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► **To cite this version:**

Julien Dalmaso, Marie-Lise Flottes, Bruno Rouzeyre. TAM Design and Test Data Compression for SoC Test Cost Reduction. ETS: European Test Symposium, May 2007, Freiburg, Germany. 12th IEEE European Test Symposium, pp.241-246, 2007. lirmm-00159044

**HAL Id: lirmm-00159044**

**<https://hal-lirmm.ccsd.cnrs.fr/lirmm-00159044>**

Submitted on 12 Nov 2007

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# TAM design and Test Data Compression for SoC Test Cost Reduction

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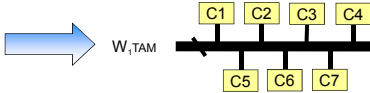
## Framework

### Motivations

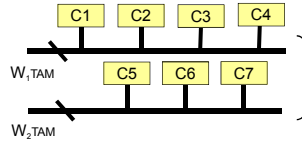
- > Number of Cores  $\uparrow$
- > Complexity of cores  $\uparrow$
- $\Rightarrow$  Test Time of SoCs  $\uparrow$

- > **Goal: Test Time reduction**
- > **How: Test Parallelism  $\uparrow$**

- Standard Solution: ATE costs  $\uparrow$
- With Compression: ATE costs constant



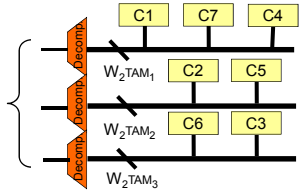
### Standard Solution



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



### With Compression



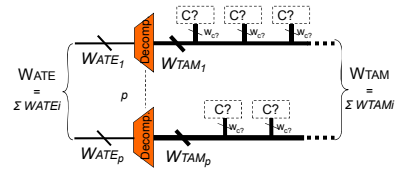
$$W_{ATE} < \sum W_{i,TAM} \Rightarrow \text{Test Parallelism } \uparrow$$

### 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 ( $W_{ATE_i} / W_{TAM_i}$ )
  - > 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<sub>i</sub>
    - 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<sub>i</sub> of all lines is maximized

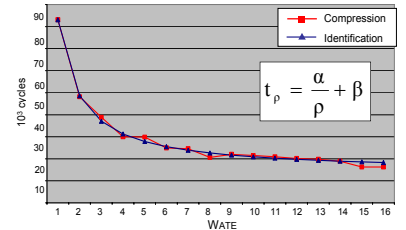
### Test Application Time

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

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

### 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

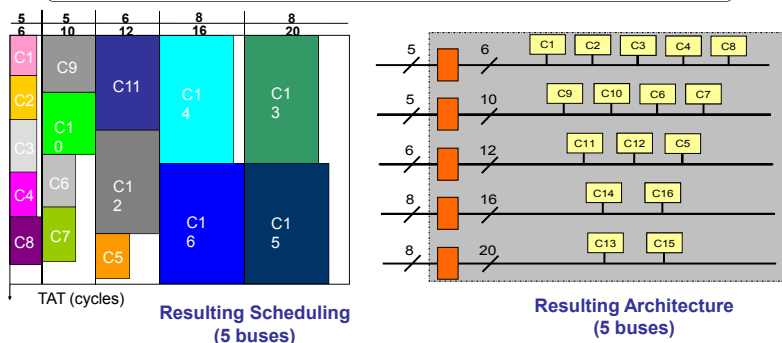
## Experimentations

### 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



### Gains

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

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

### 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