FastKLEE: Faster Symbolic Execution via Reducing Redundant Bound Checking of Type-Safe Pointers

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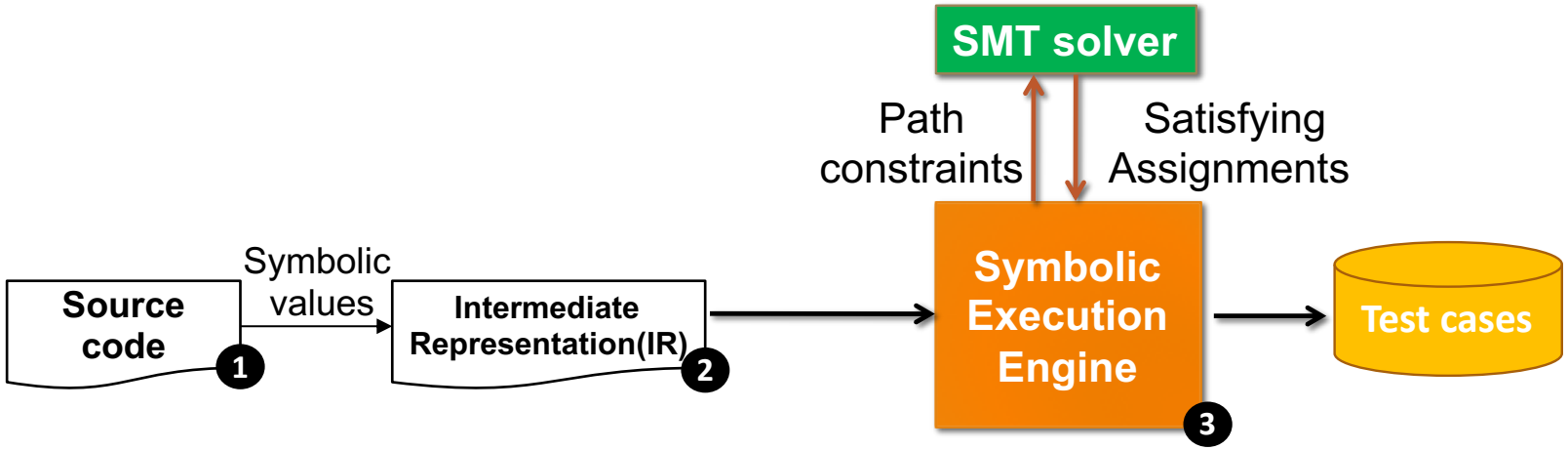
He Jiang (Dalian University of Technology)

(Accepted work on Tool Demonstration of FSE 2022)

15/04/2024, Lisbon

Background

- **Symbolic execution is popular**
- **General workflow of traditional symbolic execution engine (e.g., KLEE)**



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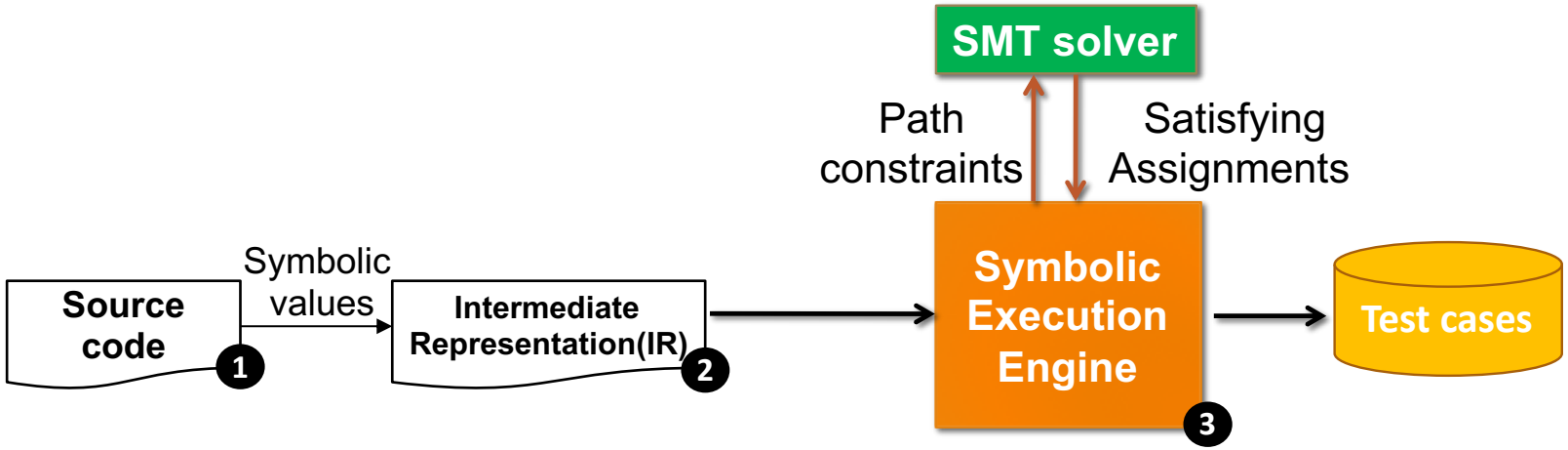

