GECOM: Test Data Compression Combined with All Unknown Response Masking

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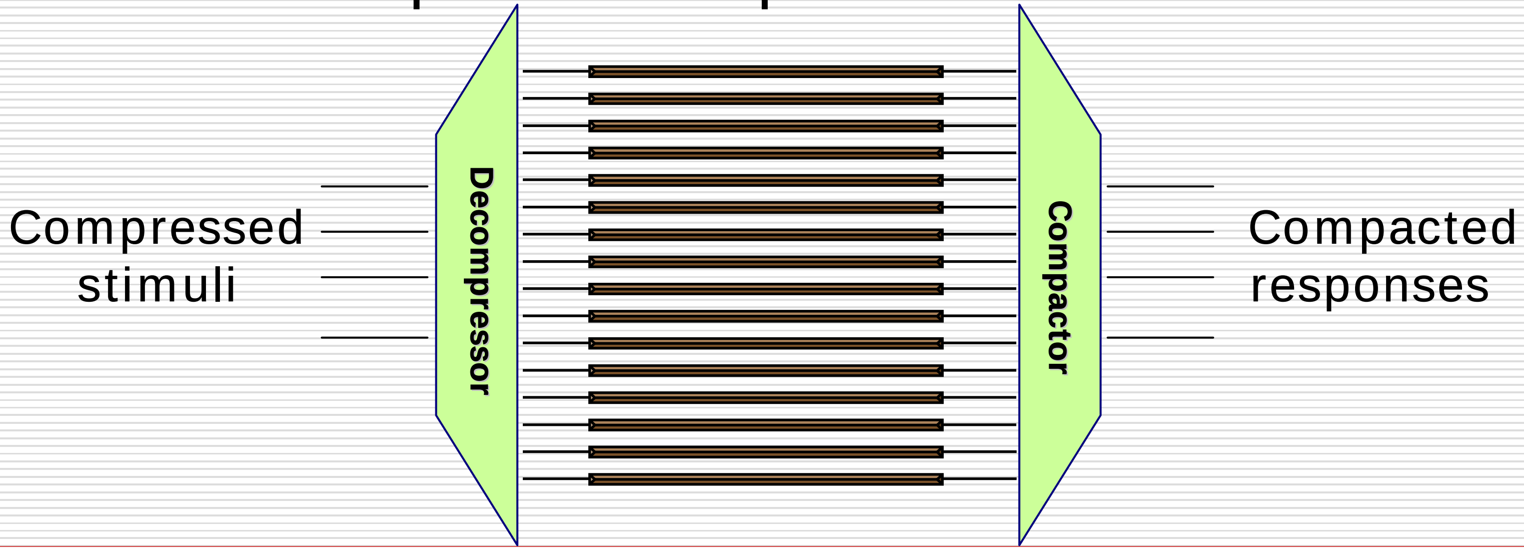
Asia and South Pacific Design Automation Conference
January 24, 2008

Outline

- Background
- Motivation
- GECOM Technique
  - On-Chip Architecture
  - Test Pattern Generation
- Experimental Results
- Conclusions

Why Test Data Compression?

- Test cost vs. test quality
- Test data compression
  - Scan stimulus compression
  - Scan response compaction



But…

- Many Sources of Unknown X’s in Output Response
  - Uninitialized non-scan FFs, Tri-State logic, Multi-cycle Paths, Etc.

- Major Issue for Test Compression
  - X’s Corrupt Final Signature
  - Prevents Observation of other responses

