Comparing the Effects of Intermittent and Transient Hardware Faults on Programs

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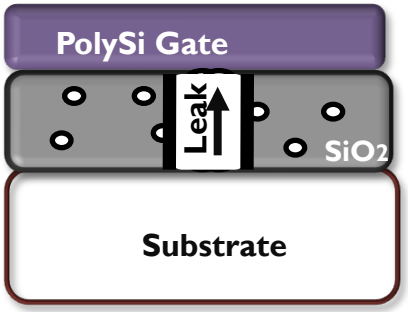
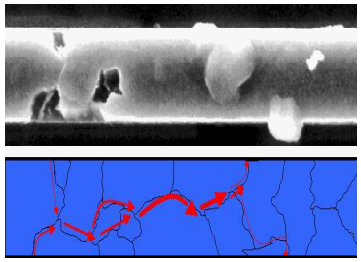
Motivation

- Consequences

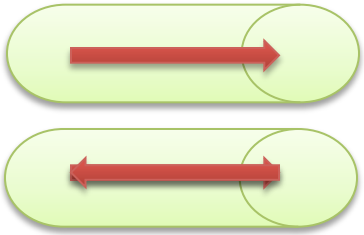
Gate Oxide Breakdown



Electro-migration



Crosstalk



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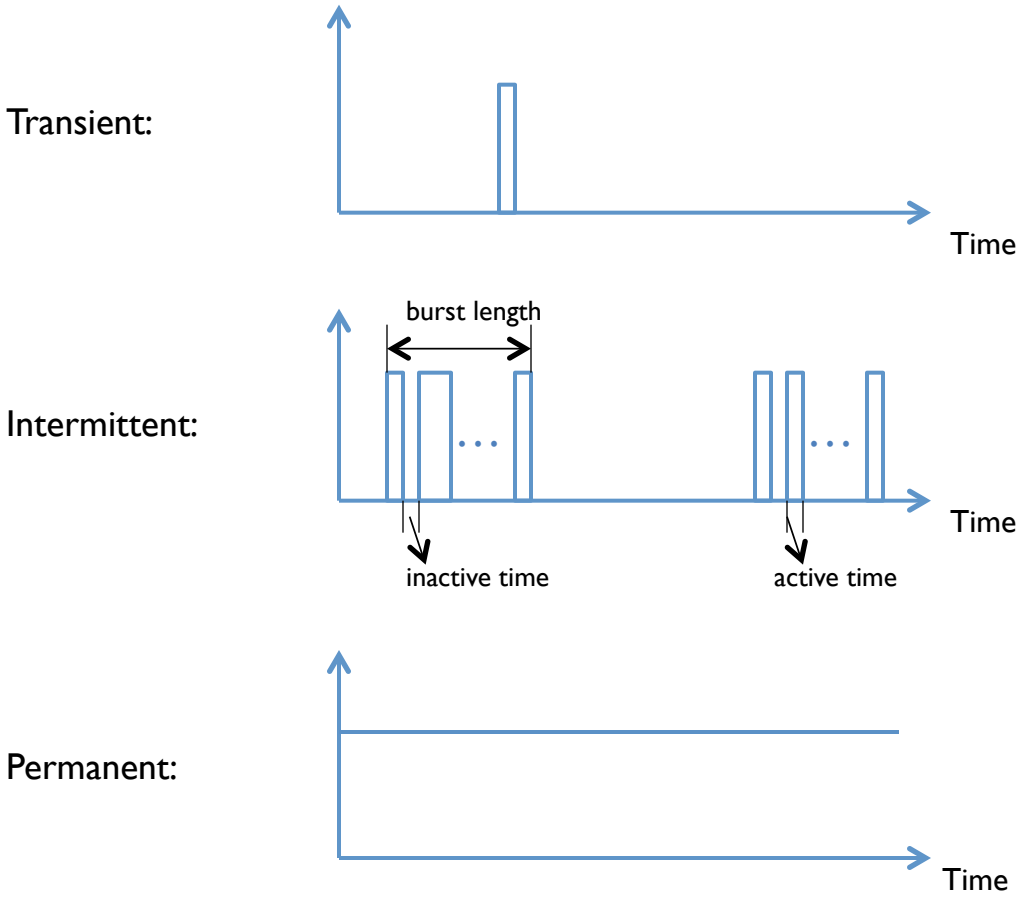
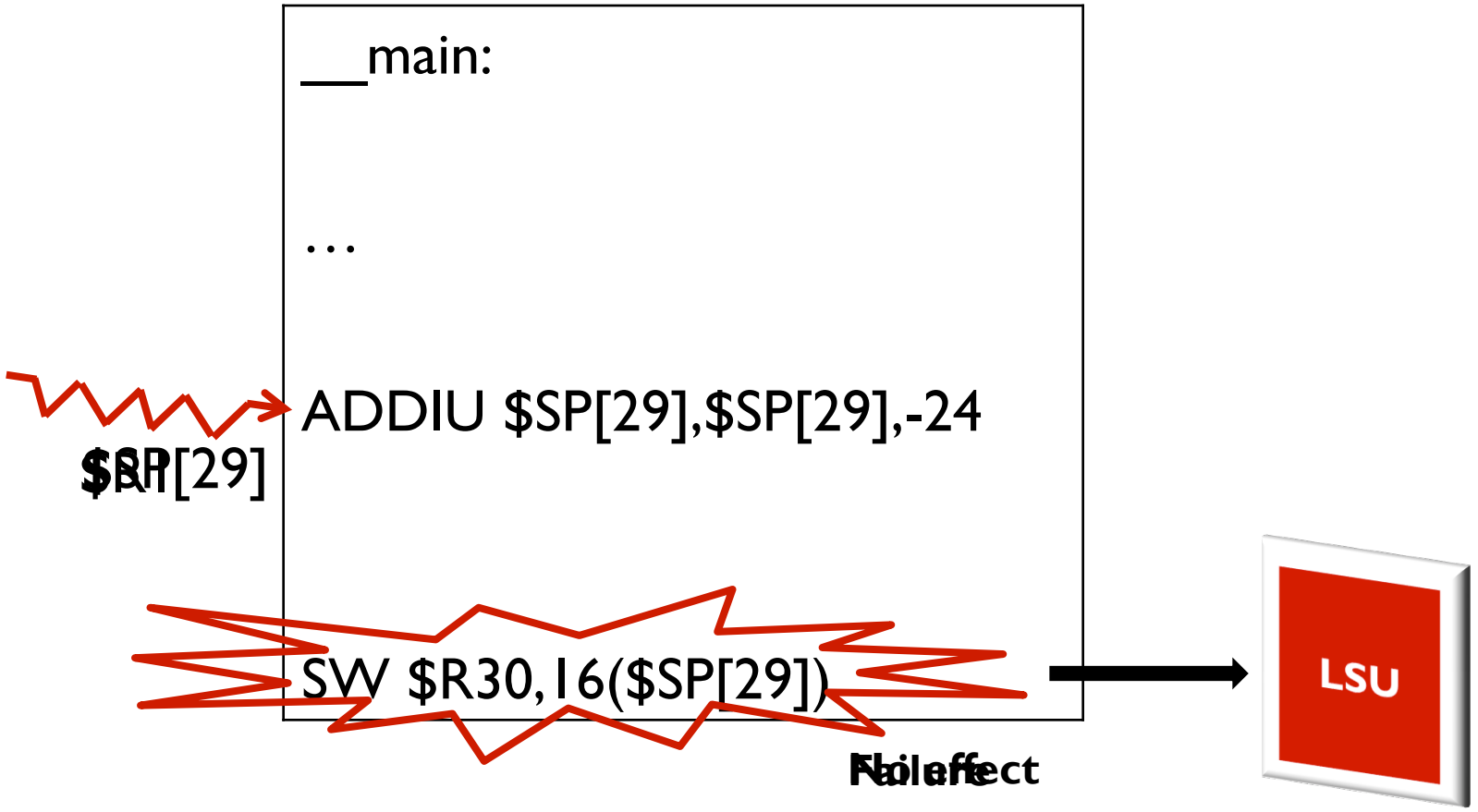
- Increase of intermittent faults [Constantinescu'03]
- Intermittent faults recur quickly [Nightingale'11]

