The Introduction to EDT (TestKompress)

High Test Quality &
Low Test Cost

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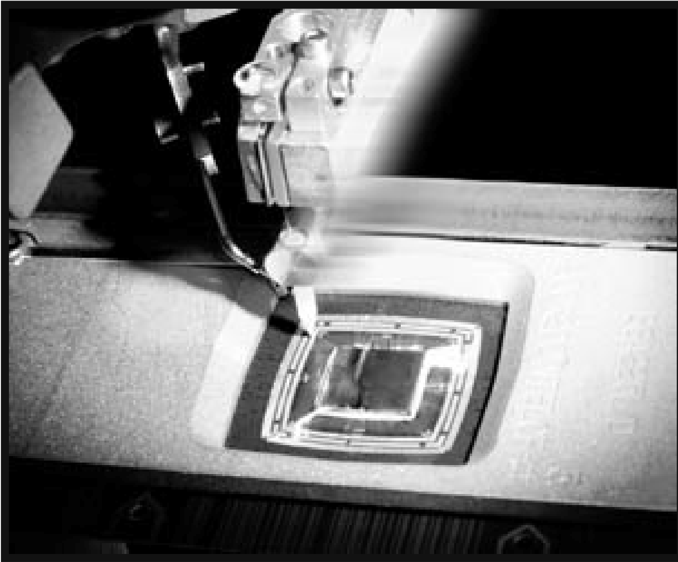
Contents

- Today's DFT Challenge
- Comparison Factors of TestKompress
- Comparing Techniques
  - ATPG
  - EDT
  - LBIST
- How TestKompress works
- Recommendations & Summary

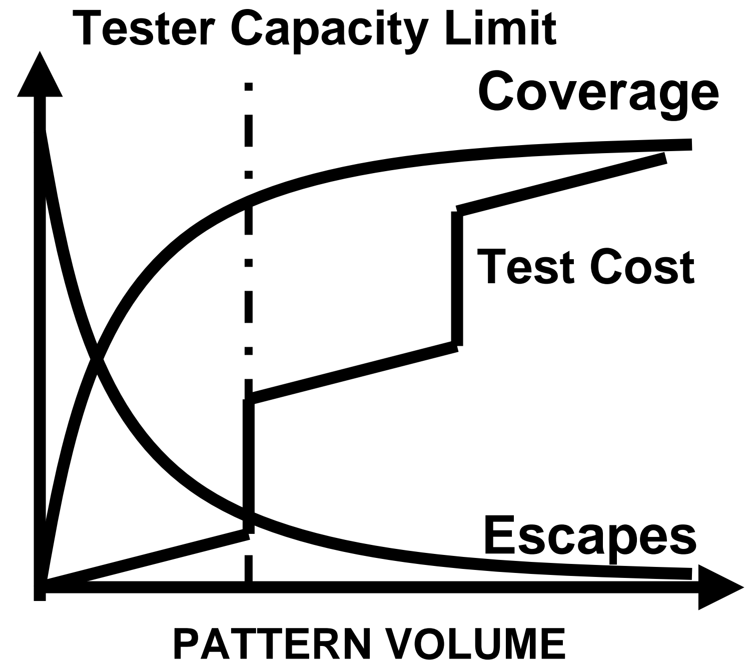
Design Trends, Test Challenges



- **Smaller DSM devices**
  - New types of defects
  - Requires at-speed testing
- **Growing gate counts**
  - **Exploding test set sizes**
  - **Requires test set compression**
- **Complex SoC architectures**
  - Diverse test methods
  - Requires integrated test products

DFT Reduces Test Cost

- **DFT reduces test set sizes**
  - **Reduces ATE memory requirements**
  - **Reduces test time**
  - **Minimizes or eliminates tester reloads**
  - **Improves tester throughput**
- **DFT offers high quality *and* reduced cost**



Quality -- The Reason You Test!

Factors to Consider Compression Methods

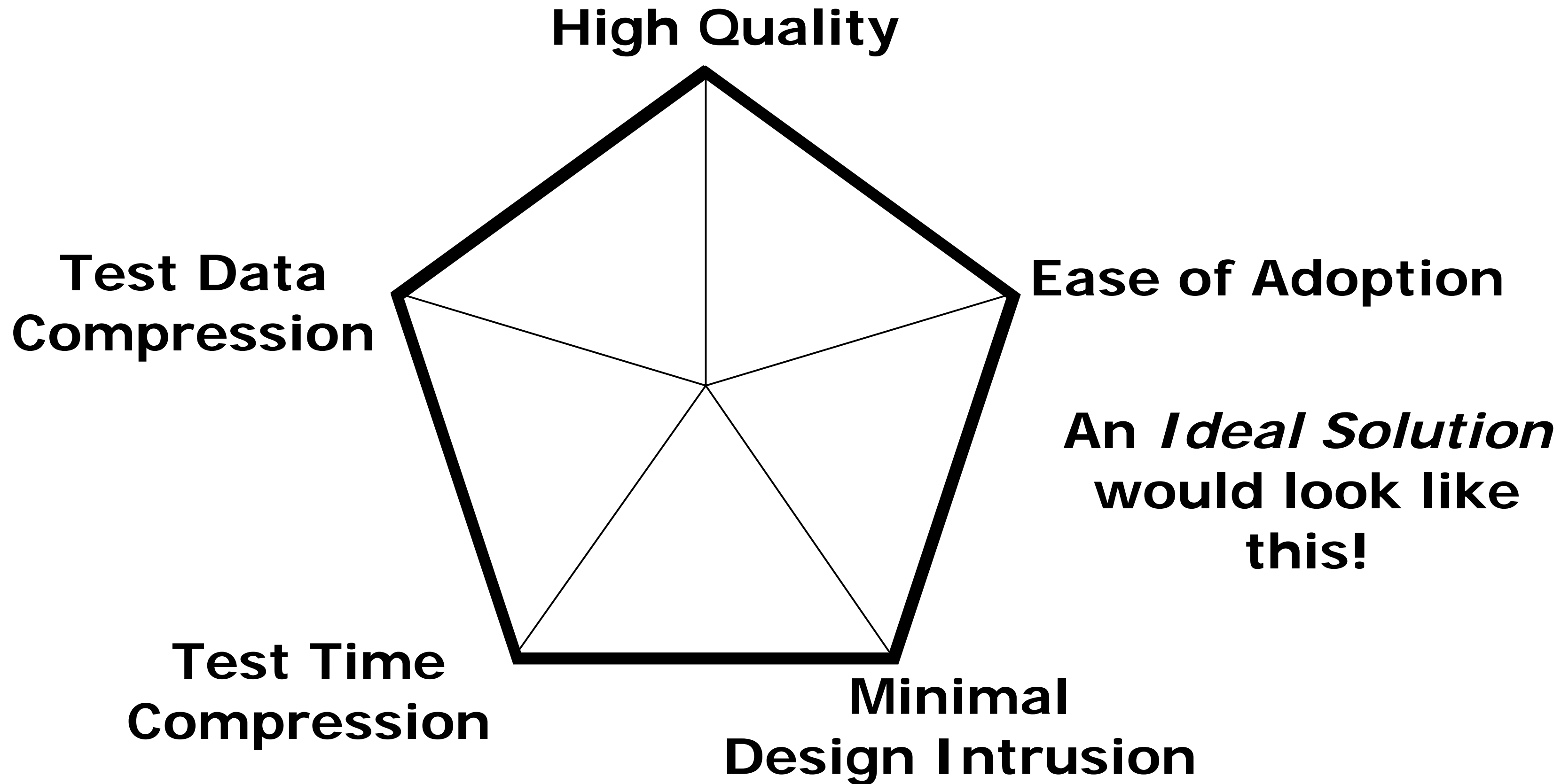
- **Support for all fault models**
  - **Ease of obtaining high stuck-at coverage**
  - **Support of IDDQ testing**
  - **Support of at-speed testing**
  - **Extendable to future fault models**
- **Support for all pattern types**
  - **Sequential patterns**
- **Testing of *all* logic**
- **Diagnostics**