- Handling X’s
  - X-Masking
  - X-Tolerant Compactor

Traditional Approach 1: X-masking

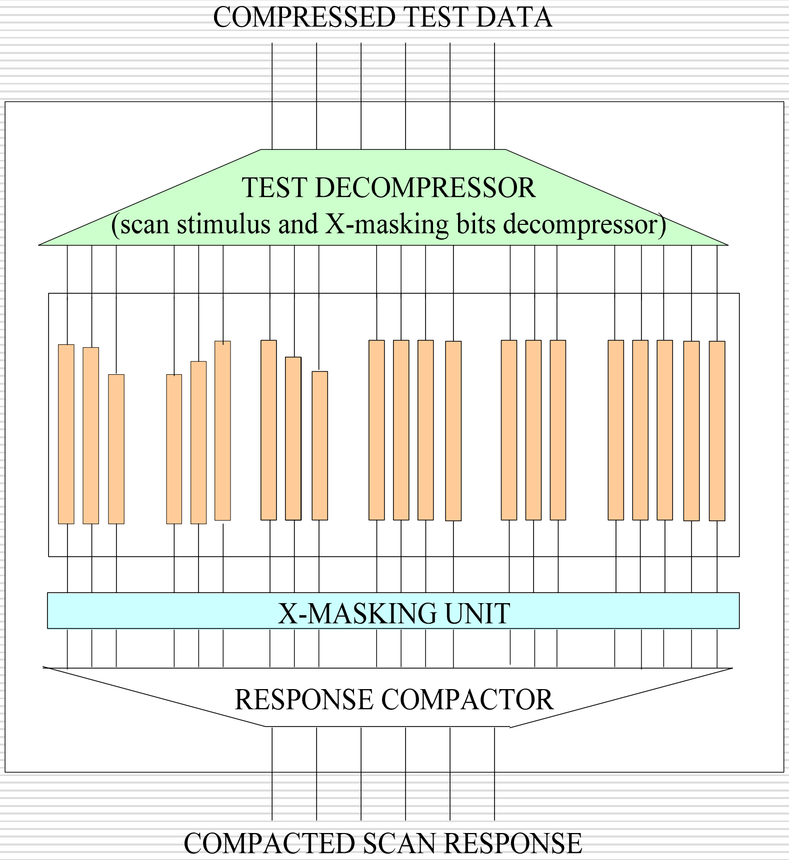
- X-Masking schemes
  - [Naruse ITC’03], [Chickermane ITC’04], [Mitra DAC’05]
- Problems
  - Masking data required
  - Overmasking some non-X responses

Traditional Approach 2: X-tolerant

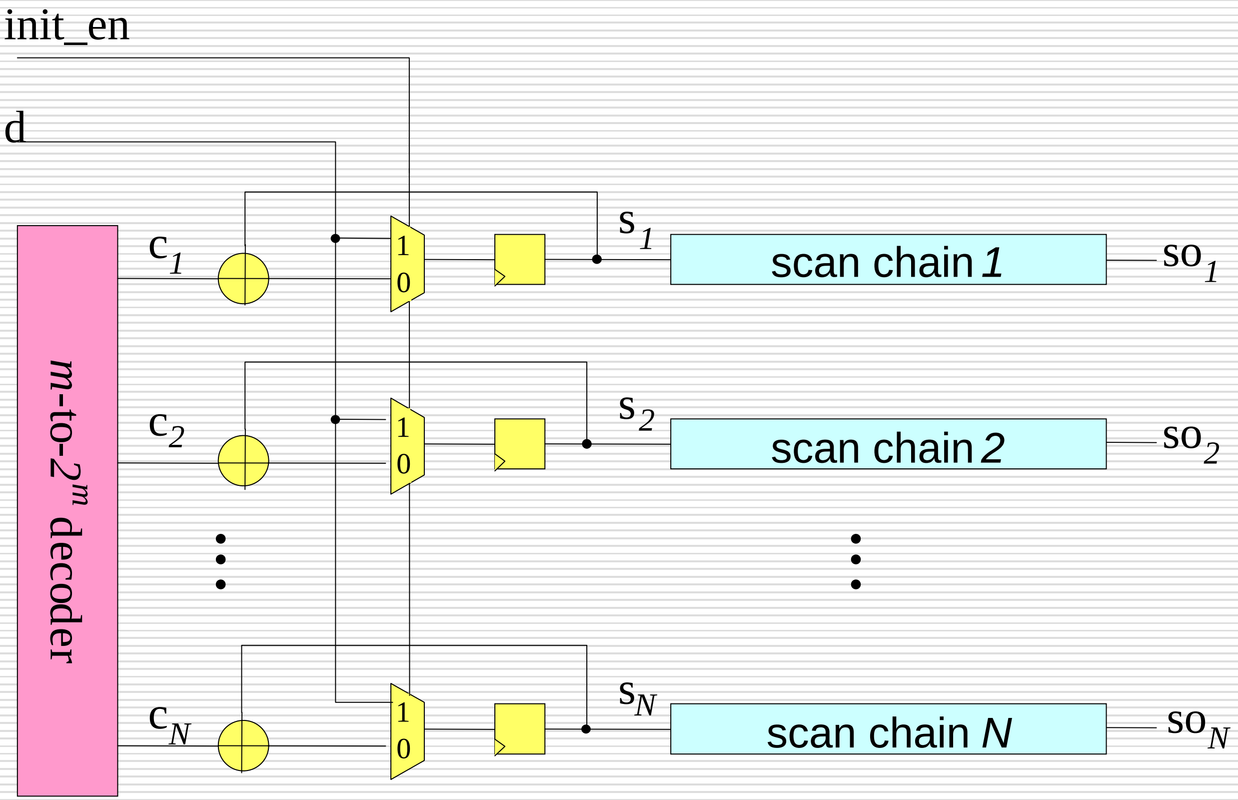
- X-Tolerant Schemes
  - Selective Compactor
    - [Wohl ITC'03], [EDT US patent]
    - Discard majority of responses
  - ECC-based Compactor
    - Use Xor matrix to propagate one response to multiple outputs : reducing X-induced masking probability
- Problems
  - All above approaches guarantee error detection in presence of one X
  - No guarantee for multiple unknowns