Efficiency **matters when performing symbolic execution**

Motivation

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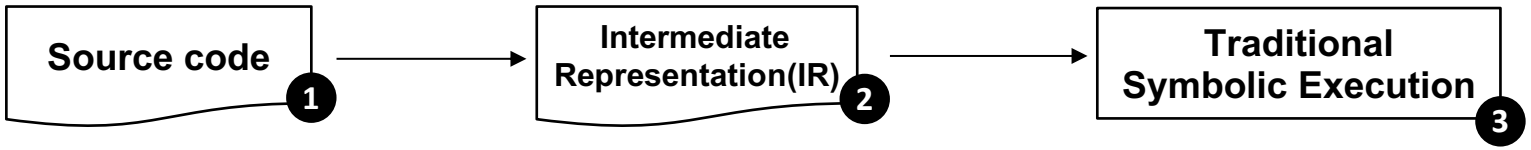
Source code
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Intermediate Representation(IR)
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Traditional Symbolic Execution
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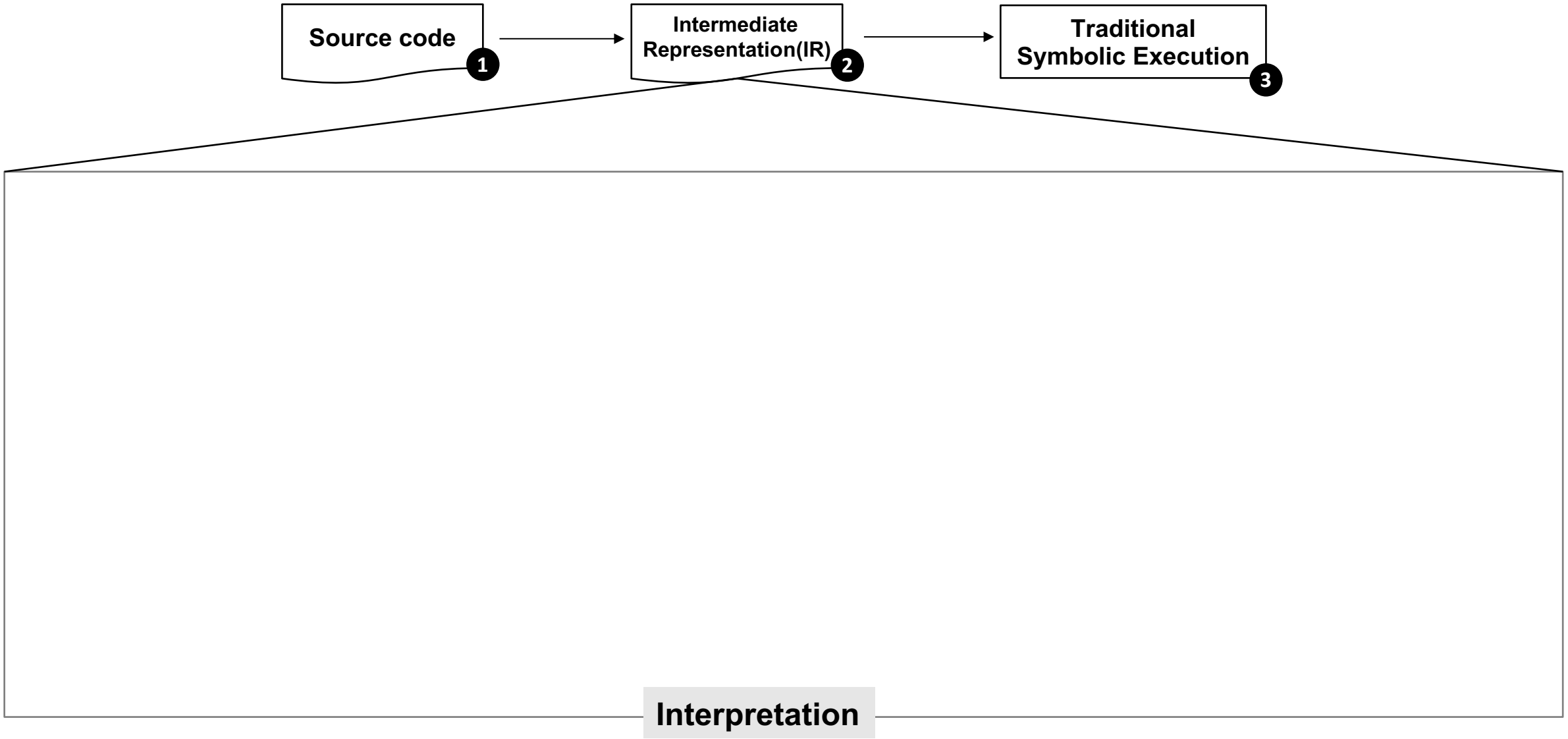
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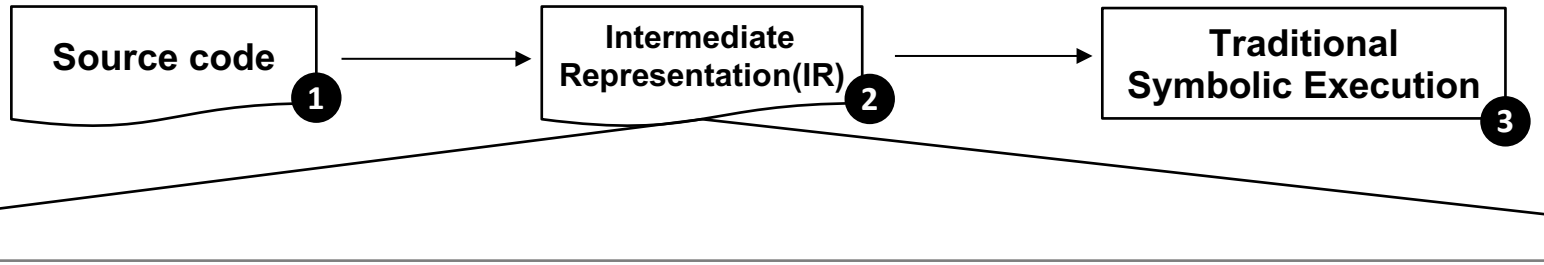

