SWAT-Sim: Accurate Microarchitecture-Level Fault Models

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Resilient Theme, Task # 1.2.2.5

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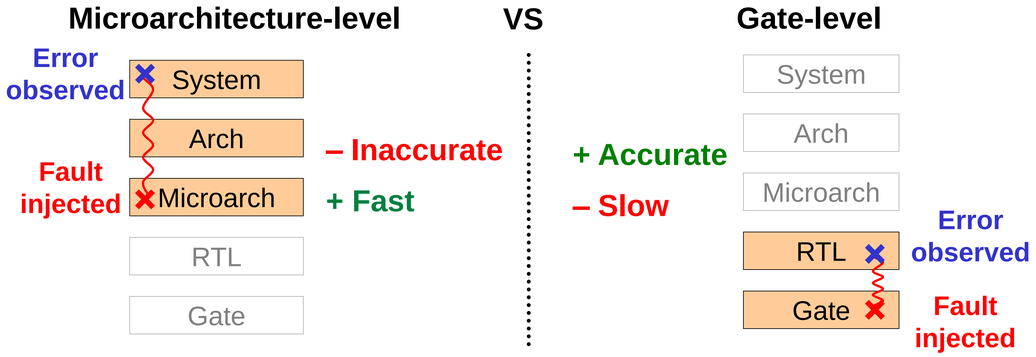
Need Accurate Microarchitecture-Level Permanent Fault Models

Microarchitecture-level solutions require observing system-level effects

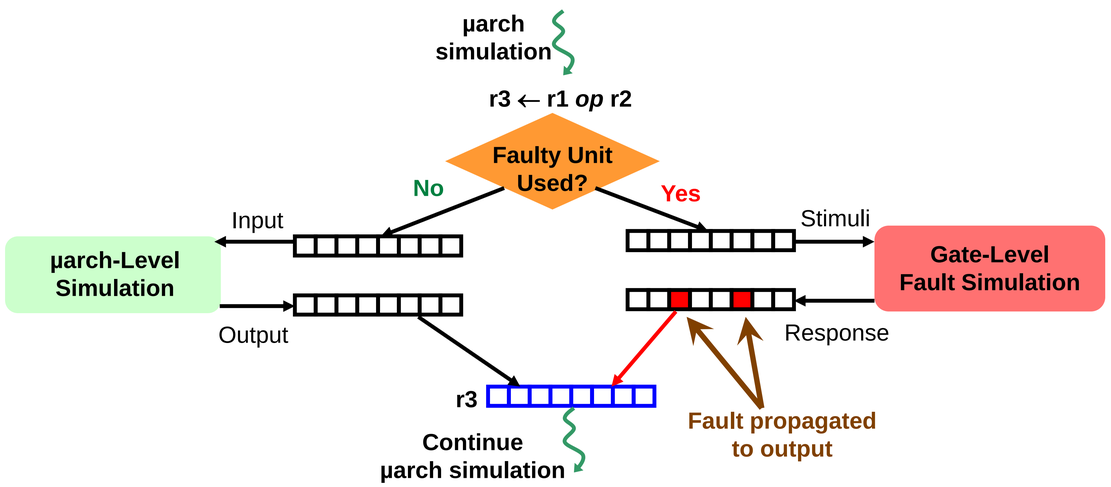


SWAT-Sim: Accurate and Fast Hierarchical Fault Simulator

Simulate mostly at microarchitecture-level ⇒ Fast in common case

Simulate only faulty component at gate-level ⇒ On-demand invocations

Permanent faults influence future fault activations ⇒ Online simulation



Advantages: Gate-level fault modeling accuracy, µarch-level simulation speeds
SWAT-Sim propagates faults using real-world functional vectors

Experimental Methodology to compare Fault Models using SWAT-Sim

Fault injection platform: full-system (Simics) simulation of out-of-order µarch (GEMS)

Workloads: SPEC2K running on Solaris 9

Fault models: µarch-level stuck-at faults, gate-level (with NC-Sim) stuck-at and delay faults

Faulty components: Int ALU (ALU) or Address Generation Unit (AGEN) (from OpenSPARC)