Compression

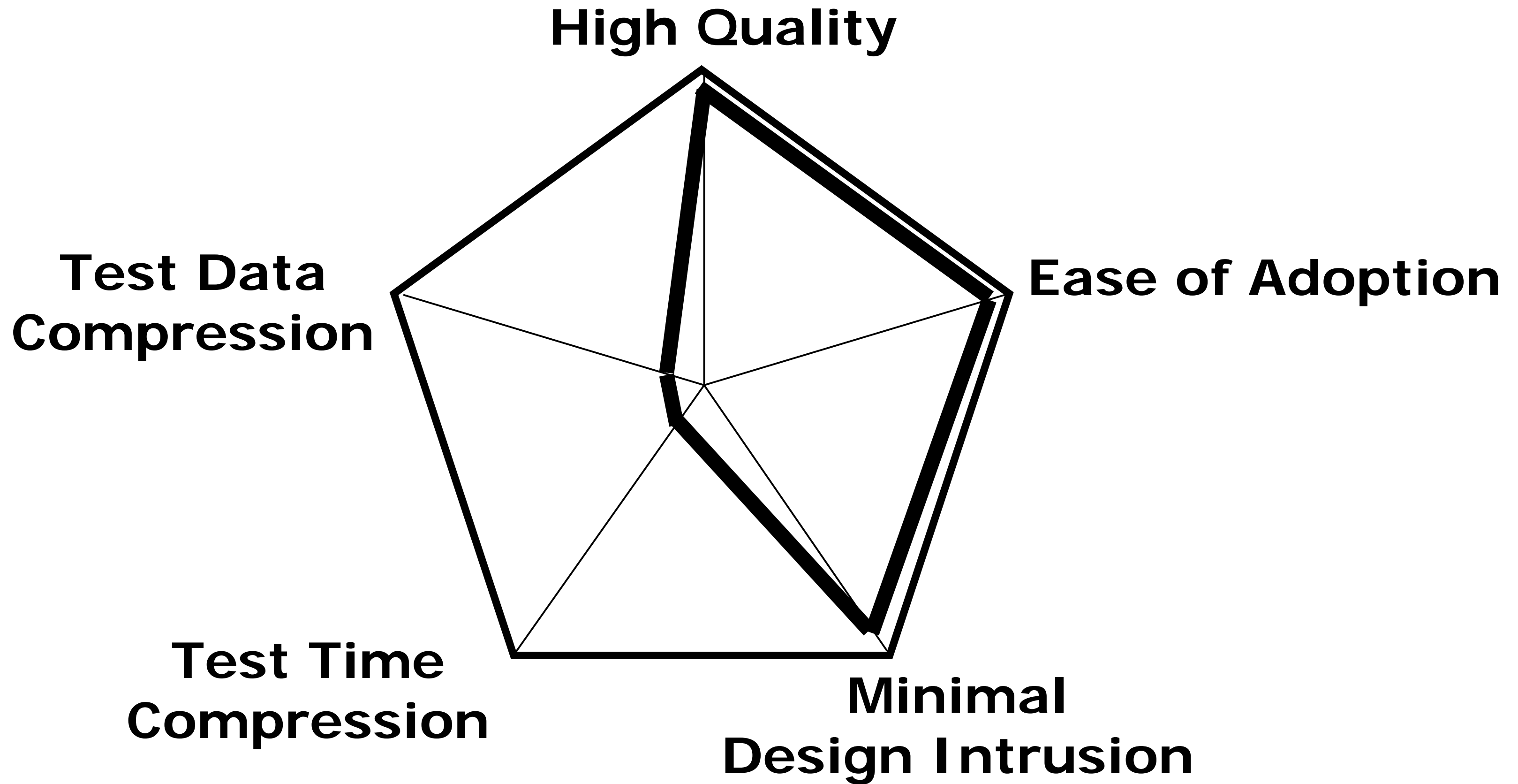
Factors to Consider Compression Methods

- ***Compression results* are what you're after**
- ***Compression* factors**
  - **Test time**
  - **Test data volume**
  - **Compatibility with existing ATE**
  - **Scalability of approach**