Intermittent VS. Transient Faults



Propagation of Intermittent Faults

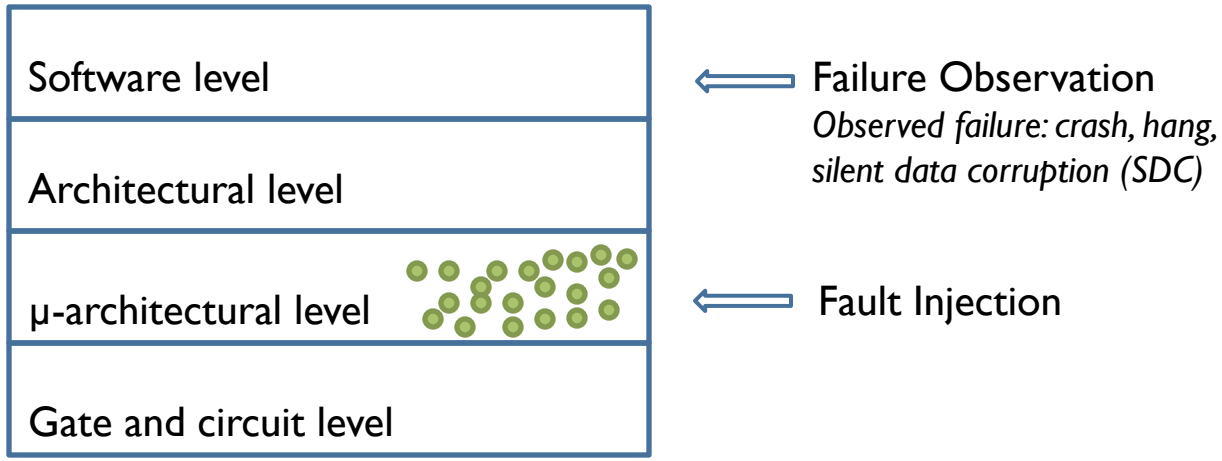


Research Questions

- Do intermittent faults *differ* significantly with transients in their *impact* on software programs?
- If yes, how do the differences vary with the *length* (i.e., duration in cycles) of the fault?
- How do the differences vary with the *micro-architectural unit* in which the fault originates?