GECOM Technique

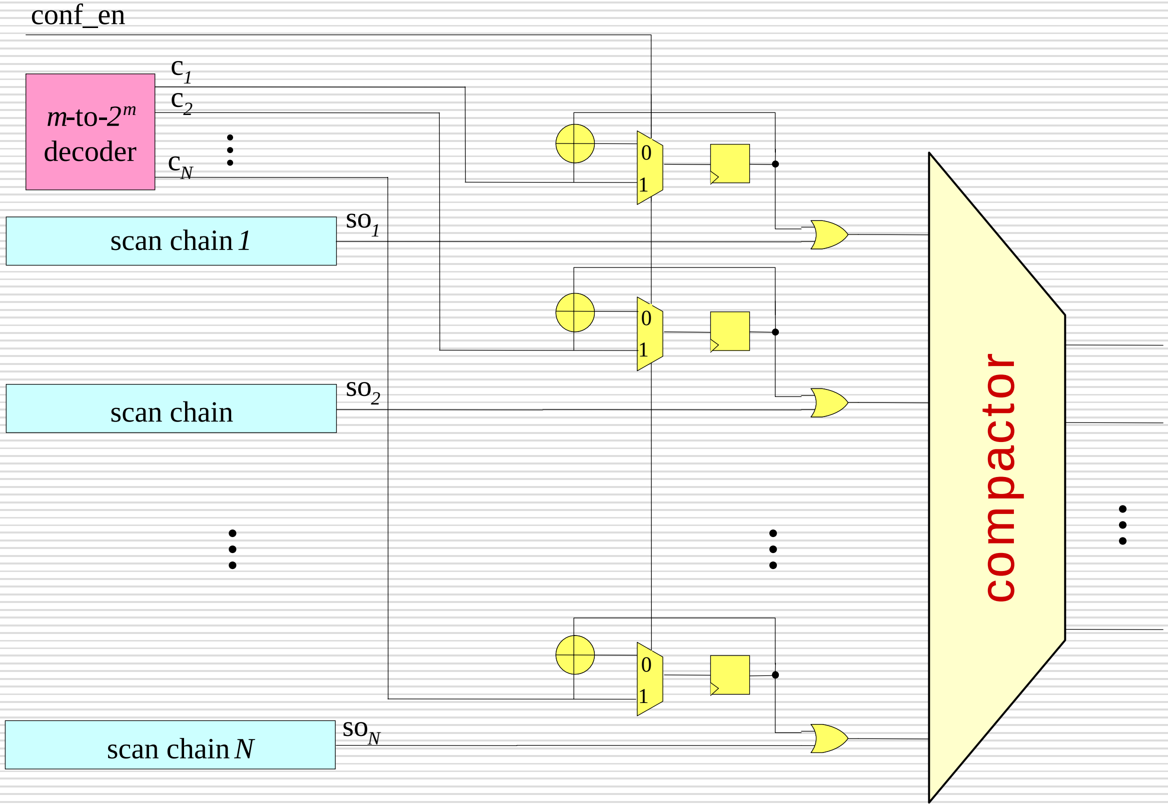
- Intergraded approach: **Ge**neration, **Co**mpression and **M**asking
- High compression
- No limit on number or distribution of Xs
- No test loss
  - Xs never block non-X values
  - Xs don't increase pattern count
  - Xs don't limit test coverage
- design simplicity