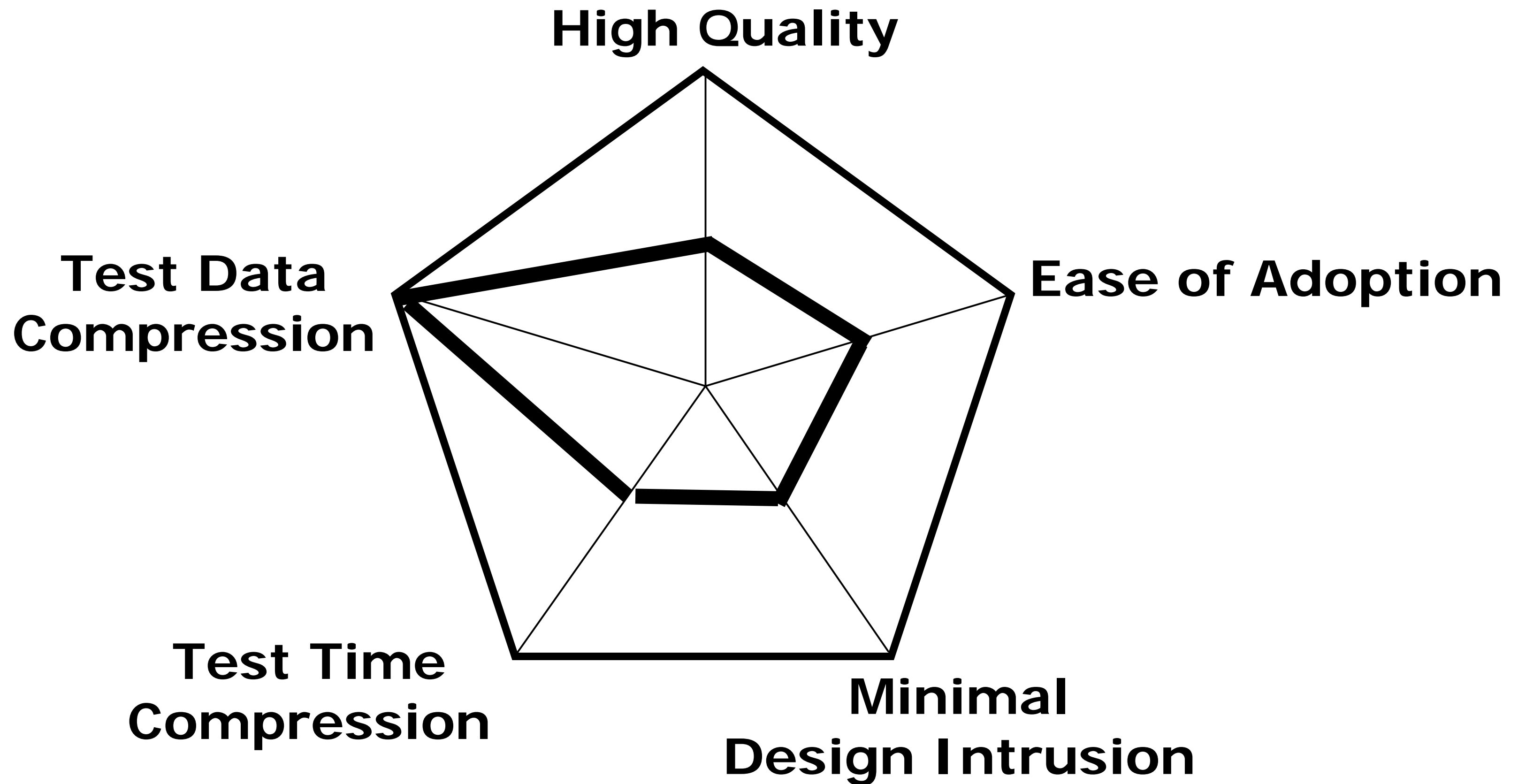
Comparison Factors Summary



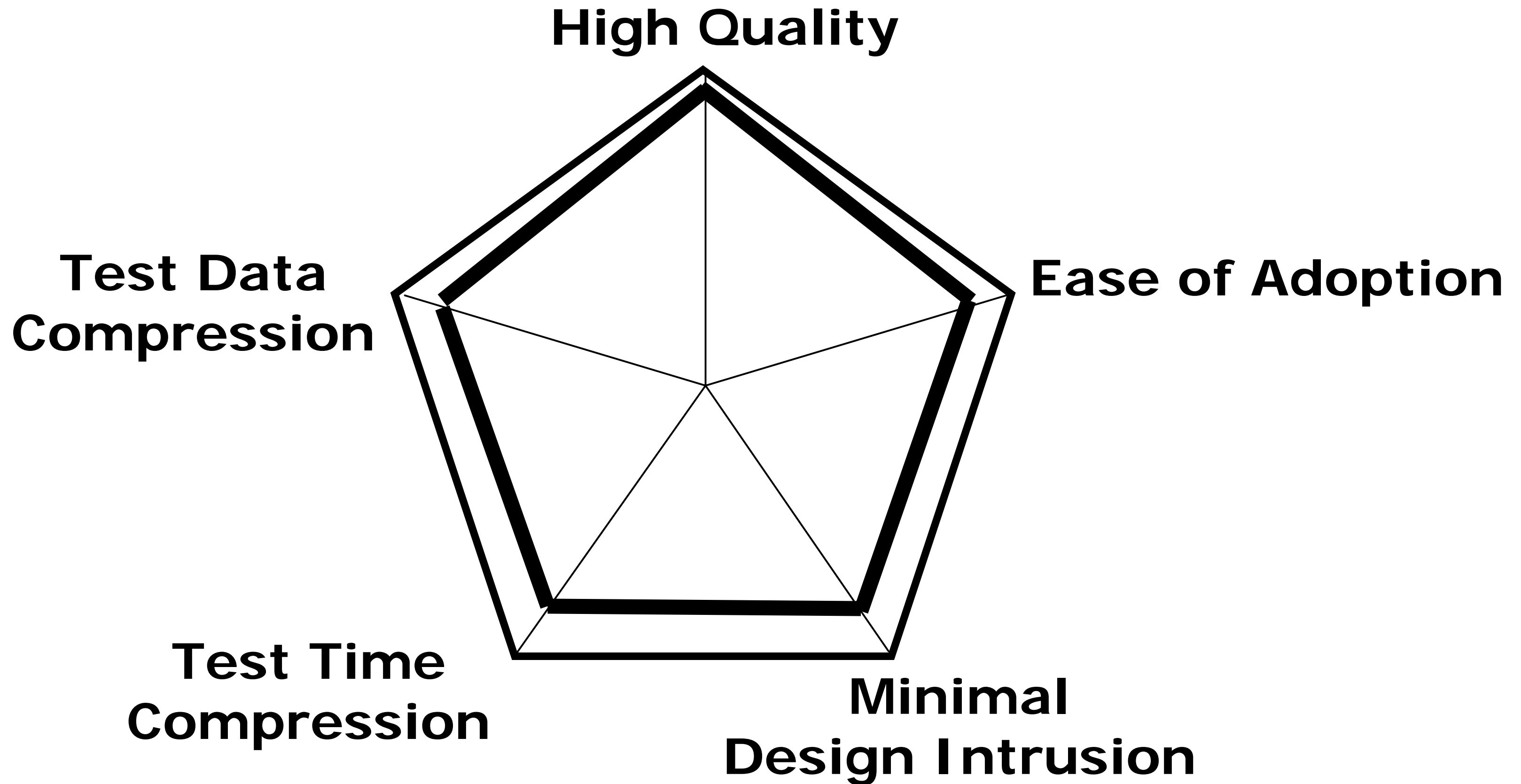
ATPG Comparison Factors



LBIST Comparison Factors



EDT Comparison Factors



EDT Compared to Standard ATPG

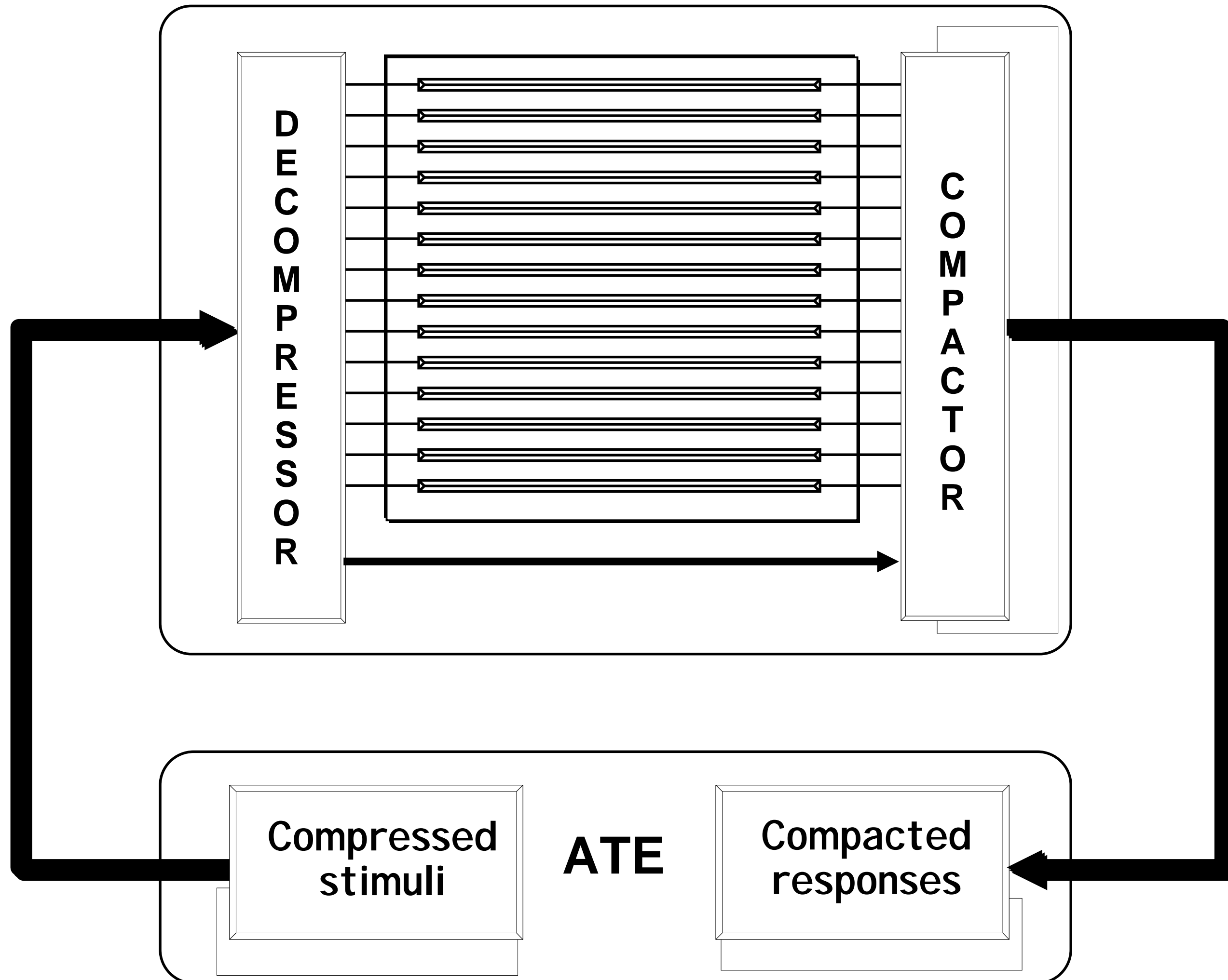
ATPG

EDT

- Shorter scan chains
- Up to 100x:
  - Less cycles
  - Less test data
  - Shorter test time