High-level Methodology

- Perform fault injection at µ-architectural level
- Study effect of the faults at software level



Outline

- Motivation and Overview
- Fault Model
- Experiment Setup
- Results
- Conclusion and Future Work

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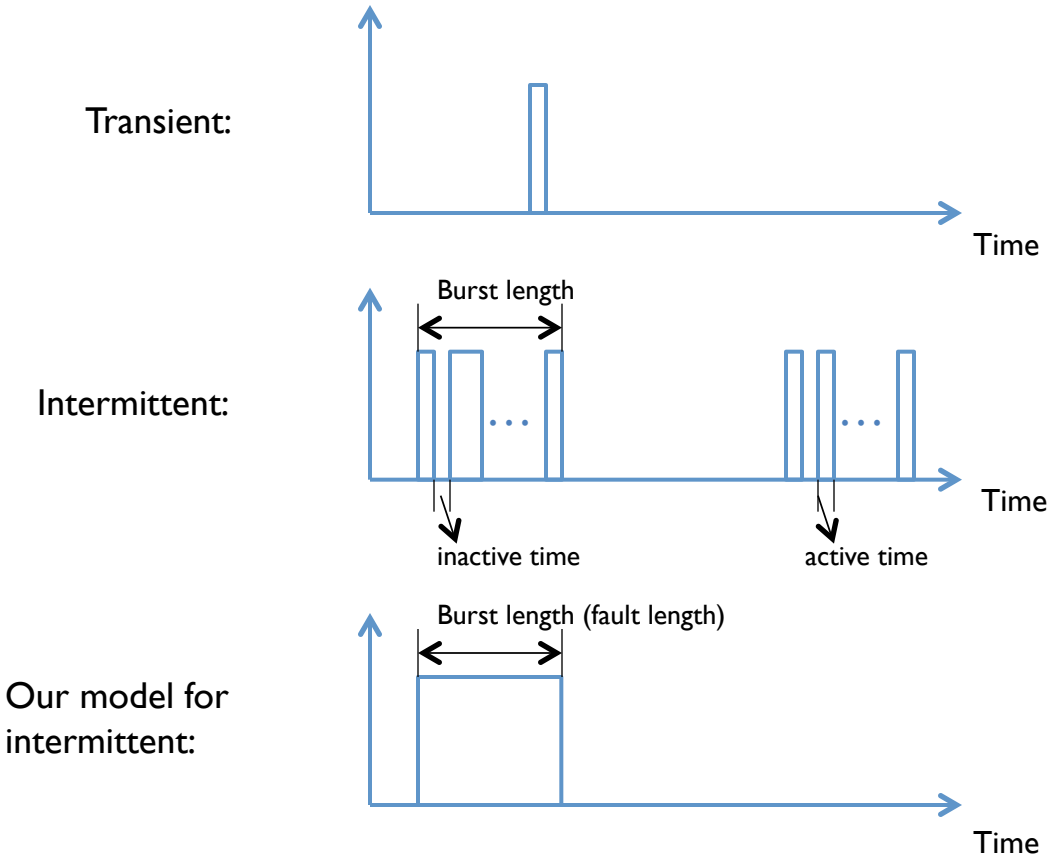
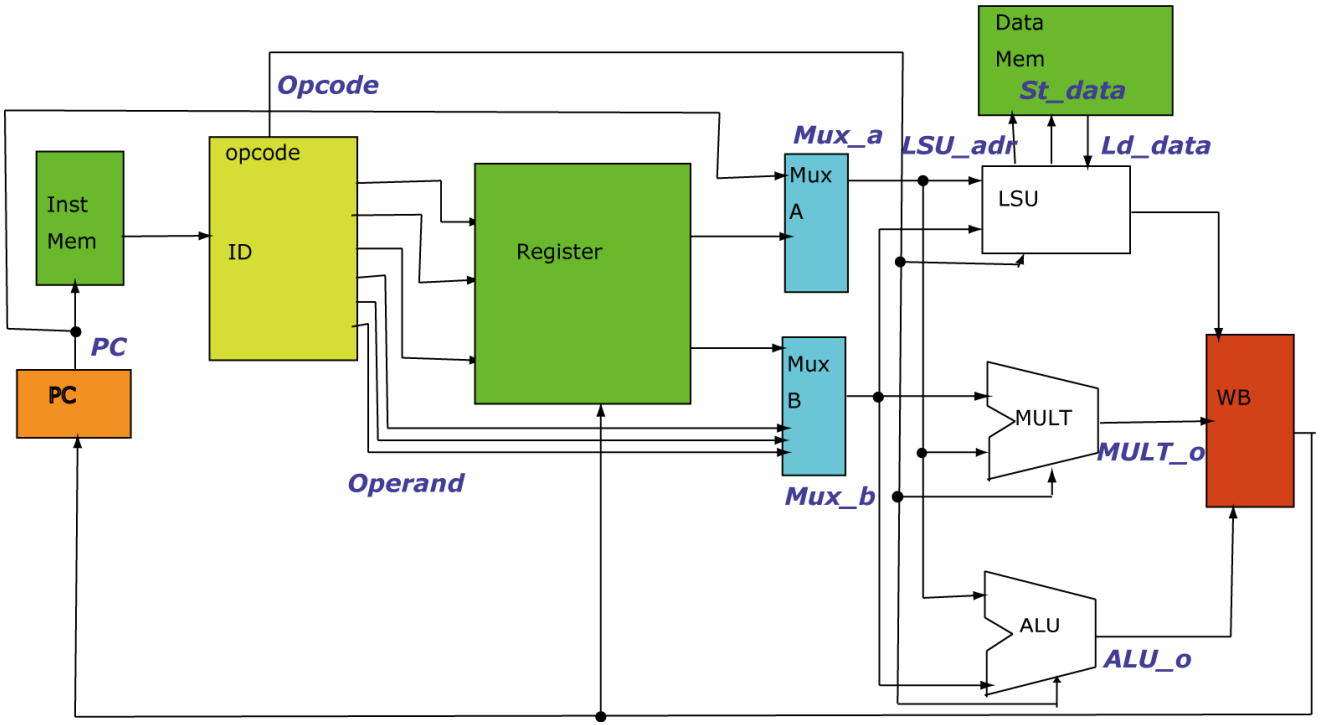
Fault Type