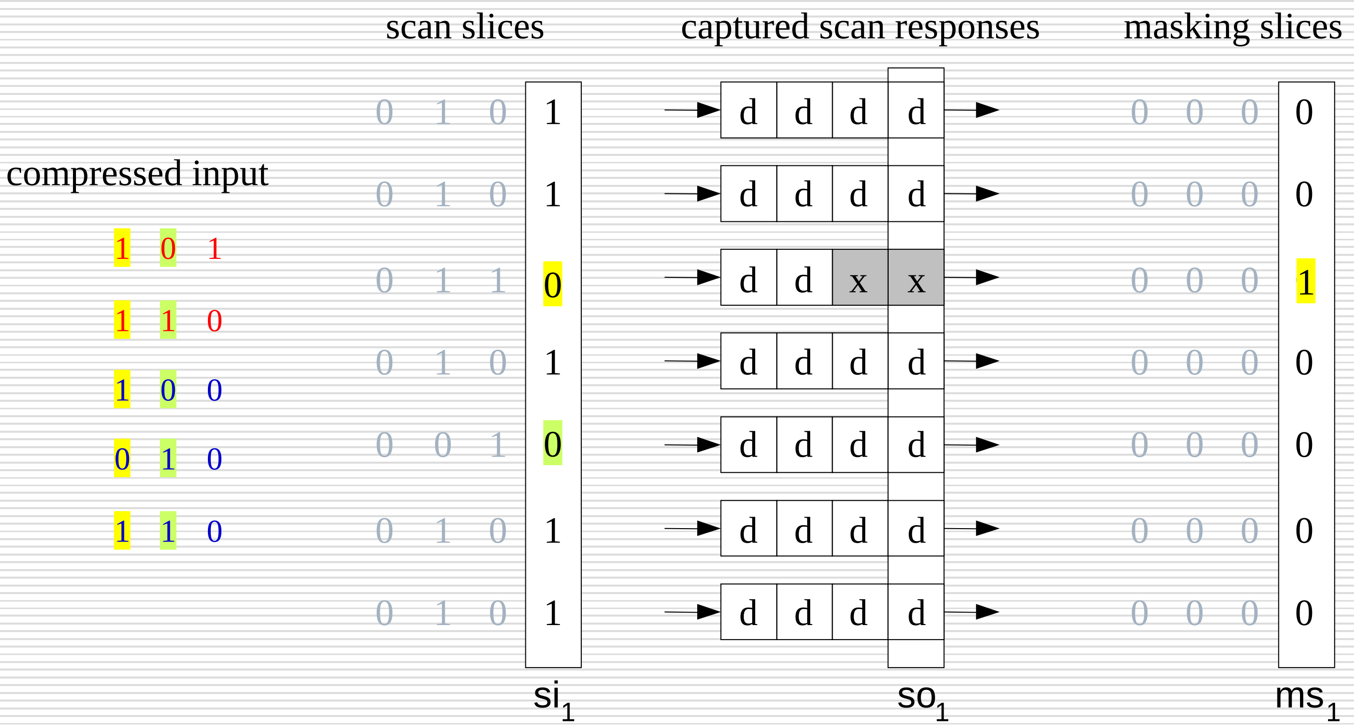
Scan Stimulus Decompression



Unknown Masking



Decompression Example



Test Generation in GECOM

1. Run ATPG
2. Extract the Xs' positions and set constraints
3. Run ATPG again to obtain a test cube
4. Count the number of specified 0s and 1s
    - If (p(0) < p(1)), then the unspecified bits with unknown responses in the previous vector are assigned 0s, and the other unspecified bits are assigned 1s; and vise versa.
5. Perform fault simulation and drop all detected faults from the fault list.
6. If undetected faults remains, go to Step 2.