- Up to 100x less tester memory
  - Less expensive tester
  - Higher throughput
  - Improved quality wit lower cost

EDT Architecture



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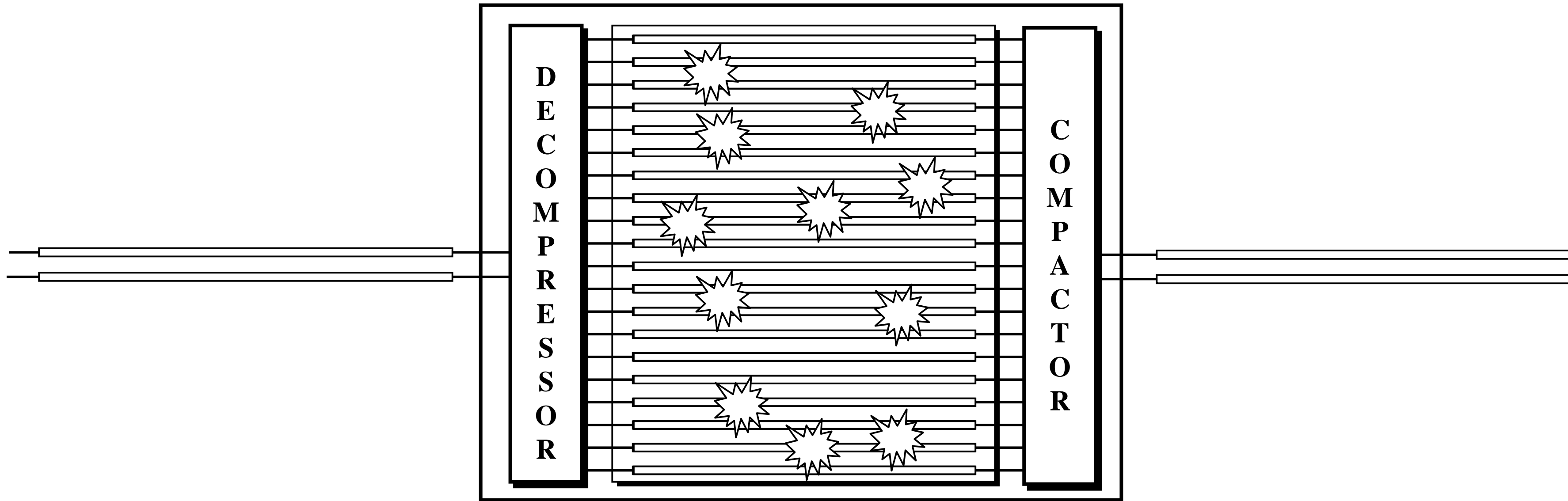
EDT Test Pattern Generation Process



1. Target faults
2. Generate test cube: 1-5%
3. Compressed stimuli: ≈1-5%
4. Random fill: ≈ 99-95%
5. Compact response

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EDT Stimuli Compression

o	0	p	0
m	0	n	1
k	0	l	0
i	0	j	0
g	0	h	0
e	0	f	0
c	1	d	1
a	1	b	1

$$e + f + j + l = 0$$

$$c + d + e + j + k = 0$$

$$d + e + f + g + k = 1$$

$$c + g + l = 1$$

$$b + c + e + f + g + i + m + p = 0$$

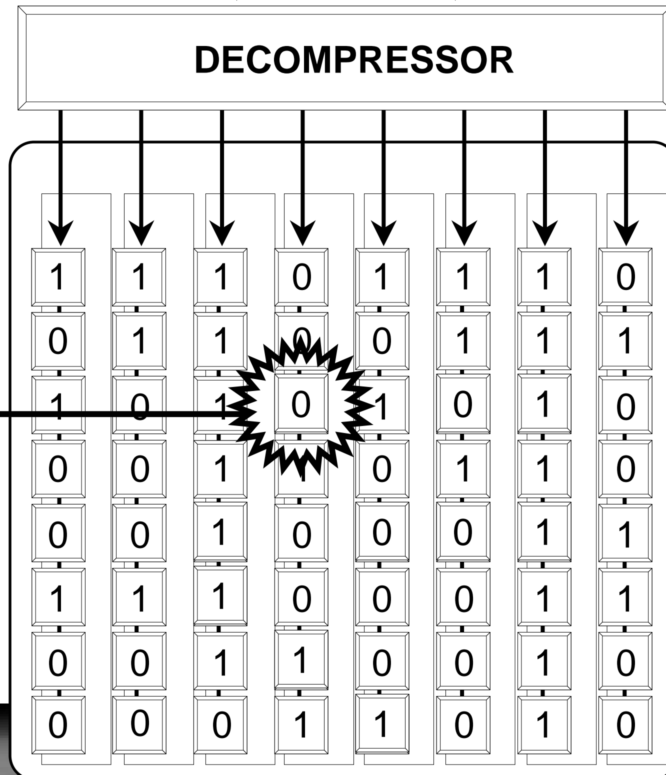
$$a + b + c + g + h + i + n + o = 0$$

$$a + b + d + h + i + j + k + o = 1$$

$$a + b + e + i + n = 1$$

$$a + c + f + m + n + r + t = 1$$

$$a + b + d + f + h + i + k + l + m + o + s + v = 1$$

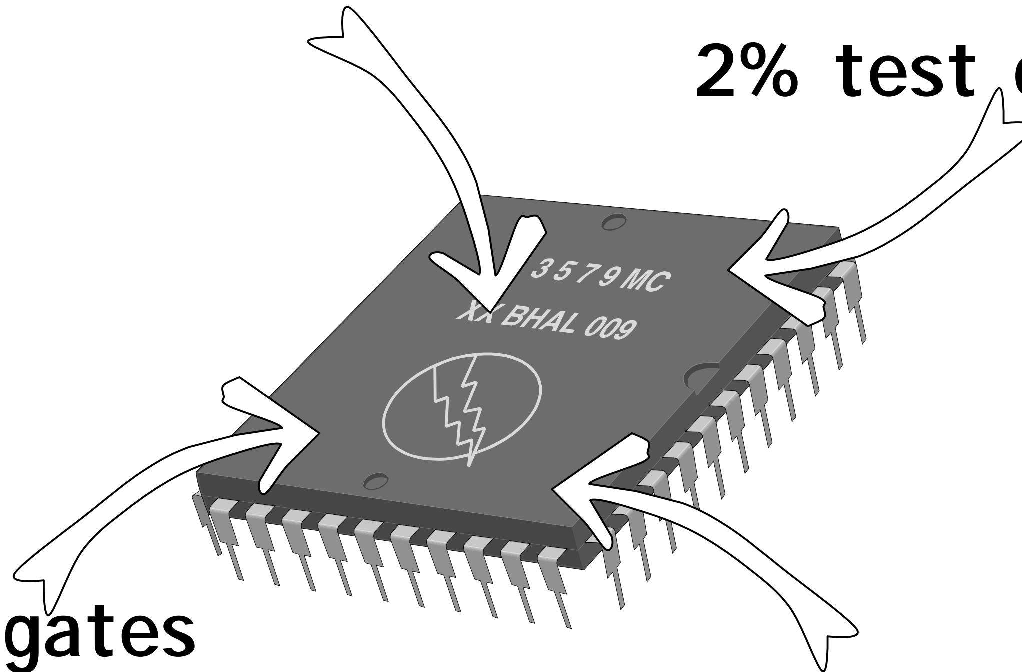


Compression Factors:Encoding Capacity

How many care bits are in a test cube?

