A Stochastic Computational Approach for Accurate and Efficient Reliability Evaluation

A Python Implementation

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Reliability of Circuits

Gates in a logic circuit are, alas, not perfect. They are susceptible to error, of which there are three main types:

- **Stuck-At-One Error:** The output of the gate goes high, regardless of the expected output.
- **Stuck-At-Zero Error:** The output of the gate goes low, regardless of the expected output.
- **Von Neumann Error:** The output of the gate becomes the inverse of the expected output.

Masking Effects

However, there is a chance that errors in one gate will not propagate all the way to an output. This could be due to one of the following *masking effect*s

- **Electrical Masking:** The error does not have a large enough effect on the amplitude of the logic signal to be detected at an input.
- **Temporal Masking:** The error is input to a latch but occurs at some point in time outside of the latch's detection window.
- **Logical Masking:** The error does not pass through a multi-input logic gate because the value of the other input(s) fix(es) the output of the gate.

Reliability Analysis Principles

As it happens, Logical Masking is the most prominent masking type in logical circuits. It is therefore useful to be able to analyse circuits on their ability to logically mask errors.

If we define the *probability* of a signal as the proportion of time that it is logically True, then the basic idea is as follows:

- Construct a faulty representation of the circuit, which takes into account probabilities of each gate failing.
- Derive the probabilities of the output signals.
- Then the *reliability* of an output signal is the probability that it takes the same value in both the ideal and faulty circuits.

Reliability Analysis Probabilistic Gate Models

However, existing algorithms are inefficient!

For example, *Probabilistic Gate Models* (PGMs) attempt to analytically derive the output probabilities as functions of the input probabilities and gate error probabilities.

The problem occurs when the inputs to a gate are not statistically independent, such as is the case when there are *reconvergent fanouts*. That is, when two or more inputs to a gate originated from a single signal.

The PGM equations do not account for statistically dependent signals, and the solution involves splitting the circuit into two sub-circuits. This approximately doubles the cost of the algorithm for each reconvergent fanout.