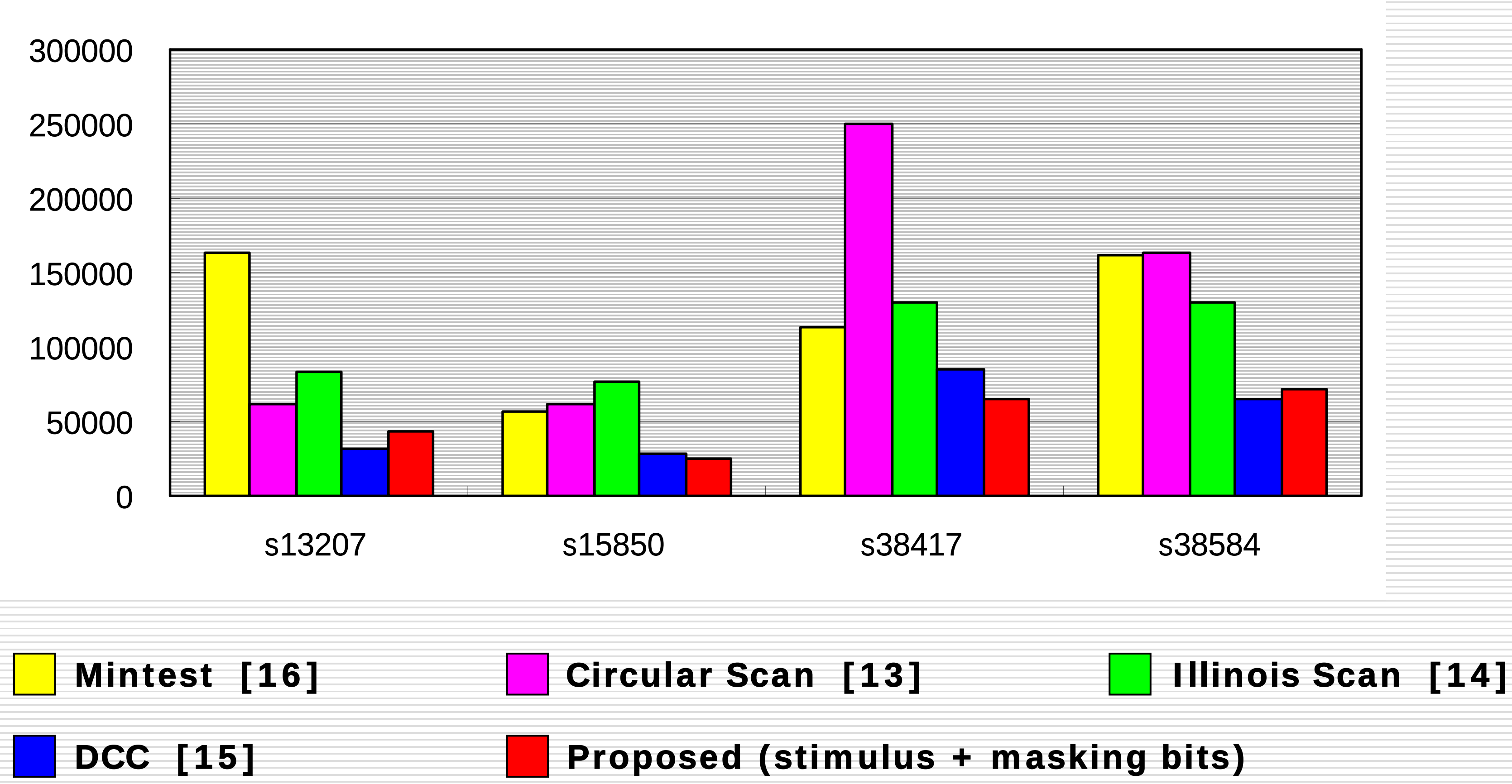
Compression Results

ckt.	***Nsc***	***Nc***	***Ng***	***TD***	***TE***	***Cr***
s13207	50	8	231	309,078	77,616	74.9%
	100	9	257	343,866	48,573	85.9%
	200	10	271	362,598	**43,360**	88%
s15850	50	8	157	187,458	30,144	83.9%
	100	9	170	202,980	27,540	86.4%
	200	10	168	200,592	**25,200**	87.4%
s38417	50	8	198	647,856	104,544	83.9%
	100	9	220	719,840	100,980	86.0%
	200	10	239	782,008	**64,530**	91.7%
s38584	50	8	287	833,448	137,760	83.5%
	100	9	299	868,296	80,730	90.7%
	200	10	297	862,488	**71,280**	91.7%

Comparison on Compression

ckt	**SCC**		**Proposed (stimulus + masking bits)**	
	vectors	**TE**	**vectors**	**TE**
s13207	178	22784	271	43360
s15850	264	25344	168	25200
s38417	312	89856	239	64530
s38584	203	38976	297	71280

Comparison on Compression



Comparison on Test Quality

CUT	wo GECOM masking		GECOM masking	
	U.O. Res	Obs. Loss (%)	U.O. Res	Obs. Loss (%)
s13207	933	18	0	0
s15850	908	16.99	0	0
s38417	3778	18.99	0	0
s38584	2770	16.1	0	0
ASIC 1	5460	4.5	0	0
ASIC 2	204730	29.5	0	0
ASIC 3	29585	1.0	0	0

Overall Comparison

	ATPG-dependent Compression	GECOM
Traditional ATPG reusable	Maybe	Yes
Fault Coverage Loss	Maybe	No
Integrated Compression on Stimulus and masking bits	No	Yes
Computation Overhead	High	Neglectable
All-X Masking	No	Yes
Encode/Decode Complexity	High	Low
Compression Efficiency	High	High

Conclusions

- Novel test technique
  - Integrated with test generation, test compression and unknown masking
- Great compression
- All unknown response masking
  - Any number and distribution of Xs
  - No overmasking
  - No observable response coverage loss
- Suitable for both space compactors (e.g. XOR-tree) and time compactors (e.g. MISR)

Thank You!!!

- Questions ?

- Comments / feedback welcome:
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