **Note:** Any other technique meeting these requirements can be used in this framework



Goal: Minimize Test Time

- > How: by determining:
 - > Number of Buses (p)
 - > Compression ratio for each bus (W_{ATE} / W_{TAM})
 - > Assignment of cores to buses

Test Architecture Exploration

Partition algorithm

1. For all ATE channels partitions into p parts
2. For each compatible TAM partition into p parts
3. Find the best assignment of the cores to the p lines (that minimize TAT)
 - If this assignment reduces the global TAT, memorize this assignment and ATE/TAM architecture

Core Assignment algorithm

- // Initial Solution
 - Assign each core on the smallest possible bus
 - Compute TAT
- // Improvement of the solution
 - While TAT is reduced
 - Find the line i with the highest TAT_i
 - For each core c assigned to i,
 - For all other lines k (k ≠ i)
 - Move core c from i to k
 - Compute new_TAT and memorize i, k, j, and new_TAT
 - Move back core c from k to i
 - Move core c from i to k such that:
 - 1/ the smallest TAT has been obtained
 - 2/ the number of useless bits on k is minimized
 - 3/ the standard deviation between TAT_i of all lines is maximized

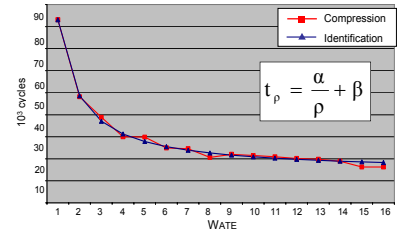
Test Application Time

$$TAT = \max(TAT_i, i = 1, \dots, \# \text{ buses})$$

$$\text{and } TAT_i = \sum_{\text{cores } c \text{ assigned to } i} t_{c,p_i}$$

Test times interpolation

- > Each Test Time / core / compression ratio must be known
- > IMPOSSIBLE: Too many configurations to be computed
- \Rightarrow For each W_{TAM} , Identification of test time
- \Rightarrow Only $2 \cdot W_{TAM}$ computations instead of $(W_{TAM})^2$



S38417 from ISCAS'89 benchmarks with 16 scan chains test times identification

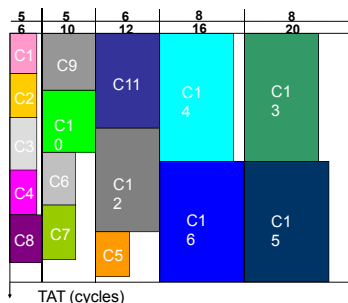
Experimentations

Results

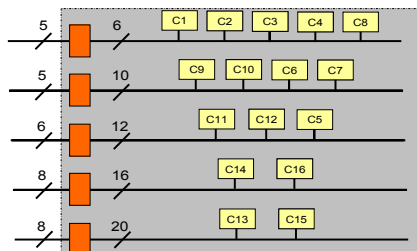
| # bits | TAT | Compression parameters (W_{ATE-i} / W_{TAM-i}) | #bits used on TAM | # config. |
|--------|-------|--|-------------------|-----------|
| 2 | 89892 | (16,16) / (16, 48) | 28 | 522 |
| 3 | 63441 | (5,13,14) / (9,14,41) | 36 | 44639 |
| 4 | 50249 | (3,7,7,15) / (10,14,15,25) | 48 | 1345142 |
| 5 | 42513 | (5,5,6,8,8) / (6,10,12,16,16) | 60 | 18605924 |
| 6 | 42513 | (1,4,5,6,10,10) / (4,6,10,12,16,16) | 60 | 142238520 |
| 7 | 44090 | (1,1,1,1,6,7,15) / (5,5,6,6,12,14,16) | 64 | 648424515 |

- SoC with 16 cores
- 32 ATE channels
- TAM bitwidth: 64

Resulting Test Architecture and Scheduling



Resulting Scheduling (5 buses)



Resulting Architecture (5 buses)

Gains

| ATE Interface: 32 channels | | |
|-------------------------------------|--|--------------------------------------|
| Test Application Time | | Gain |
| No Compression 32 bits / 2 buses | With Compression 32 \rightarrow 64 bits / 5 buses | |
| 89892 | 42513 | + 53 % test time 0 % ATE Channels |

| TAM: 64 bits | | |
|-------------------------------------|--|--------------------------------------|
| Test Application Time | | Gain |
| No Compression 64 bits / 6 buses | With Compression 32 \rightarrow 64 bits / 5 buses | |
| 35402 | 42513 | -17% test time +50 % ATE channels |

Conclusion

- > Compression increases test parallelism without any ATE Cost
- \Rightarrow Thus it decreases Test Application Time

Note: Any compression technique compliant with SOC test paradigm can be used