(1) Observation

- The number of interpreted instructions tends to be **huge** (several billion only in one hour run)

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Elapsed: 01:00:04
KLEE: done: explored paths = 125017
KLEE: done: avg. constructs per query = 74
KLEE: done: total queries = 8859
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KLEE: done: generated tests = 65
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Interpretation

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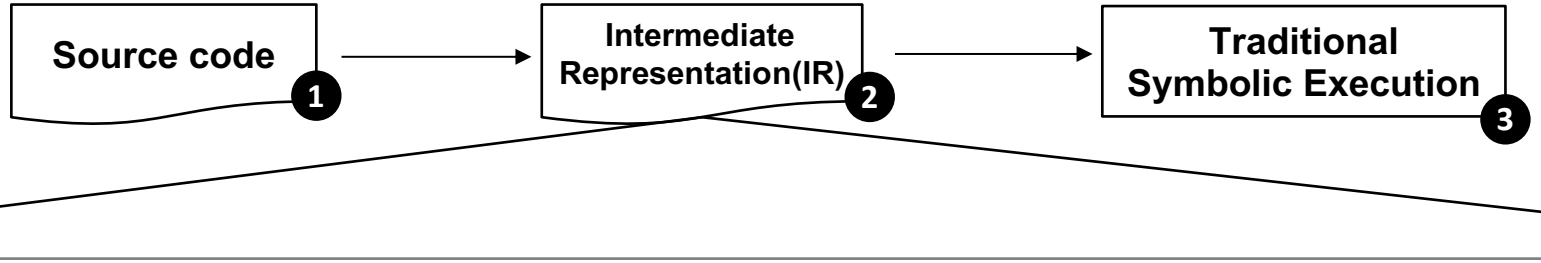

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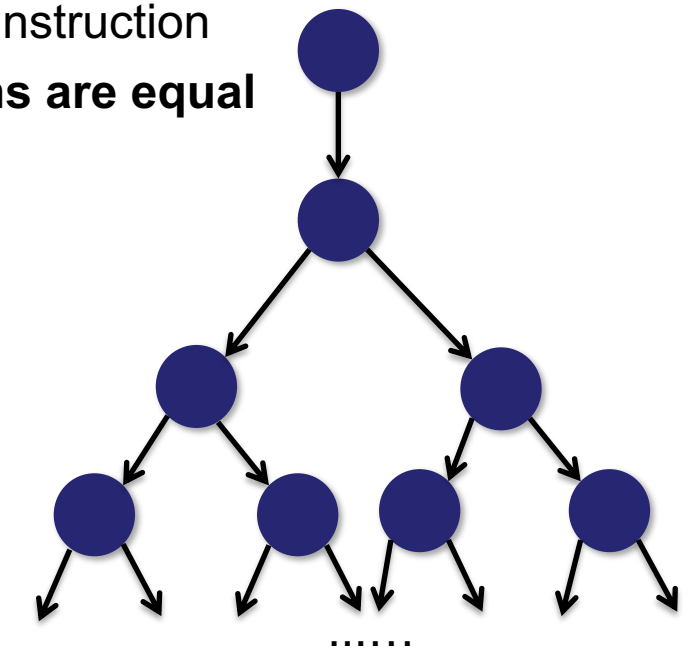
(2) Overheads in current symbolic execution

- The color depth represents the overheads of an interpreted instruction
- **All instructions are equal**



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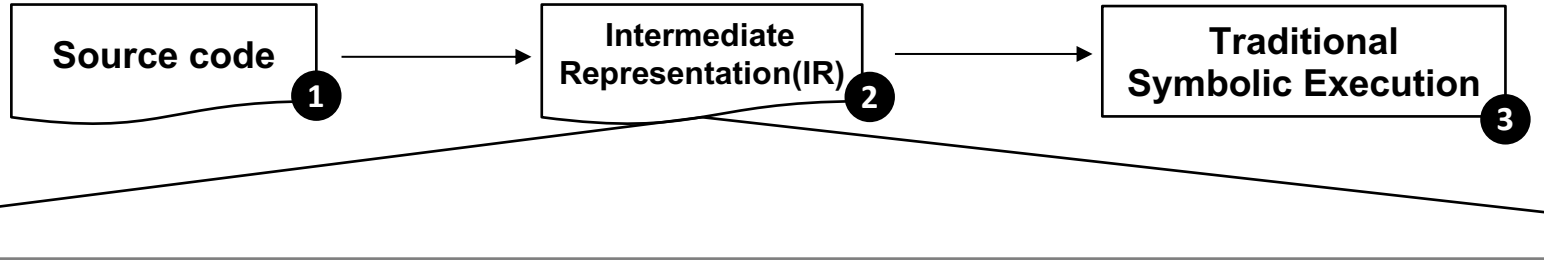

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Can we reduce the overhead of interpreted instructions for faster symbolic execution?