500K scan cells

2% test cube fill rate

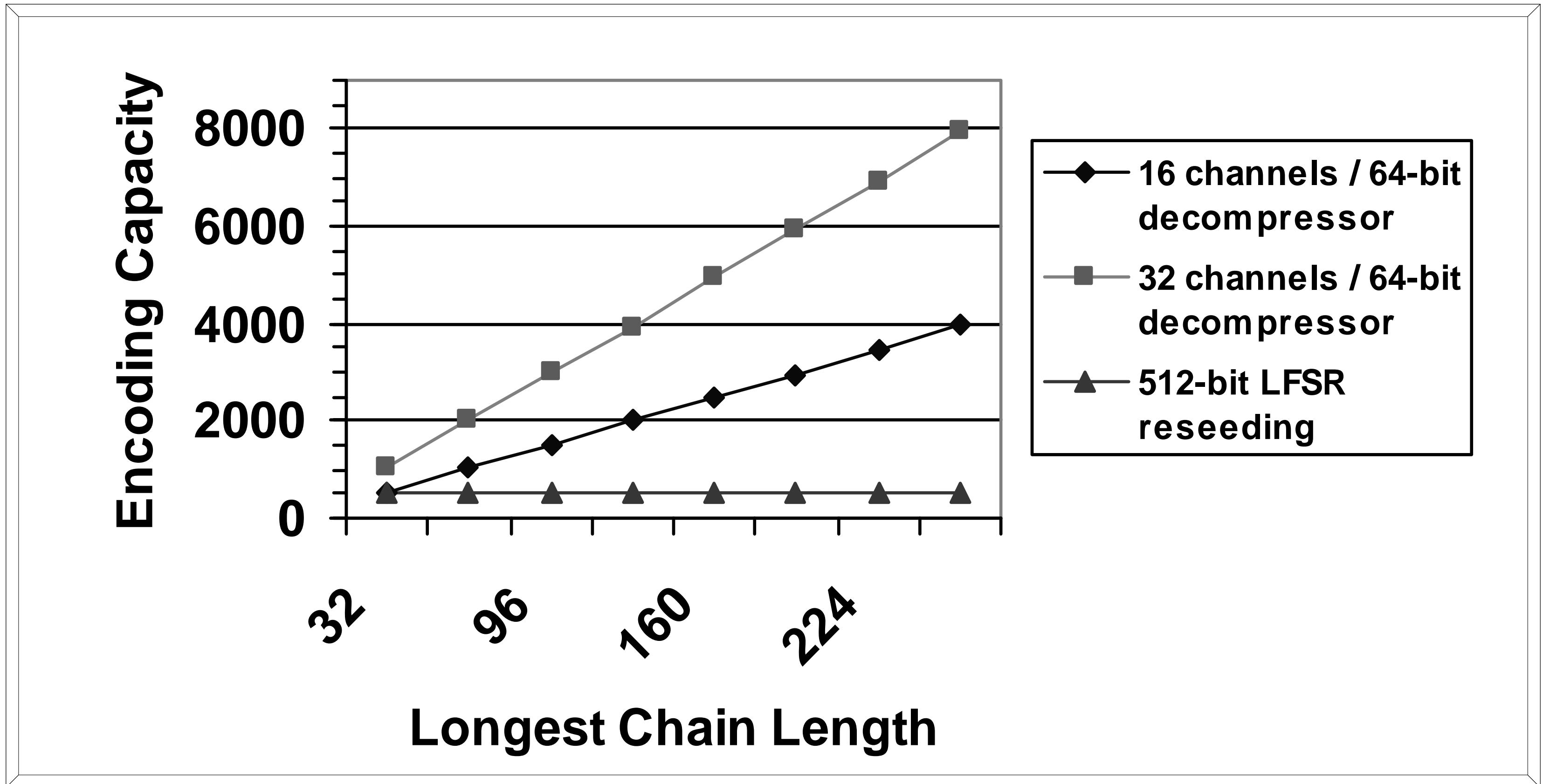


10M gates

10,000 care bits

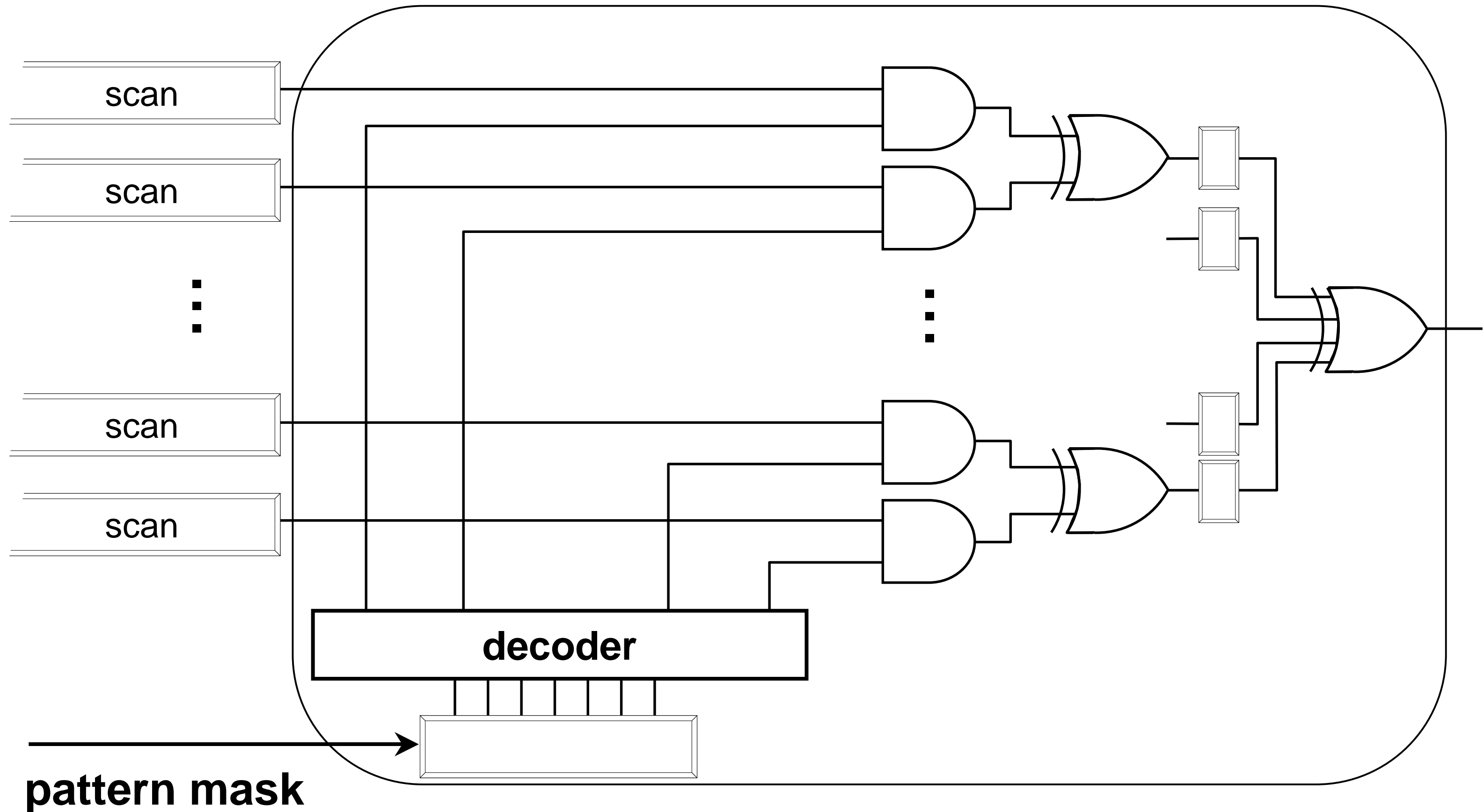
EDT Encoding Capacity

How Scalable is it?



