Hardware Error Injection for Coverage Analysis of CVR

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Background

- Error Injectors are necessary to study coverage of error detection techniques.
- Most software error injectors can target only memory registers and user level code, whereas hardware injectors can target locations beyond process memory space.
- Hardware implemented error-injectors can inject intermittent and permanent errors.

![Fig: Hardware and software error injectors target space.]

Goals

- Development and testing of a hardware error-injection prototype on real applications running atop the Leon3.
  - This includes:
    - Introduction of error to memory by modifying hardware description of leon3 pipeline or write-back.
    - Introduction of error according to Poisson distribution.
    - Testing the error injector on the RSE (Reliability and security) framework.
    - Studying coverage of the SDM/Microcontroller which implements CVR to detect errors.

![Fig: Error injected in conjunction with Leon3.]

Fundamental Questions/Challenges

- Identifying vulnerable locations in processor integer-unit pipeline and data cache write back to inject errors.
- Determining factors and parameters which should be used to trigger the injection. E.g., time, specific memory.
- Passing parameters from application and not hard code in hardware description.
- Recording the injected errors.
- Determining injected error distribution and implementing/imitating it on hardware.

Research Plan

- Getting acquainted with CVR error detection strategy and its microcontroller-based implementation.

Research Results

- Developed, simulated, and synthesized a Poisson hardware error injector with <target memory location> and <specific data> as trigger using specialized CHK instruction.
- Developed and simulated hardware to record finite latest error injections.
- Tested the error-injector with applications running atop Leon3 in conjunction with the microcontroller.

![Fig: Error injection flow]

Related Work/Interaction with Other Projects

- NFTAPE is a general-purpose configurable tool for software fault injection based coverage analysis.
- Microcontroller-based CVR technique for error detection can be used in conjunction with hardware error injector.