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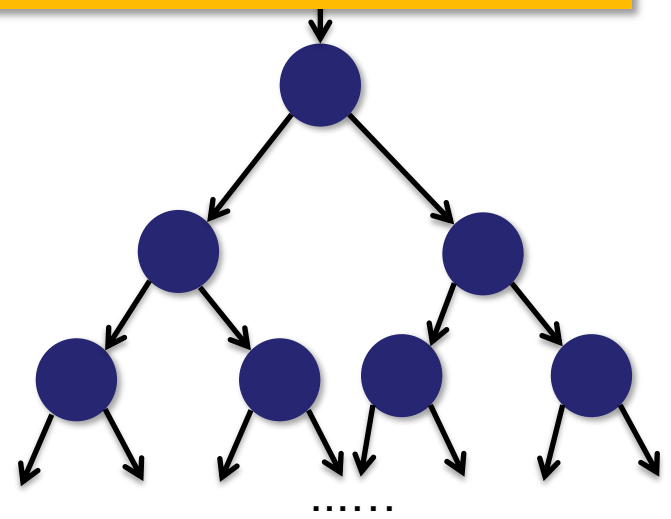

Interpretation

Solution – FastKLEE (1/2)

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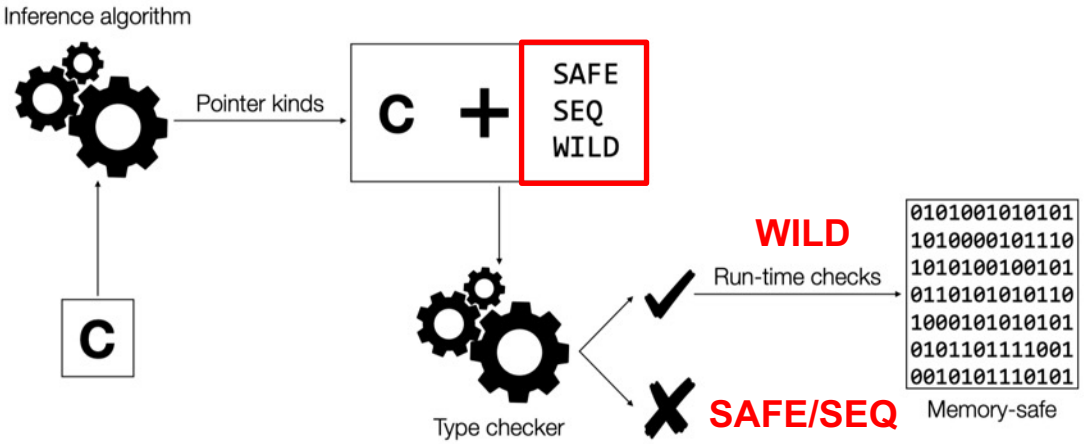