EDT decompressor is highly scalable with minimal overhead

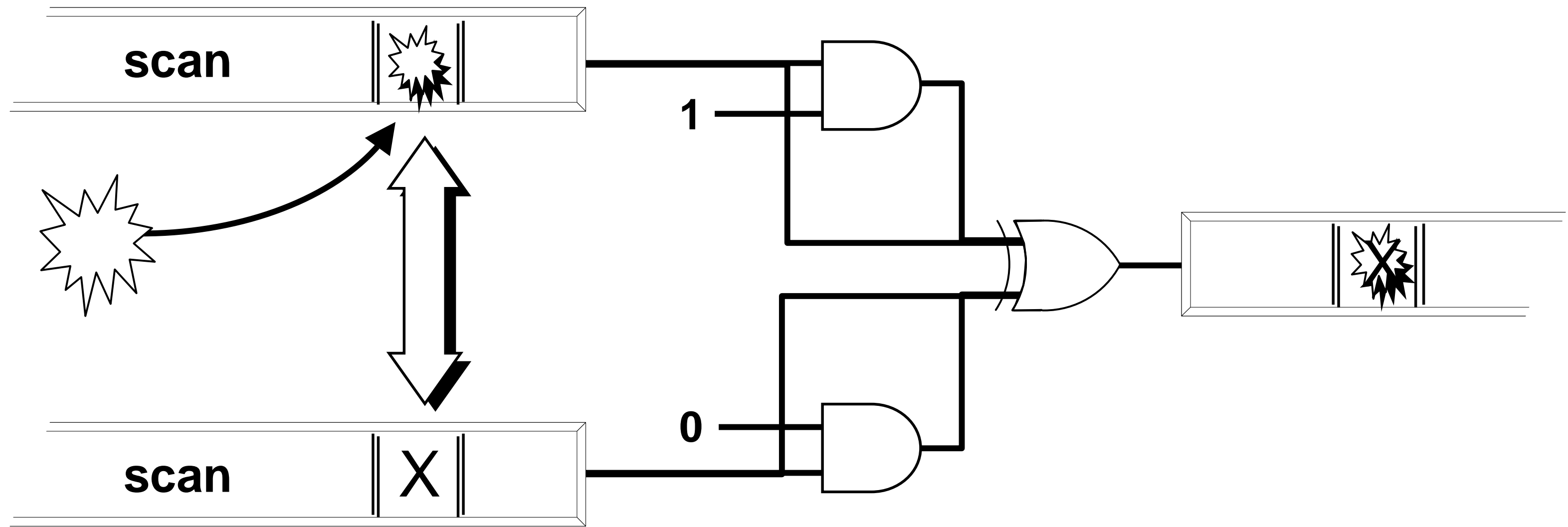
EDT Response Compactor



- **Per pattern programmable scan selection**

Unique Compaction Features

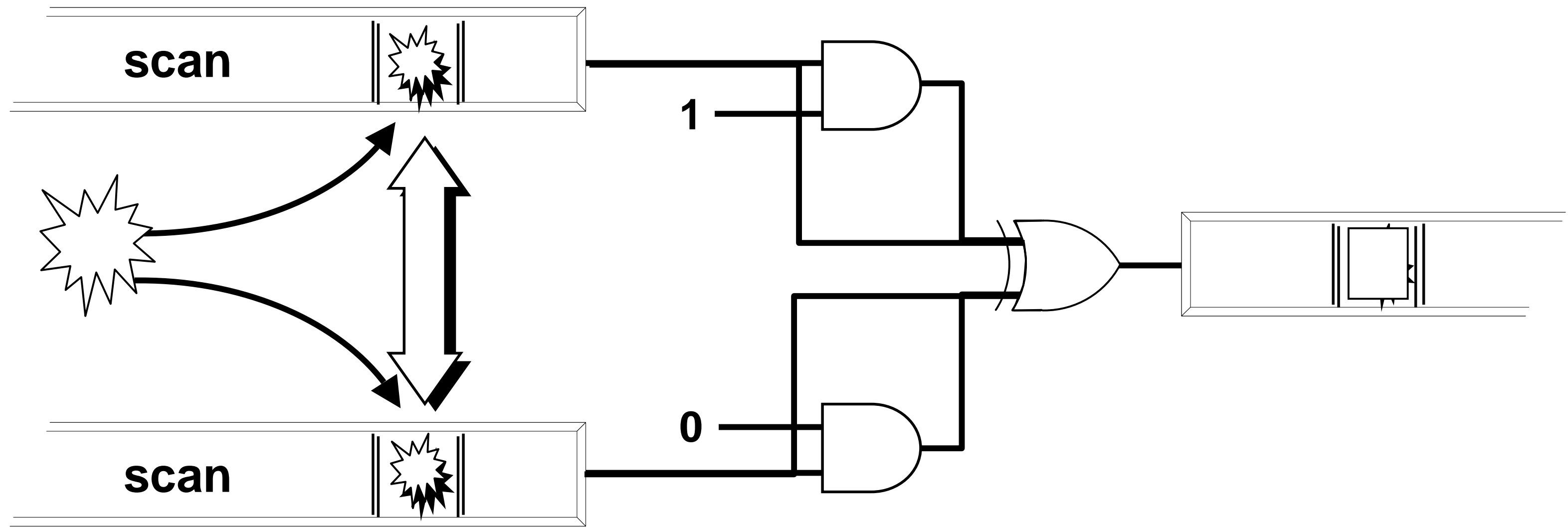
Handling of X states



- **Programmable scan selection eliminates impact of X states**
- **No X bounding logic required**

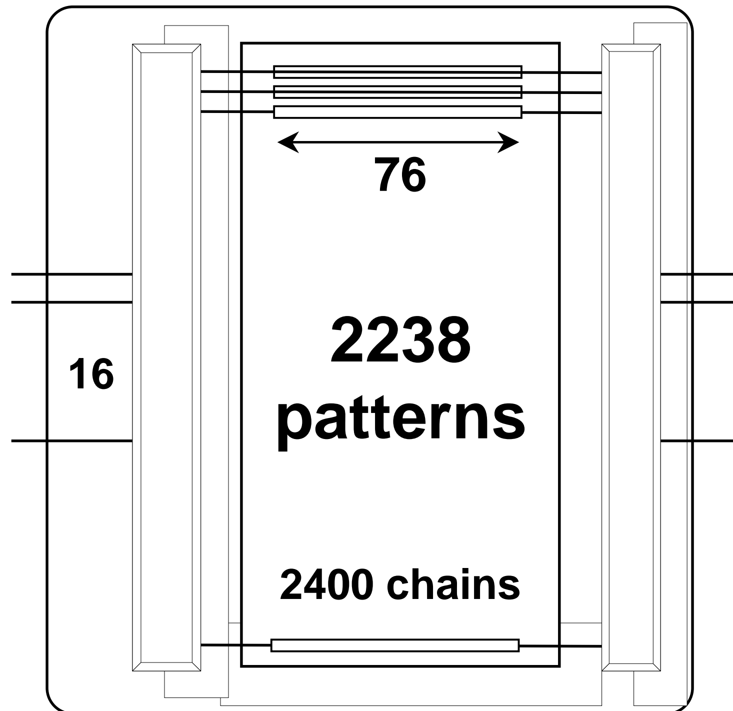
Unique Compaction Features

Zero Aliasing



- **Programmable scan selection eliminates aliasing**
- **Fault coverage computed on compactor outputs**