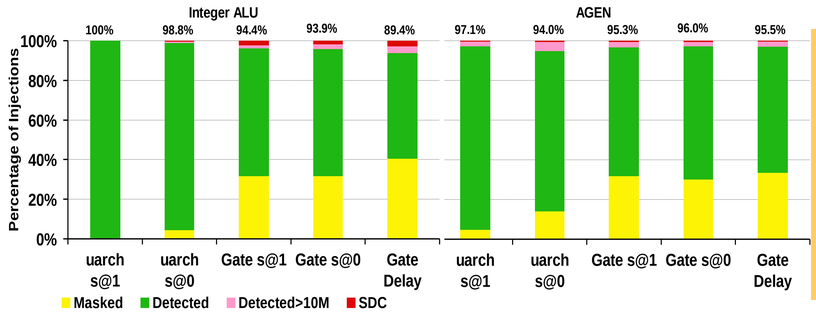
Metric for accuracy: Coverage & latency (not shown) of SWAT detectors (system-level effects)

How Fast is SWAT-Sim?

100,000 times speed of pure gate-level simulation, same fault modeling fidelity

< 2x avg slowdown from µarch-level simulation, but higher accuracy

Are Existing µarch-level Fault Models Accurate?



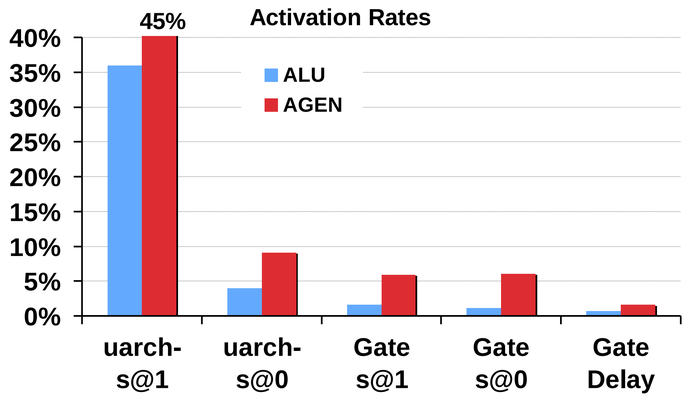
Existing Fault Models inaccurate

Coverage:

- µarch s@ generally inaccurate
- Accuracy depends on structure

Latency:

- µarch s@ inaccurate



Bit-flips	µarch	Gate s@0	Delay
Int ALU			
Single	100%	84.4%	90.4%
Multiple	0%	15.6%	9.6%
AGEN			
Single	100%	75.5%	90.5%
Multiple	0%	24.5%	9.5%

µarch vs. Gate-Level

- Different activation rates
- Ability to corrupt multi bits

Can We Derive Accurate µarch-Level Fault Models?

Use SWAT-Sim to generate µarch-level models

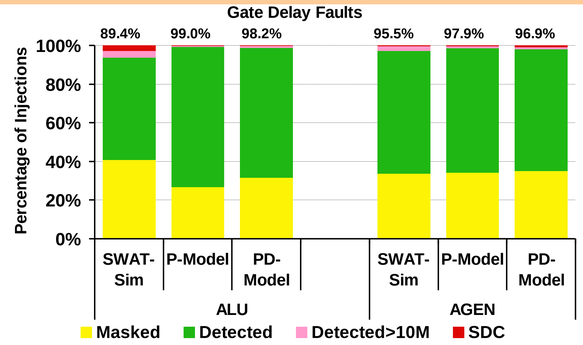
Accurate model ⇒ only µarch sim ⇒ Fast!

Probabilistic models from SWAT-Sim data

Collect *number*, *pattern,* and *direction of flips*

Generally unable to mimic gate-level faults

Accuracy depends on structures



Conclusions + Future Work

SWAT-Sim achieves high speed and fault modeling fidelity

Exisiting µarch stuck-at fault model generally inaccurate

Unsuccessful in deriving accurate µarch fault models ⇒ need SWAT-Sim!

Future work: complex gate-level timing faults (e.g., path delay), interfacing larger modules