Center for Embedded Systems
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Accurate and Scalable RTL-level Fault Injection Simulation for Industrial and Automotive Standards

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Overview and Executive Summary

- **Problem**
  - Industrial and automotive standards (ISO 26262) require that the fault coverage be reported at the gate-level.
  - Fault injection-based techniques are not scalable to industrial Systems on a chip (SoC).
  - Existing fault-injection-free RTL-level fault simulators do not meet the required fault coverage standards.
- **Project Description**
  - Fault-injection-free simulation for the test sequence.
  - An abstract quantity (metric) at each RTL module estimates accurately the fault coverage at the module.
  - Probabilistic inter-module error propagation.
  - Statistical evaluation framework to ensure accuracy of the estimated fault coverage so that it meets the ISO standards.

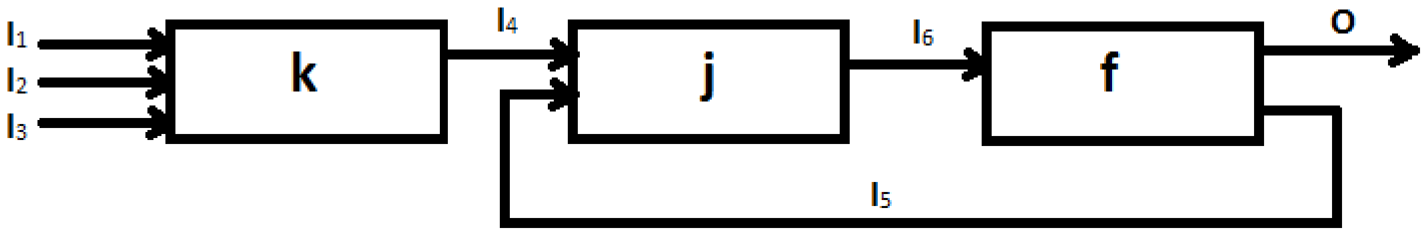
Approach

- **Novelty**
  - Intra-module fault coverage using metrics.
  - Inter-module error propagation.
  - Statistical evaluation framework.
- **Scalable Intra-Module Coverage using metrics**
  - Probabilistic Metric:
    - 0/1 line controllabilities with a logic simulation for sequence.
    - Calculate fault observabilities using controllability values [1].
    - Fault detectability: Product of controllability and observability.
  - Critical Path Trace metric [2]:
    - Pessimistic fault coverage that uses a single logic simulation and one back-trace per output cone.
  - Metrics will be evaluated.

[1] L.T. Wang, Y.W. Chang , K.T. Cheng, “Electronic Design Automation”, Morgan Kaufmann, February 2009
[2] M. Abramovici, P. R. Menon and D. T. Miller, "Critical Path Tracing - An Alternative to Fault Simulation," Proc. 20th Design Automation Conference, pp. 214-220, June 1983.

Approach

- **Probabilistic Inter-Module Error Propagation**
  - Boolean difference function based on SoC functionality
  - Disjoint covers determine error propagation probability



- **$O(t)=f(I_6(t-1))=f(j(I_4(t-2),I_5(t-2))= f(j(k(I_1(t-3),I_2(t-3),I_3(t-3)), I_5(t-2))$**
- **Fault is at I_5 is observed twice in the functional expansion of the output**
- **Probability is estimated by choosing disjoint covers which satisfy the Boolean difference of the function**

Approach

- **Statistical Framework: Linear regression analysis**
  - Determine the correlation between fault cover by proposed metric (m_cover) and actual fault cover (*i* is the sequence size) [1]:
    - $r_{m\_cover,fc} = \frac{cov(m\_cover,fc)}{\sigma_{m\_cover}\sigma_{fc}} = \frac{\sum_{i=1}^{n}(m\_cover_i - \overline{m\_cover}) \times (fc_i - \overline{fc})}{\sqrt{\sum_{i=1}^{n}(m\_cover_i - \overline{m\_cover})^2} \times \sqrt{\sum_{i=1}^{n}(fc_i - \overline{fc})^2}}$
  - Best fit line for number series m_cover_i, fc_i is found with regression analysis
  - Accuracy of the approach is determined by obtaining the residuals (difference between actual and estimated fault cover).
    - For each set of data points (m_cover_i,fc_i), the mean of residuals must be zero
    - For each set of data points (m_cover_i,fc_i), the variance of residuals must be a constant value
    - The residuals should be uncorrelated with each other
    - The residuals should be normally distributed

[1] EAGLE: A Regression Based Model for Fault Coverage Estimation Using a Simulation Based Metric (ITC-2014)

Project Tasks/ Deliverables

	Description	Date	Status
1	**Intra-Module level grading tool**	**09/15/2016**	
2	**Inter-Module level grading tool**	**12/15/2016**	
3	**Regression tool**	**04/15/2017**	
4	**Detailed experimental evidence on benchmarks provided by member company**	**08/15/2017**	
5	**Determine netlist properties that support RTL metric-based accurate simulation**	**08/15/2017**	
6	**Detailed Report and Documentation**	**08/15/2017**	

- **Potential Member Company Benefits**
  - **Fast and accurate grading tool to estimate the quality of a given test set in order to assess whether ISO 26262 standards have been met**
  - **Thorough experimental evaluation on industrial benchmarks provided by the sponsor company**