EDT Example



#Gates: 2.1M

#SCs: 181K

Decompressor: 64 bit

Max Specified: 1242

#X Sources: 556

Area: 1.31%

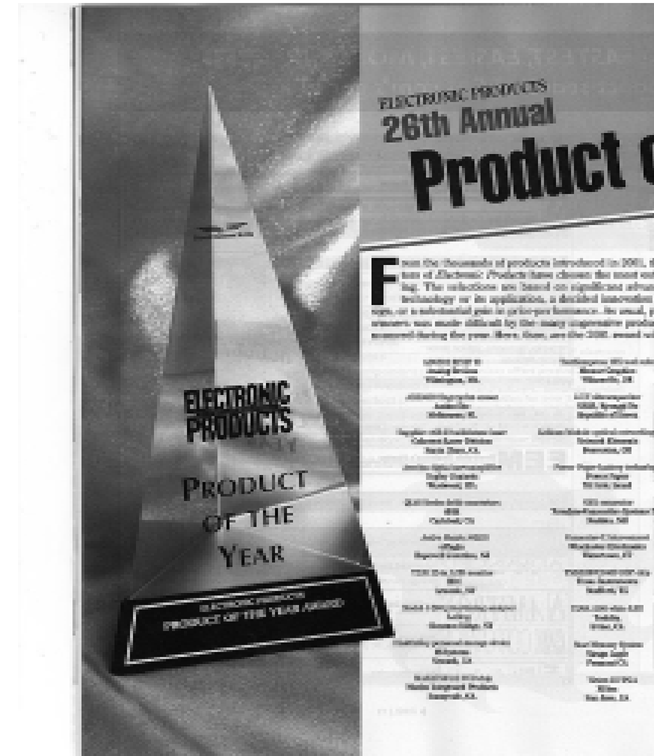
Coverage: 98.79%

$$\text{Test Cycles} = \frac{1600 * 11292}{2238 * (76 + 4)} = 100X$$

TestKompress™

Defines the Standard for Low Cost Scan Test

- **Improves manufacturing test floor throughput**
  - **Shortens scan test time**
- **Increases current ATE value**
  - **Eliminates memory upgrades**
  - **Extends ATE life**
- **Reduces capital expenditures**
  - **Fewer new ATE**
  - **Less expensive ATE**
- **Easily adopted and completely synergistic with FastScan**

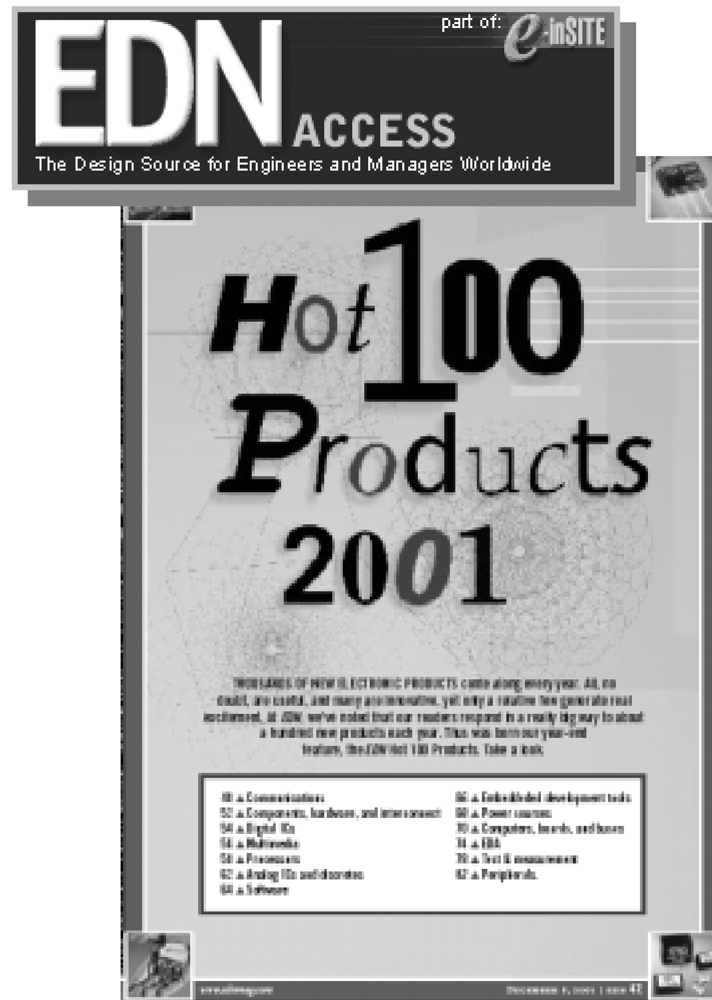


TestKompress:
Already a Winning Product

ELECTRONIC PRODUCTS *The Engineer's Magazine of Product Technology*

26th Annual

Product of the Year Awards



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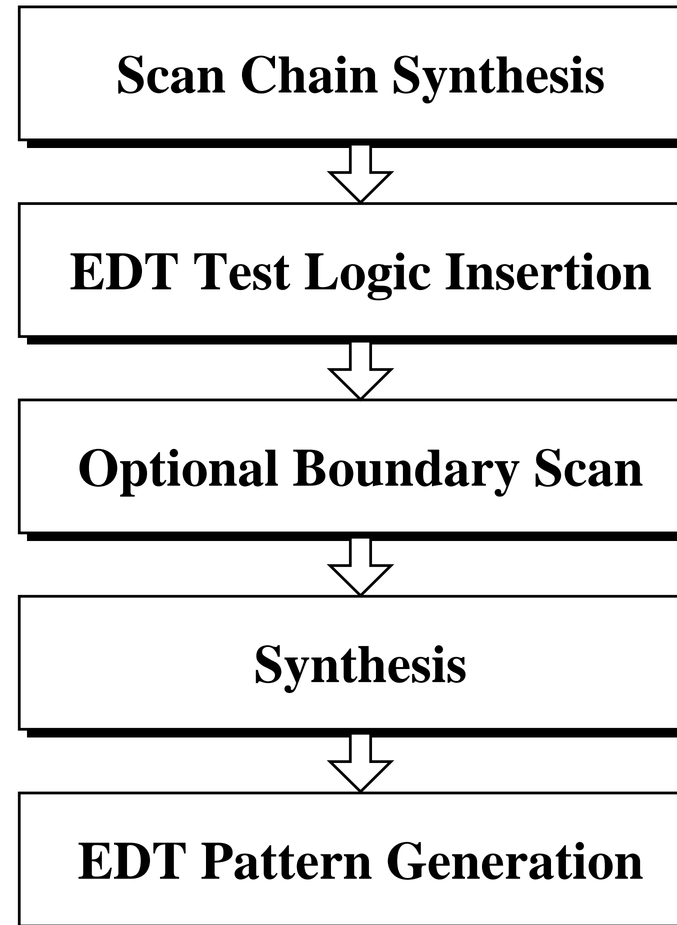
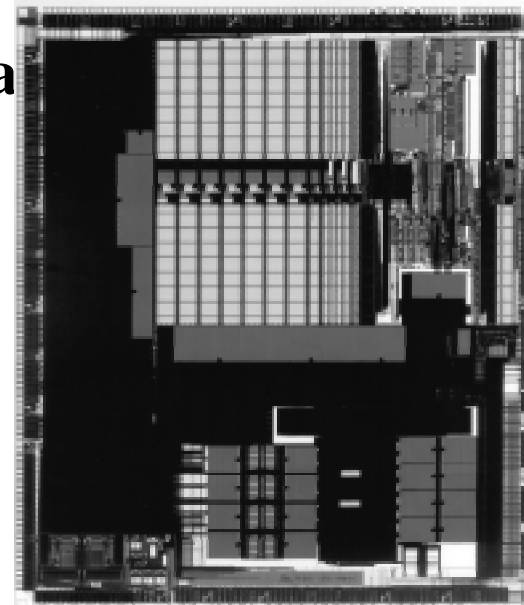
TestKompress
Similar flow to ATPG