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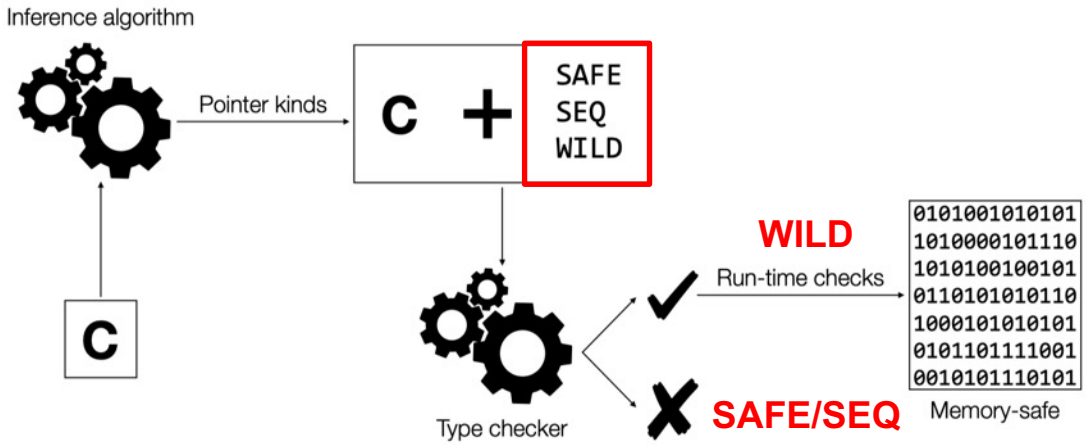
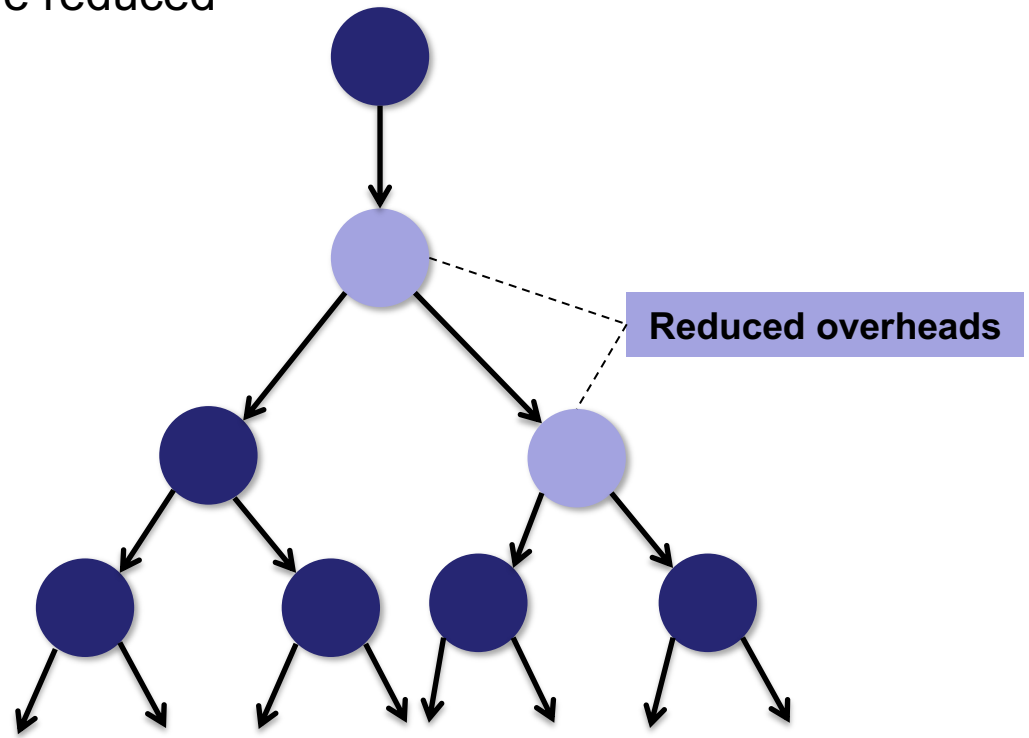


- **Advantage: overheads in FastKLEE**
  - Interpretation overheads for some instructions are reduced



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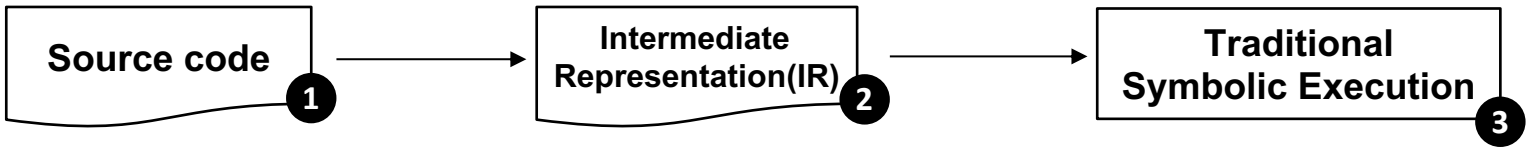

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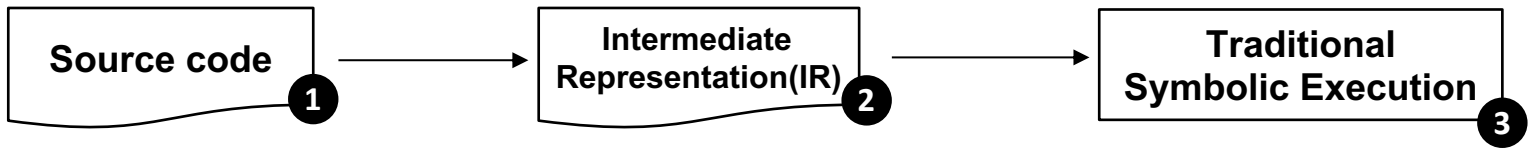

