

Functional Stimuli Generation for Burn-In Test

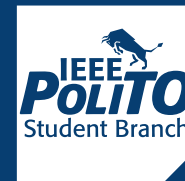
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PhD
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the PhD's pitch



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OVERVIEW

Introduction

Problem
Definition

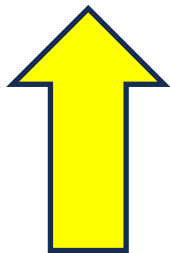
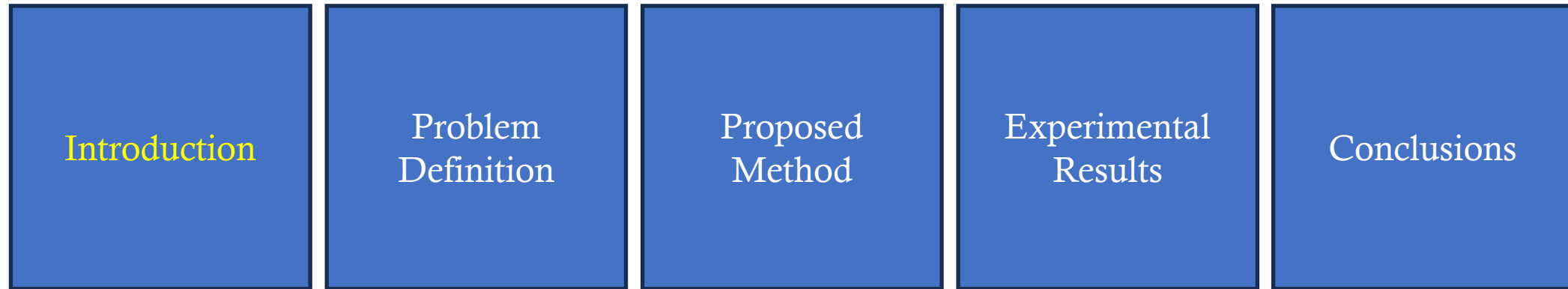
Proposed
Method

Experimental
Results

Conclusions

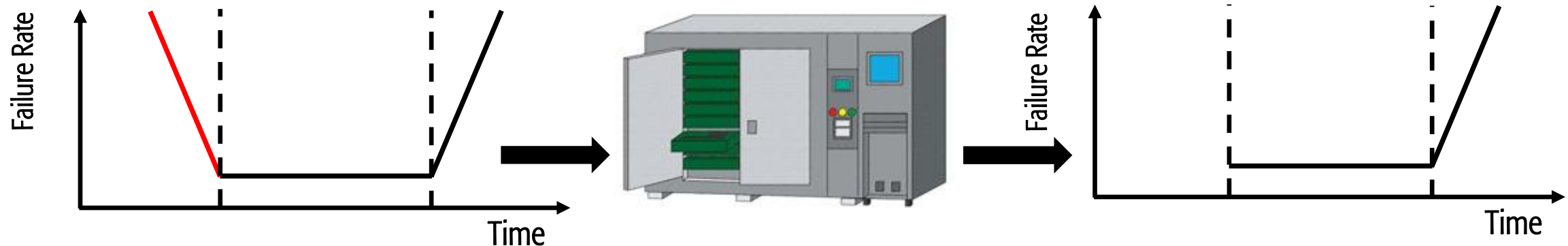


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The “what”'s and “why”'s

- **Burn-In** (BI) is an end-of-manufacturing test procedure
- Combats the “Infant Mortality” phenomenon modeled by the bathtub curve
- **Omnipresent** in the **safety-critical** domain
- Devices under test (DUTs) are placed in climatic chambers
- **Static** & **Dynamic** BI forms
 - High temperature and voltage (**external stress**)
 - Application of stress-inducing stimulus (**internal stress**).