- Intermittent: stuck-at-0/1 for specified durations of time



Fault Injection Location

- Inject faults in a RISC processor from [Patterson'08]
- Inject *only* 1 bit of the selected signal



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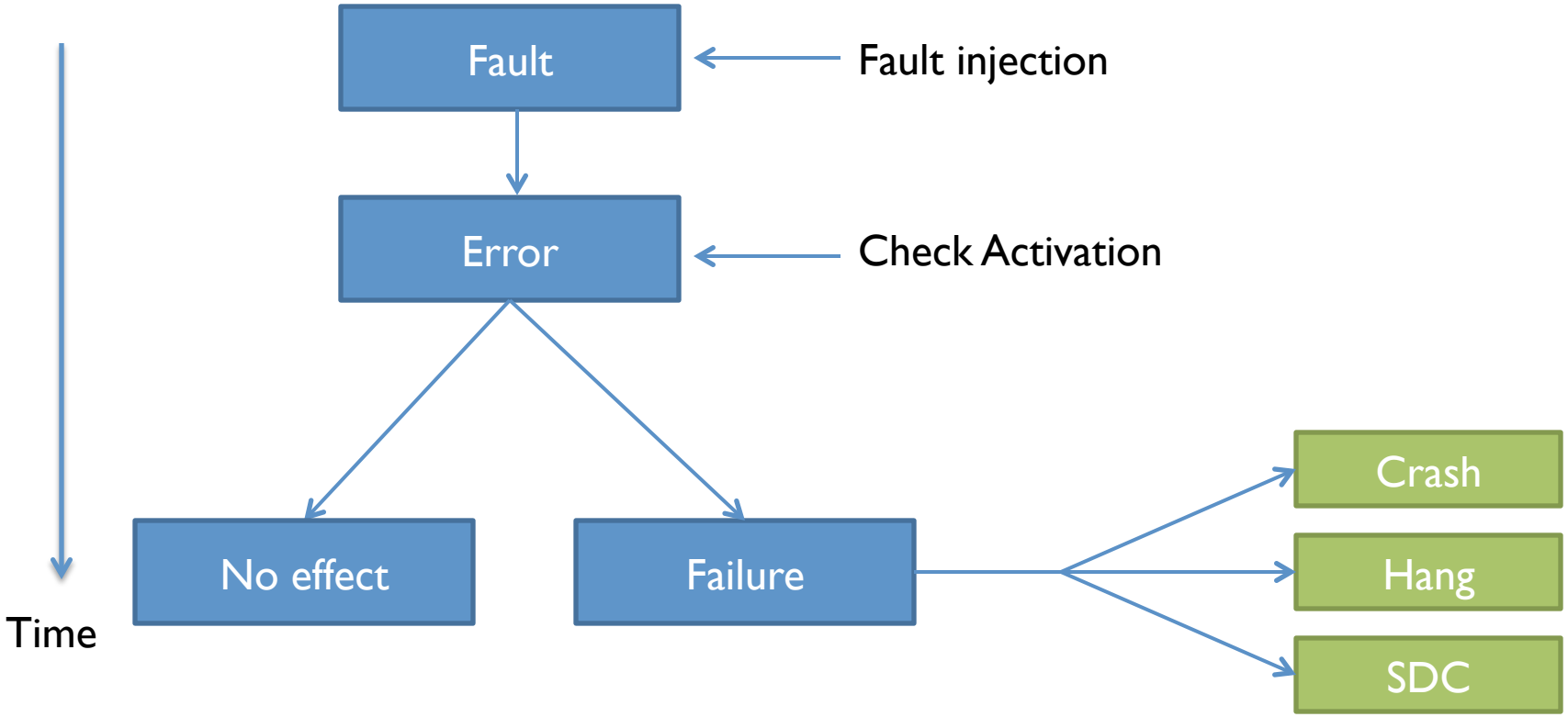
Experimental Infrastructure