- **Fits easily into all standard design flows**
  - **Vast majority of FastScan users and all current TestKompress users use Synopsys' synthesis**
  - **Very similar flow; simple migration from ATPG to EDT**
- **Reuses FastScan's *proven***
  - **Libraries**
  - **Dofiles (+ TestKompress commands)**
  - **Output vector formats**
  - **Diagnostic capabilities**



TestKompress in Production at Infineon

- **Five designs taped out in 2002**
  - **Automotive, wireless communication, data communication**
  - **1.3M - 2.8M gates**
- **Extensively validated versus ATPG (bypass)**
  - **Effective compression**
  - **Test effectiveness/quality**
- **Currently testing "extreme" compression ratios (>50X)**
- **Usage is expanding in 2003**



Comparison Factors of EDT

Quality

equirement	EDT Rating
upport all ult models	High
xtends to ther faults	High
upport at- peed test	High
upport all ttern types	High
Test all logic	High
iagnosis	Similar to ATPG

Design

Requirement	EDT Rating
Flow	Relatively easy
Ease of adoption	Easy for ATPG users
Expertise level	Low
Functional intrusion	Low
Area overhead	4-5% (for scan) 0.2-3% for EDT
Performance Impact	Low

Compression

Requirement	EDT Rating
Test time	20X-100X+
Test data volume	20X-100X+
Pattern efficiency	High
Compatible with ATE	Yes
Scalability of approach	Highly Scalab

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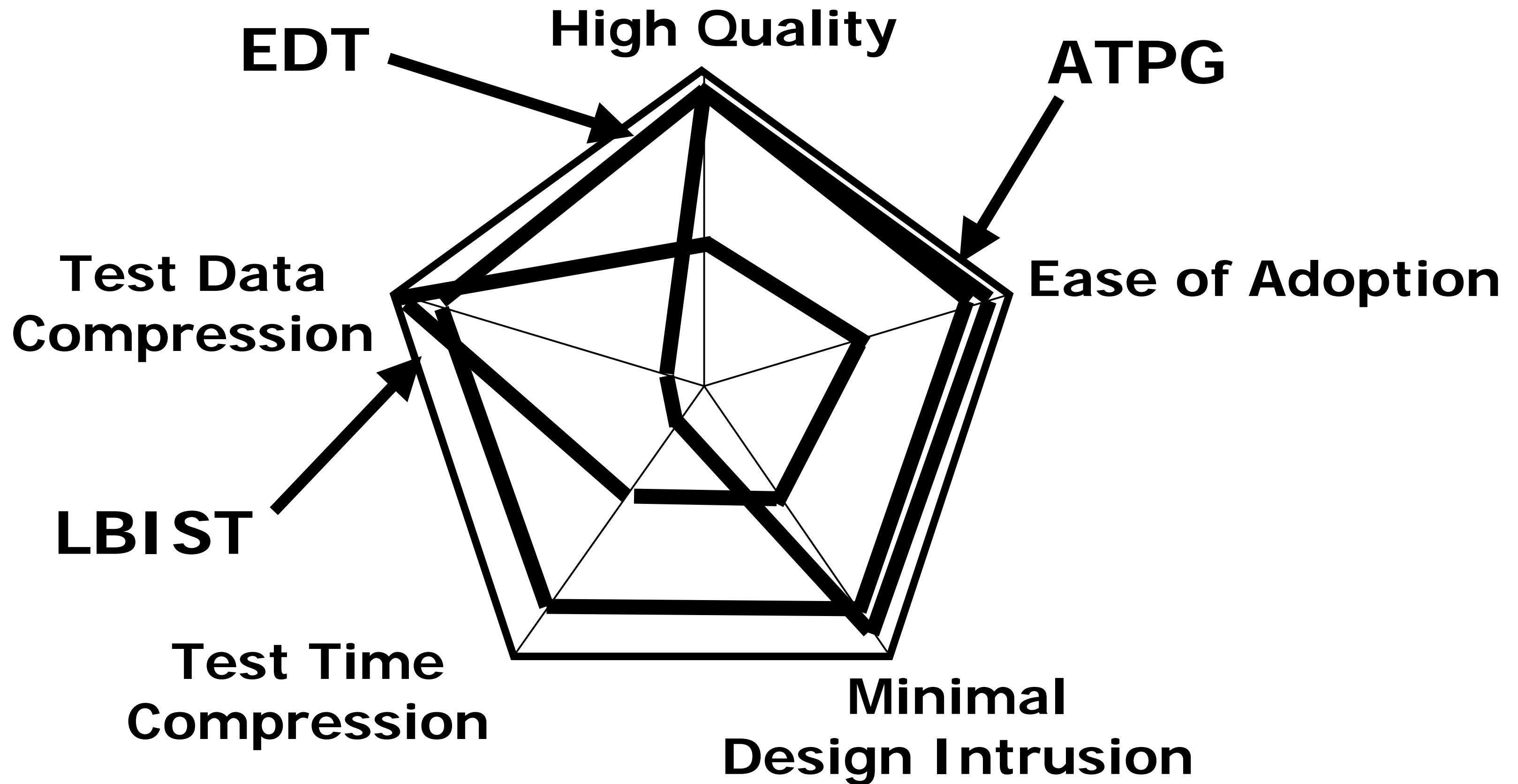
EDT Summary

- EDT is a natural extension to ATPG
  - Easy to learn and implement (similar flow to ATPG)
  - Obtains high quality tests with dramatic compression
- EDT supports
  - Reduction of test data volume and time
  - All fault models
  - All pattern types
  - X-handling without functional logic modification
- EDT is highly scalable
- TestKompress is a proven commercial EDT solution

All Methods Compared



Comparison Summary

	ATPG	EDT	LBIST
Test Quality	High, supports all fault models	Same as ATPG	High test quality hard to achieve without ATPG top-up or test points.
Design Issues	Well understood easy-to-use flow. Low design intrusion.	Easily adopted by ATPG users. No functional logic intrusion.	Requires DFT expertise. Highly design intrusive.
ompres-sion	Baseline. New techniques continue to improve results.	20X-100X+ of test time and data volume vs. best ATPG results.	Test time not reduced. Test data can be as low as 0 vectors.

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Recommendations

	EDT
When to Use	**When ATPG can not compress test data and run time enough.**
Design Style or Size	**Any.**
Typical Applications	**Any devices not requiring self-test.**