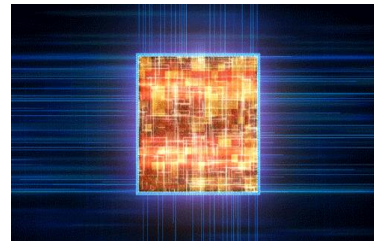


Static and Dynamic formats

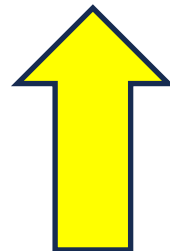
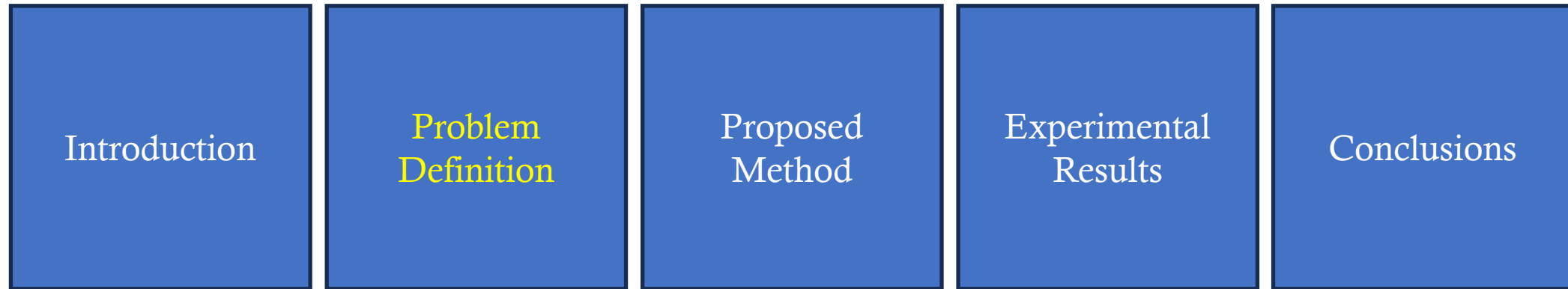
- Static BI was sufficient
- However:
 - New technology nodes → Smaller, denser circuits → Higher test complexity 😞
 - Static BI does not fully sensitize all internal parts of the circuits 😞
 - With static BI the circuit is not aged in a functional manner
- Hence, BI evolved into new forms (dynamic, monitored, test-in)
- The necessity of the appropriate stress stimulus arises...

How do we induce internal stress?

- Structural means
- State-of-the-Art:
 - Usage of Design-for-Testability structures (e.g., scan)
 - Effective, uniform temperature elevation on the devices under test (DUTs)
 - Goal: toggle each net of the DUT at least once (and then repeat)
 - Extreme caution to avoid overstressing → DUT damage → yield loss.
- Functional means
- State-of-the-Art:
 - Manually, hand-written code
 - Higher temperature increase on targeted spots on the DUTs than scan
 - Goal: maximize a *stress metric*
 - At-speed application
 - Cannot damage the DUTs.

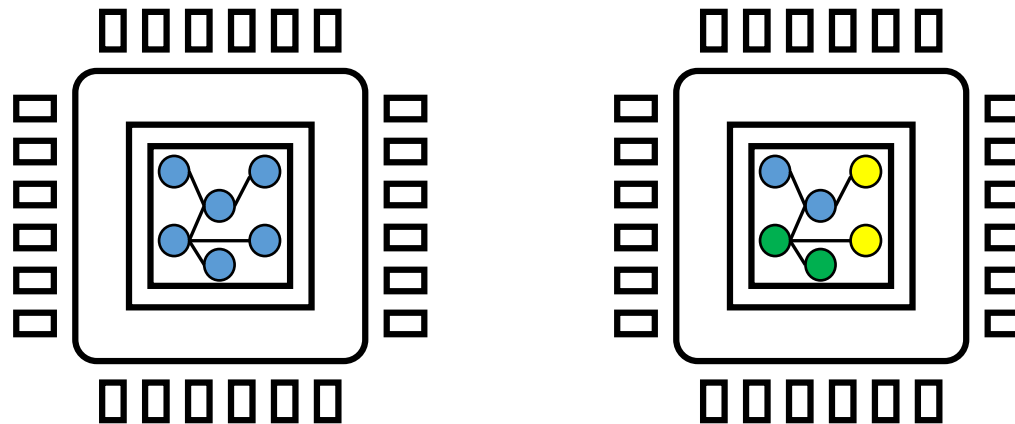


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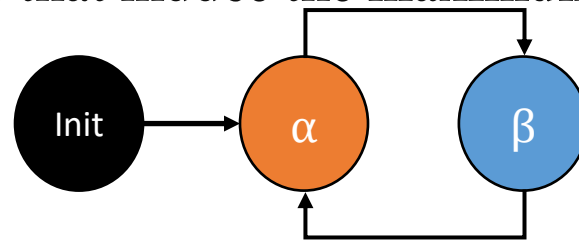
Stress evaluation metrics

- Essential for quantification of “stress”
- Single-point metrics:
 - For each net of the DUT generate a pattern to cause a toggling
- Multi-point metrics:
 - Dissect the DUT into net groups based on e.g., minimum distances
 - For each net group generate a pattern to cause a toggling to that group.