- Fault injection framework: sim-outorder in SimpleScalar

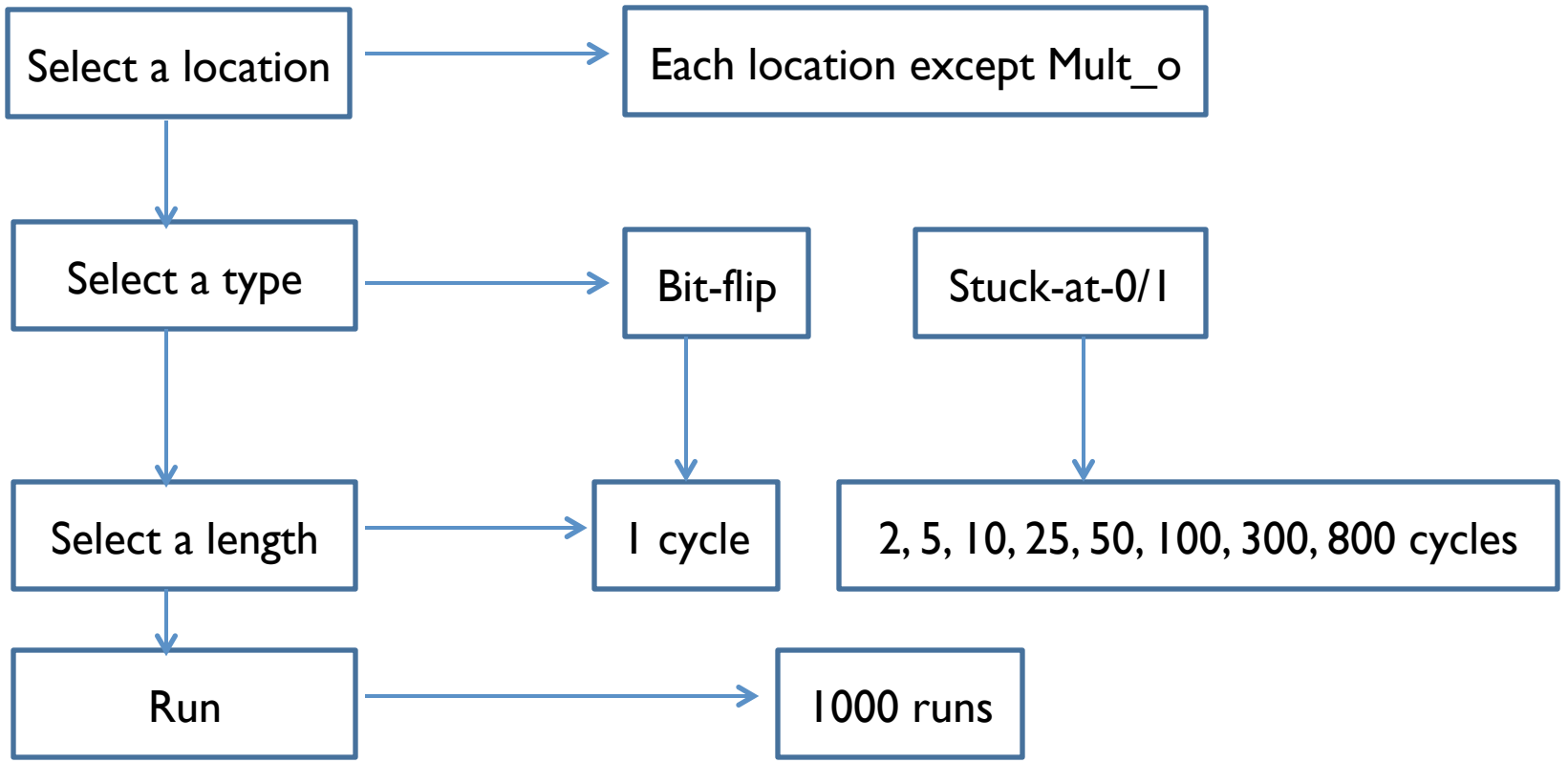
Failure Detection



Benchmark Information

- 7 benchmark programs from Siemens suite [Hutchins'94]
  - characteristics of the programs
    - Lines of codes: < 1000 lines
    - Dynamic instruction #: 9,000 ~ 240,000

Experimental Procedure