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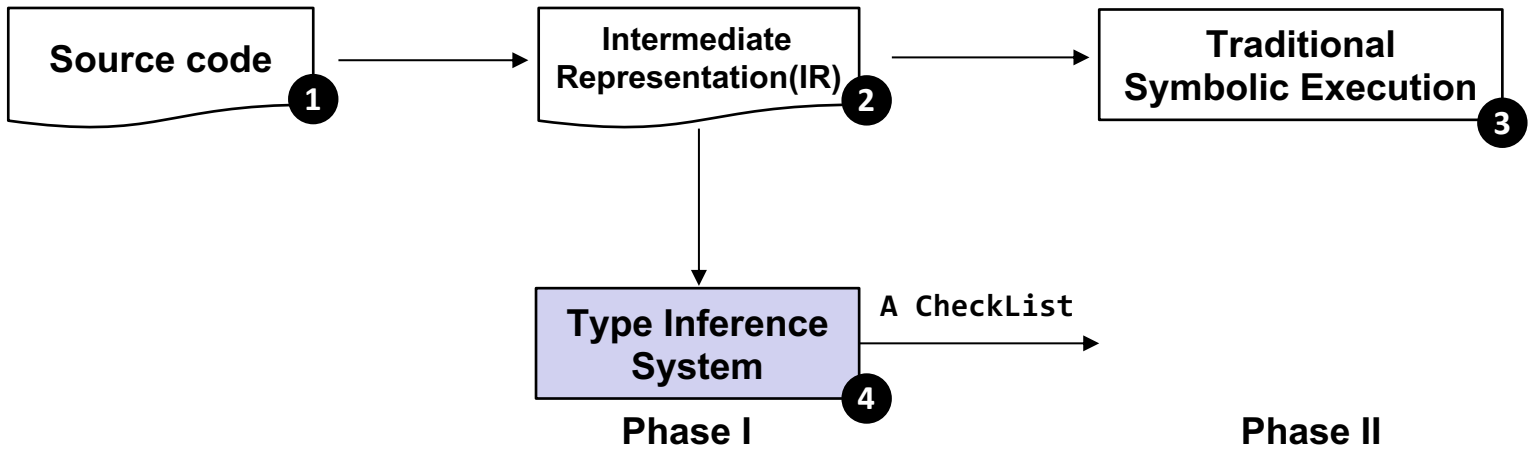

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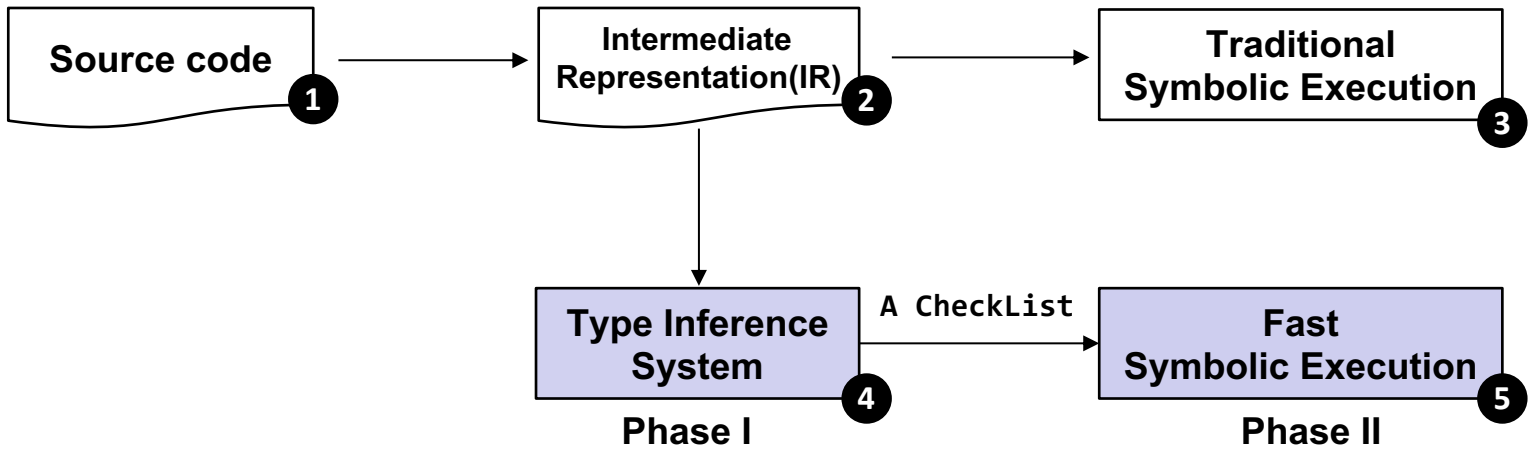

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5 • **Phase II**: Conduct **Customized Memory Operation** in Fast symbolic execution
  – Only perform checking for ***Unsafe*** memory instructions during interpretation

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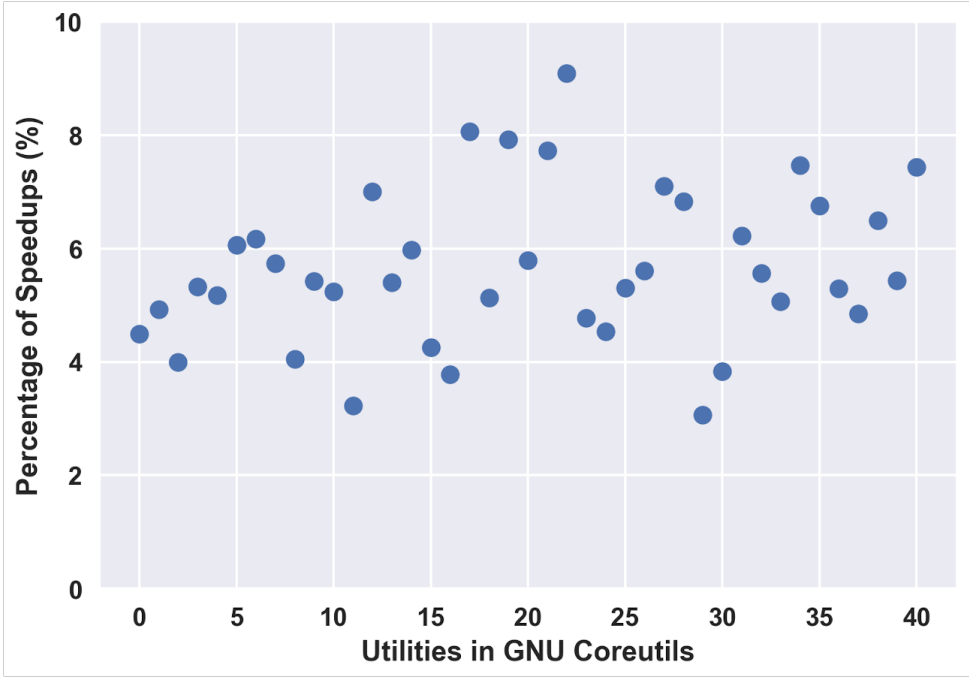