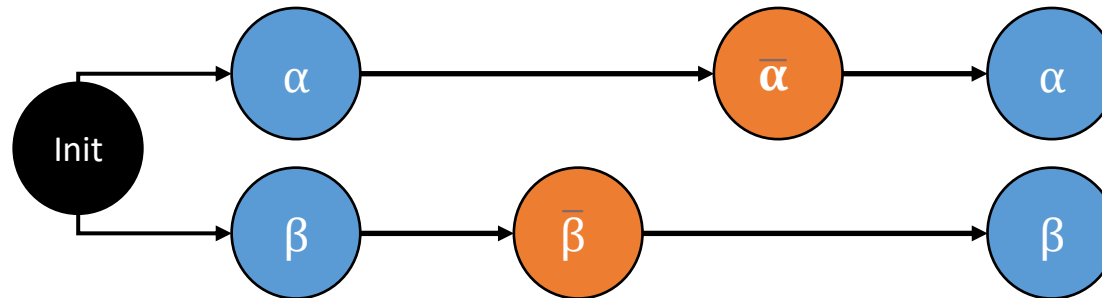


Proposed stress metrics

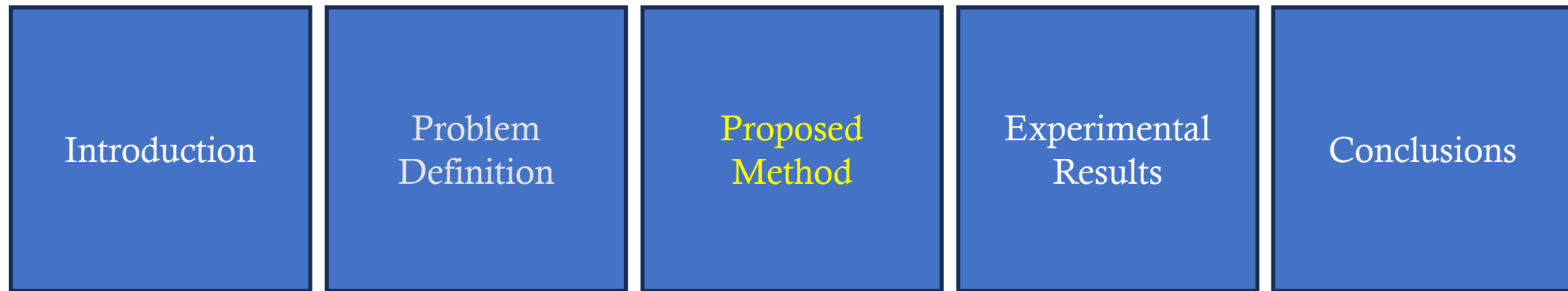
- Repeatable & Constant Switching Activity Maximization (RCSWA)
 - Identify the instructions that induce the **maximum possible** switching within the DUT



- 2-Multipoint Switching Activity Maximization (2MPS)
 - The CUT's nets are grouped into pairs (of 2 nets) based on **layout topological information**
 - Identify the instruction sequences that maximize the number of pairs switching.