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Research Questions Review

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- If yes, how do the differences vary with the *length* (i.e., duration in cycles) of the fault?
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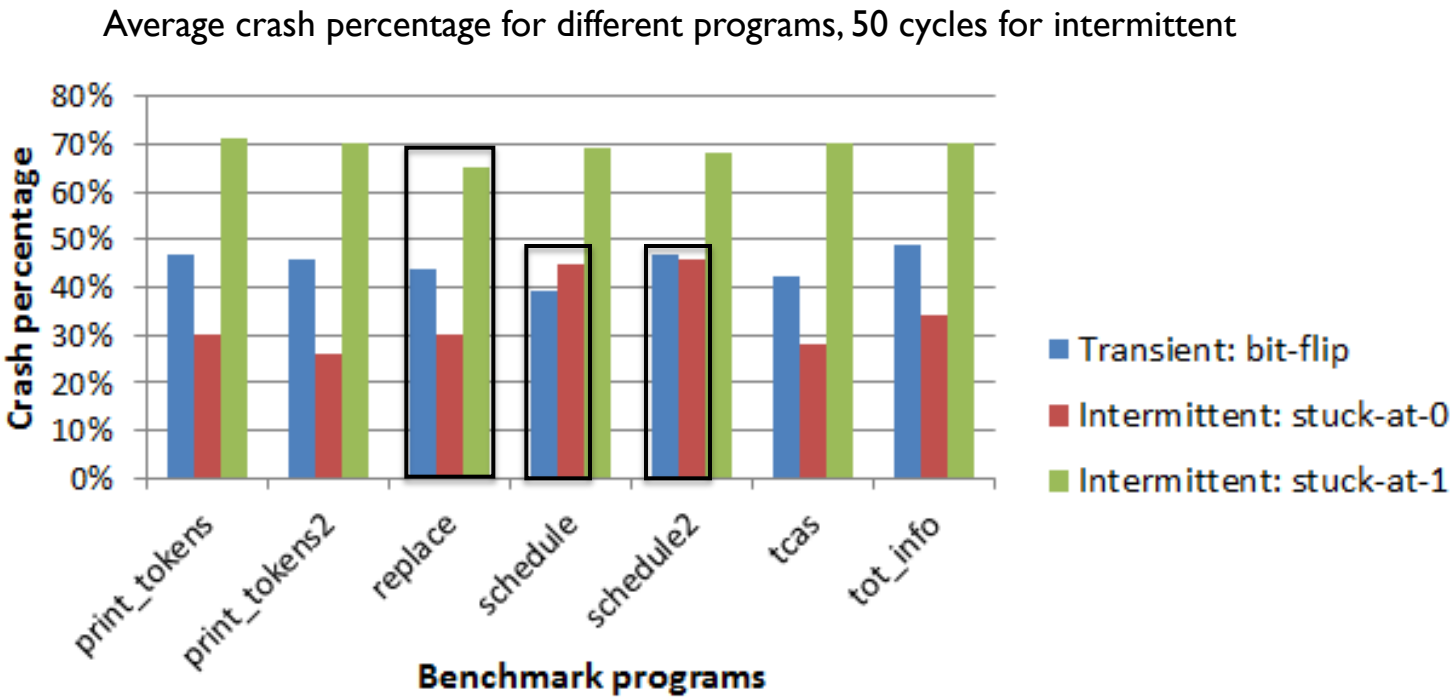
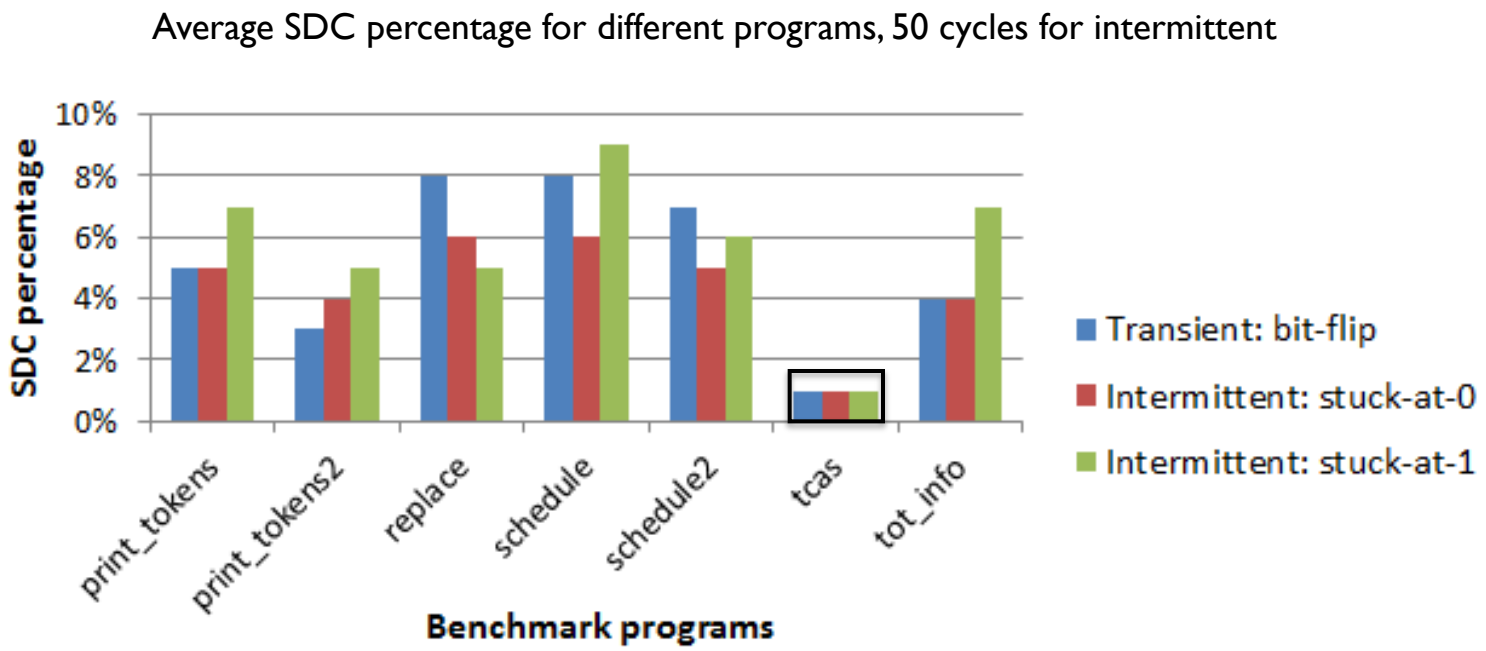
Impact of Faults on Programs