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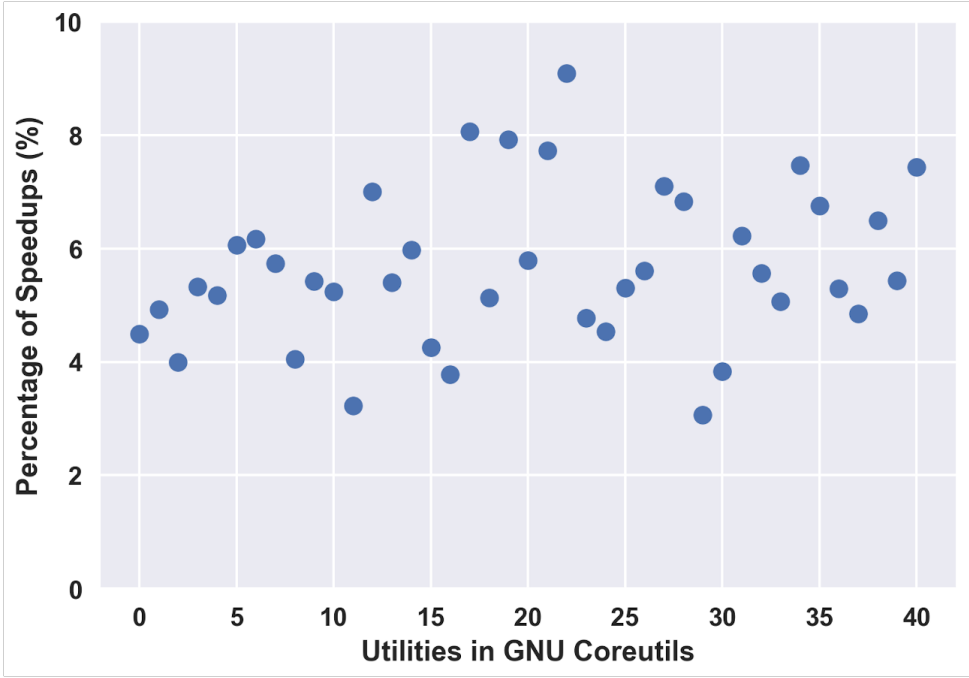

Fig. Scatter plot of the improvement in speedups

  - FastKLEE can reduce by up to **9.1%** time compared with the state-of-the-art approach (i.e., KLEE)

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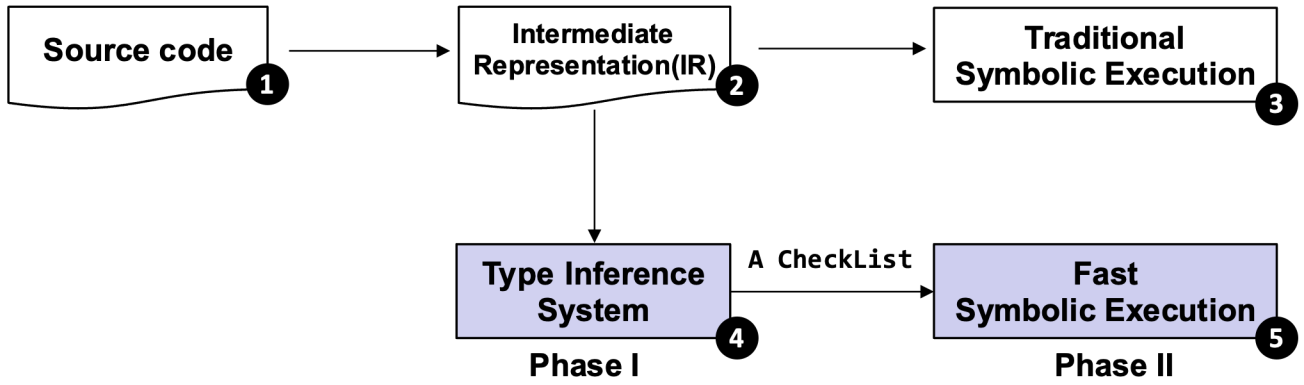