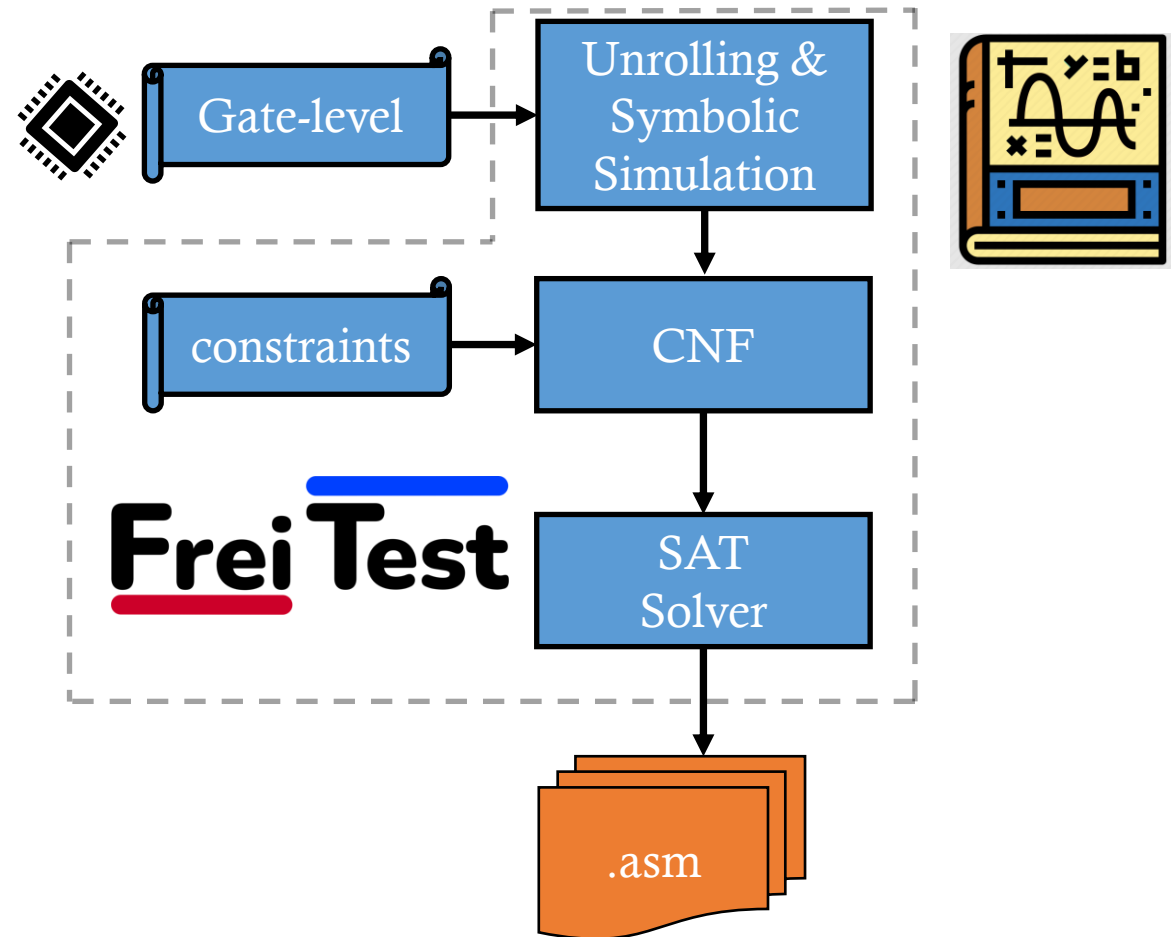


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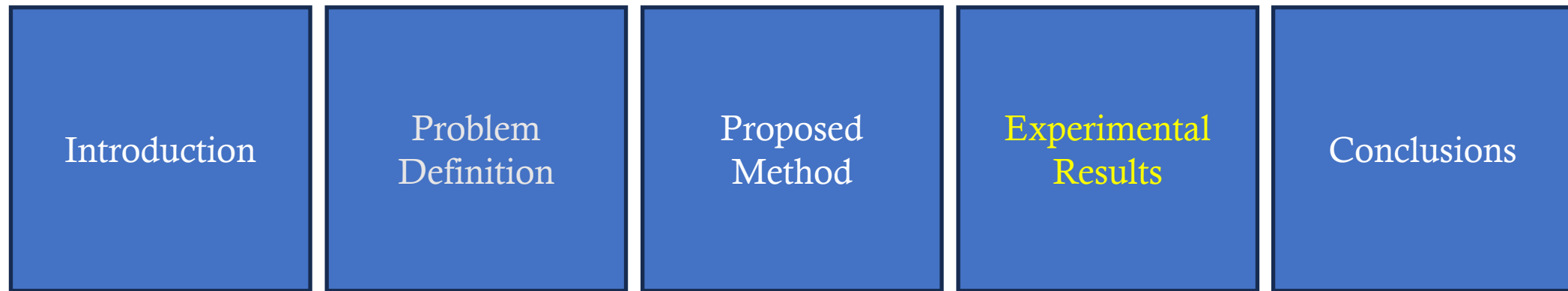