- Crash percentage:
  - Stuck-at-1 > Transient > Stuck-at-0



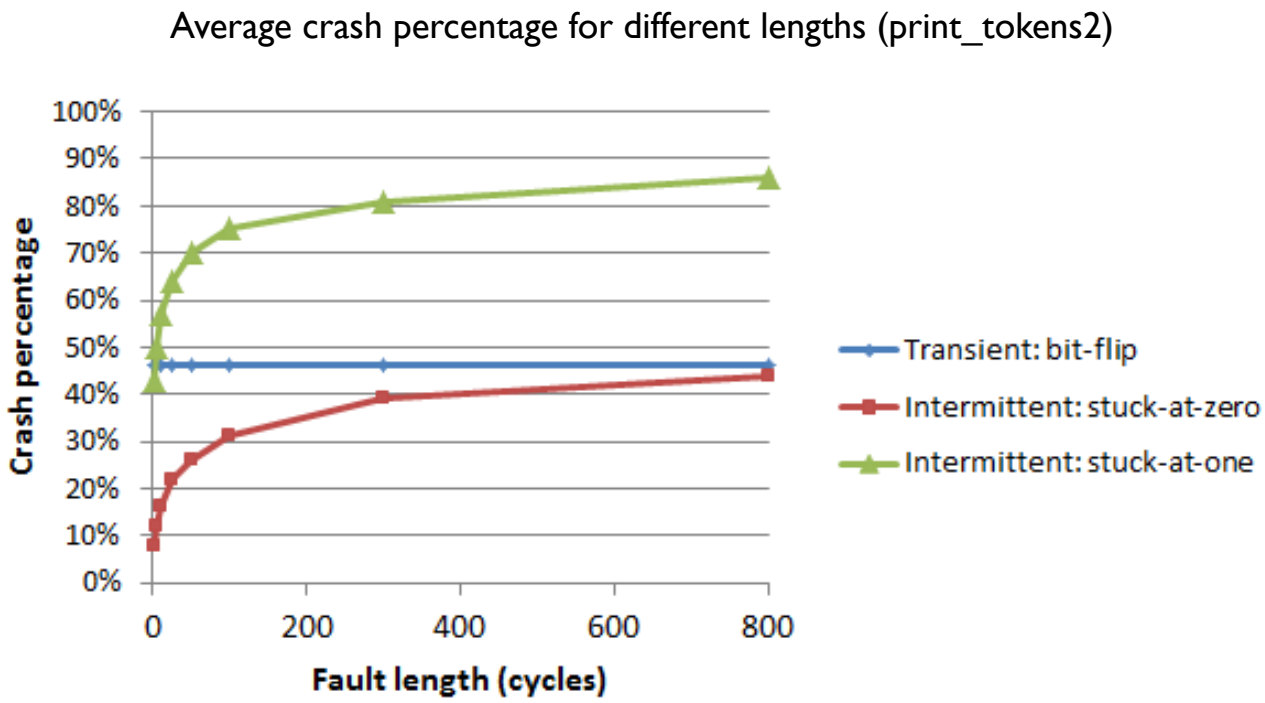
Impact of Faults on Programs (cont.)