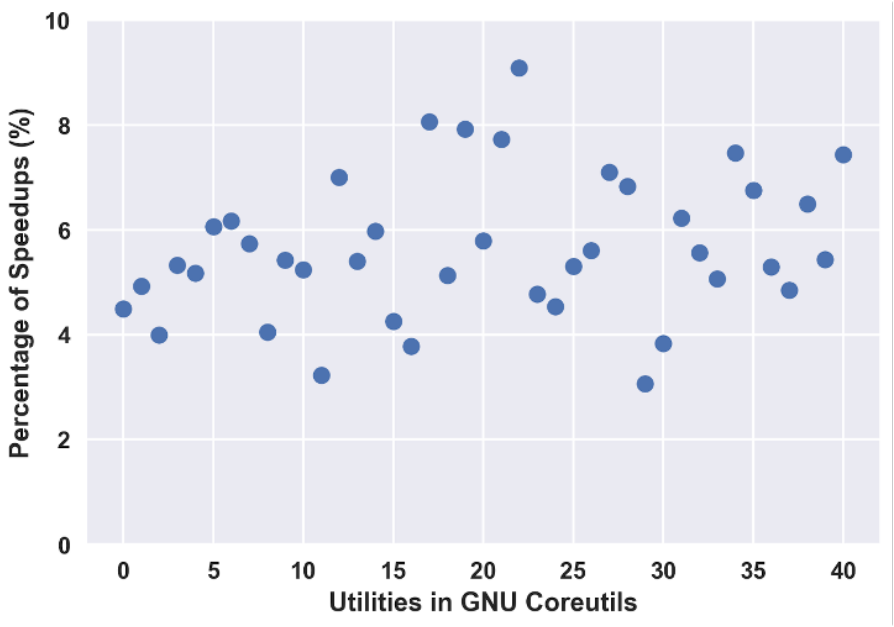

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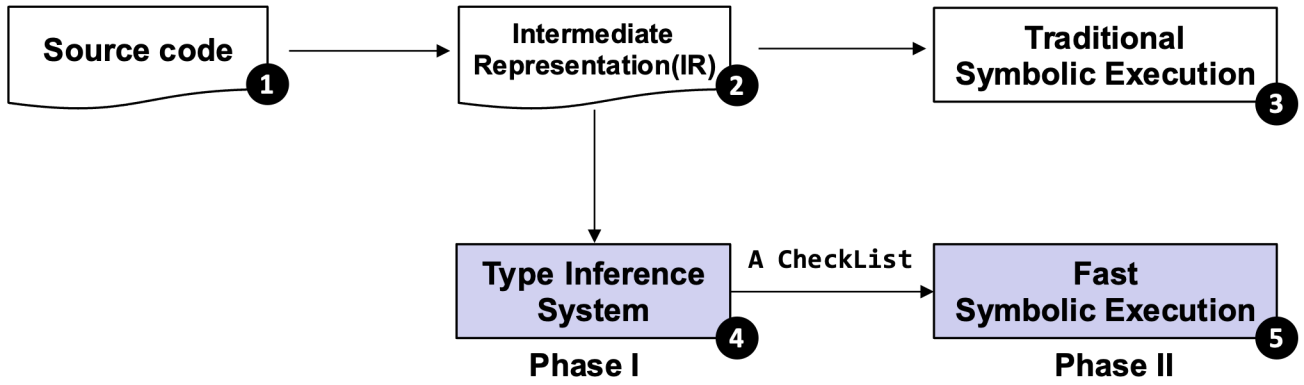

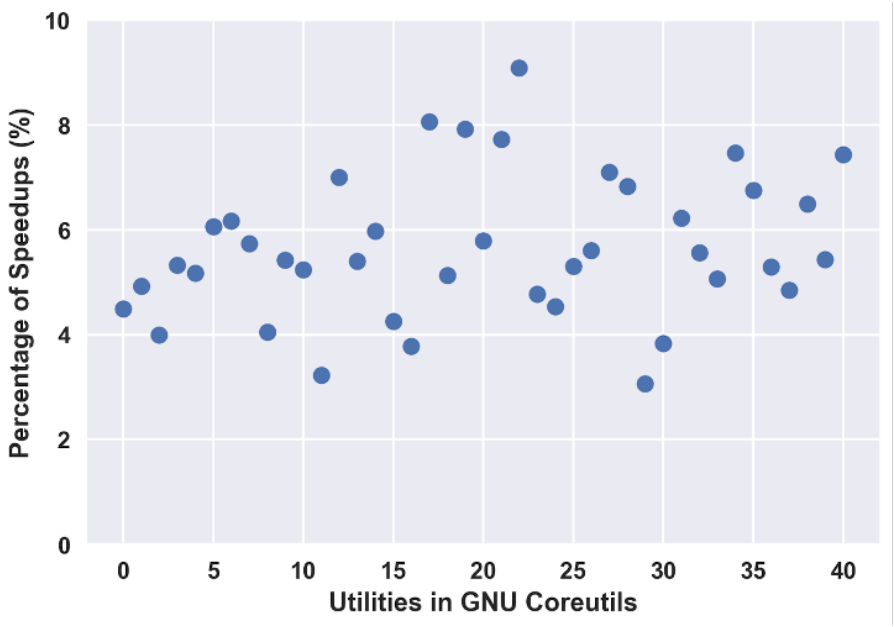

- **Future work**
  - Follow the idea of FastKLEE to conduct **vulnerability-oriented** path exploration for symbolic execution
    - Valuable paths: more likely to contain vulnerabilities

Code

Video Demo

Thank you and Questions !

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