Formal Methods (FMs)

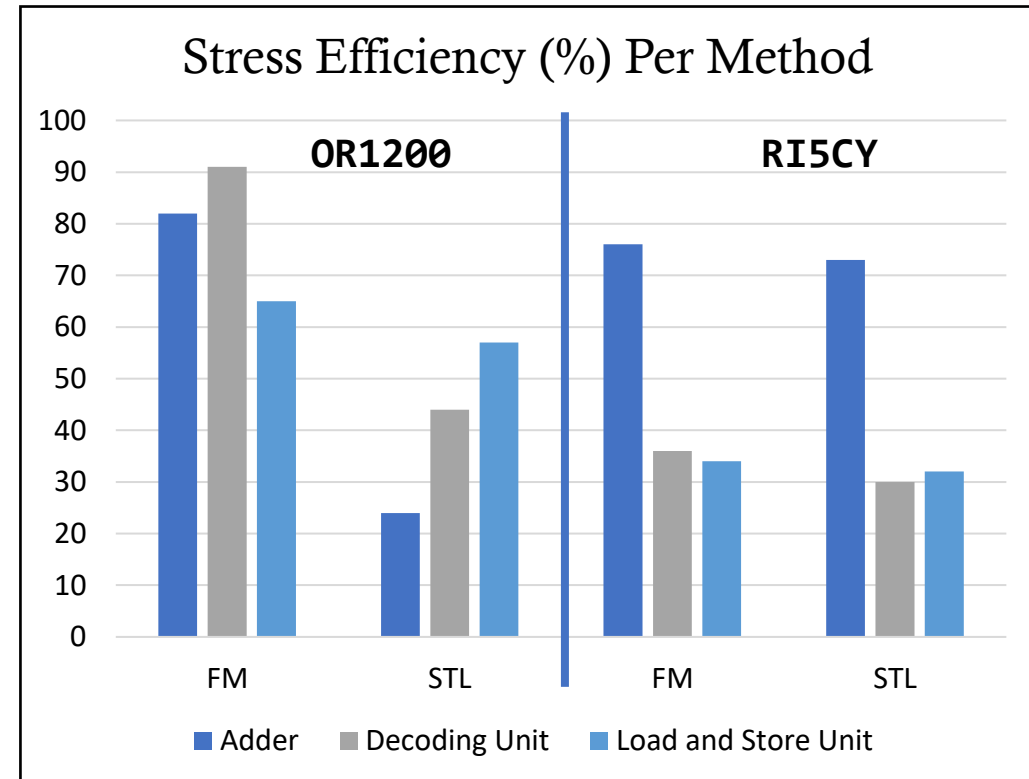
- FreiTest – FM Framework (proprietary)
- Reduction to Boolean SATisfiability (SAT)
- Functional constraints applied in the form of propositional logic (*clauses*)
- Solvers:
 - SAT
 - MaxSAT
 - Bounded Model Checking (BMC)
- **Optimal** solutions.