- SDC percentage:
  - Similar to each other



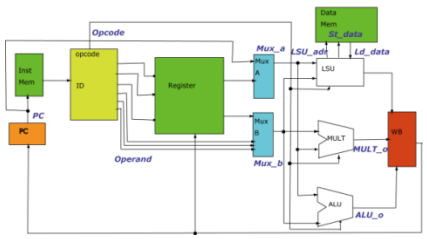
Effects of Fault Length

- Intermittent:
  - Crash percentage increases with the increase of fault length

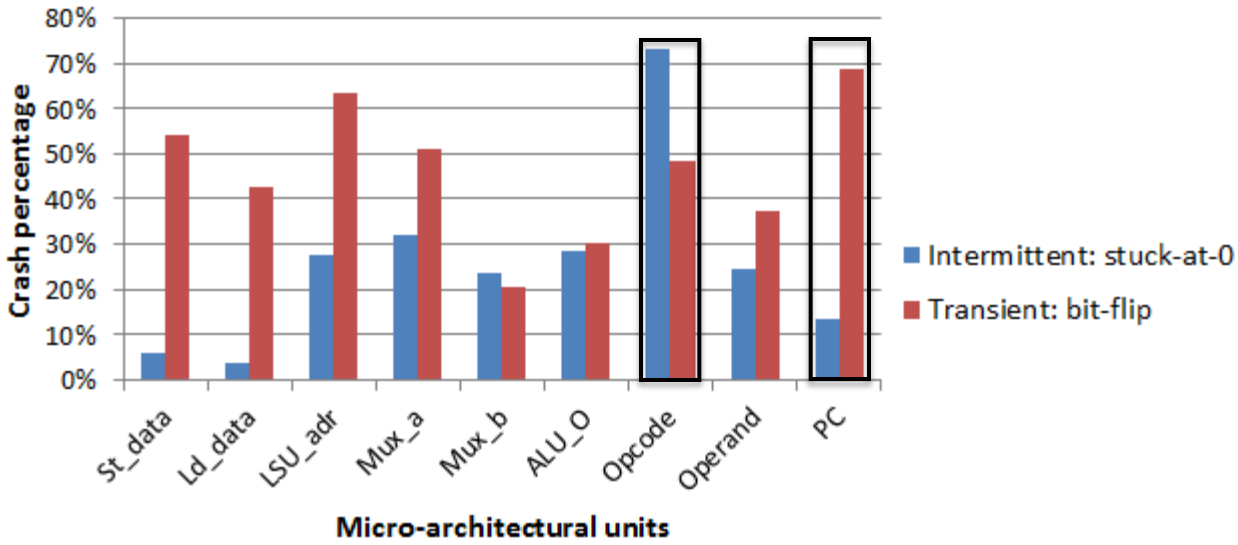


Effects of Intermittent Fault Origin

- Crash percentage:
  - Crash percentage different across different units
  - The difference between two fault types are different across different units



Crash percentage for different units(print_tokens2, 50 cycles)



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Conclusion and Future Work

- Conclusion
  - Do intermittent faults differ significantly with transients?
    - Large *difference* in *crash* percentage
    - *Similar* for *hang* and *SDC* percentages
  - How do the differences vary with the fault length?
    - Crash percentage *increases* with the increase of fault length
  - How do the differences vary with the injected μ-architectural unit?
    - The difference is *dependent* on fault origin location

- Future Work
  - Consider other models for the two faults
  - Develop intermittent-fault-tolerant software systems
  - Study more complex processors