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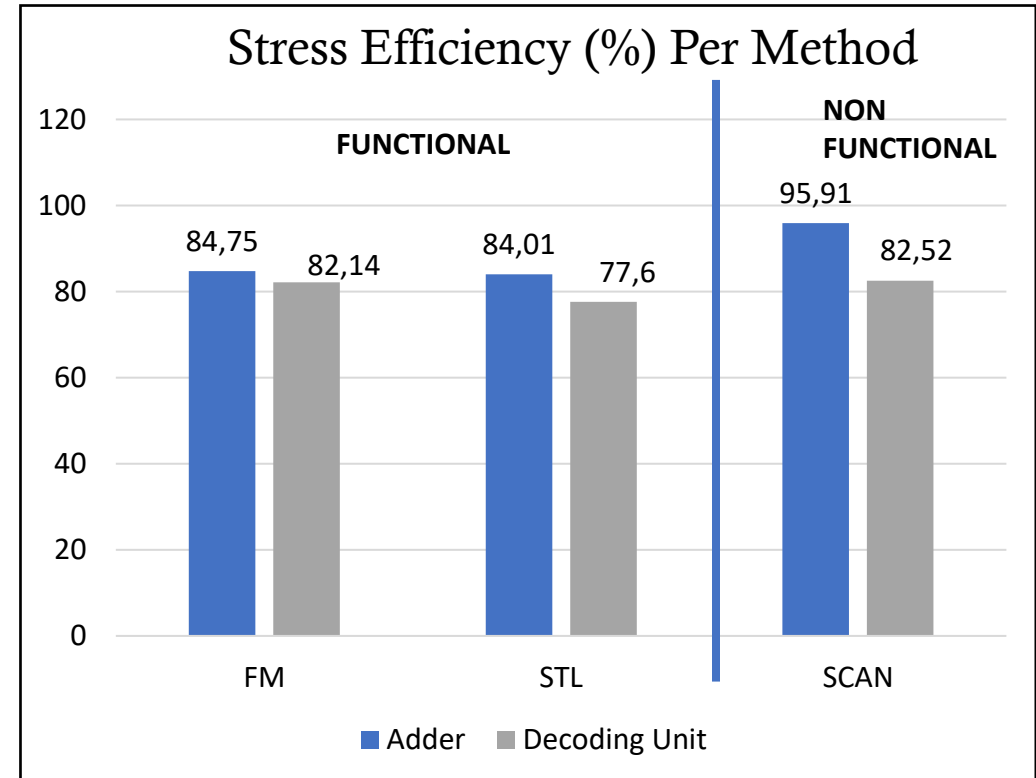


- Methods applied on units of OR1200 and RI5CY processors:
 - ALU's 32-bit Adder
 - Decoding Unit
 - Load and Store Unit
- Compared with stuck-at STL's in terms of induced stress.

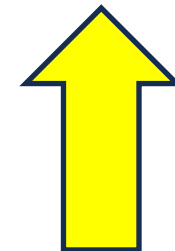
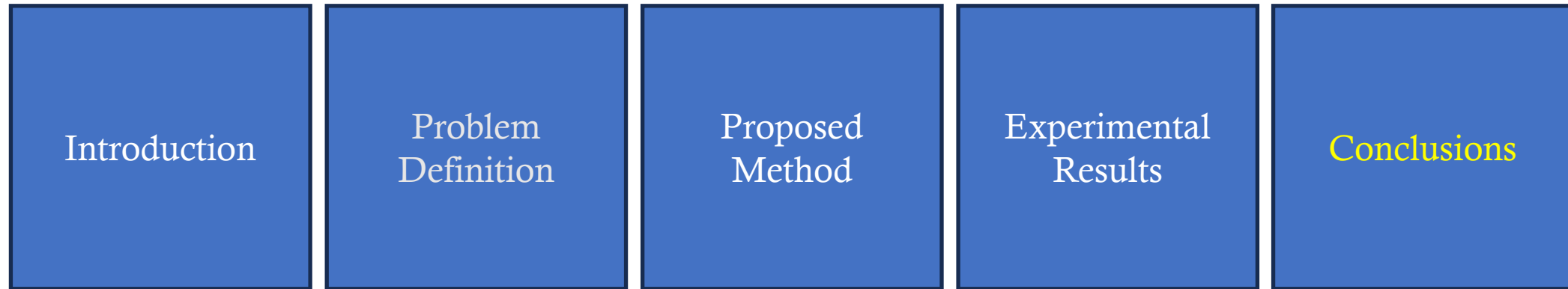


2MPS

- Methods applied on units of RI5CY processor:
 - ALU's 32-bit Adder
 - Decoding Unit
- Compared with stuck-at STL's in terms of induced stress
- Compared with Non-functional scan stimuli.



OVERVIEW



Final Remarks

- BI test is the most effective solution against infant mortality
- Static formats of BI test are no longer effective on new technologies
- A combination of dynamic and static stress is required
- Manual effort is required in order to generate stress stimuli
- Given a well-defined stress metric is feasible to generate high quality stimuli automatically
- Fully customizable and adaptable method to any kind of circuit.

THANK YOU!!!

