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

***ESEC/FSE 2022 Tool Demonstration***

**Haoxin Tu**, Lingxiao Jiang, Xuhua Ding (Singapore Management University)
He Jiang (Dalian University of Technology)

# Background

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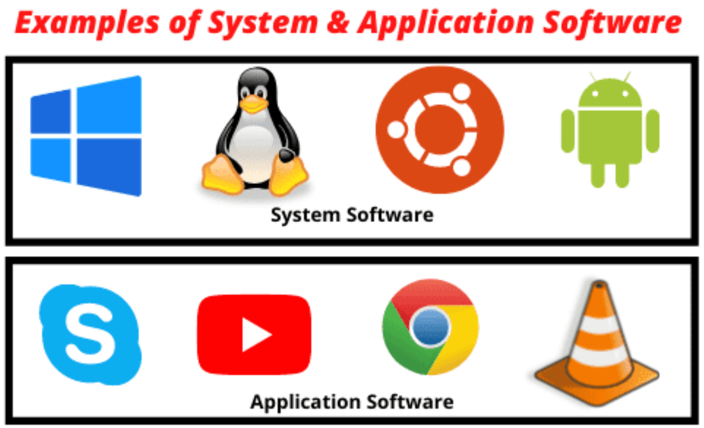
Examples of System & Application Software
System Software
Application Software

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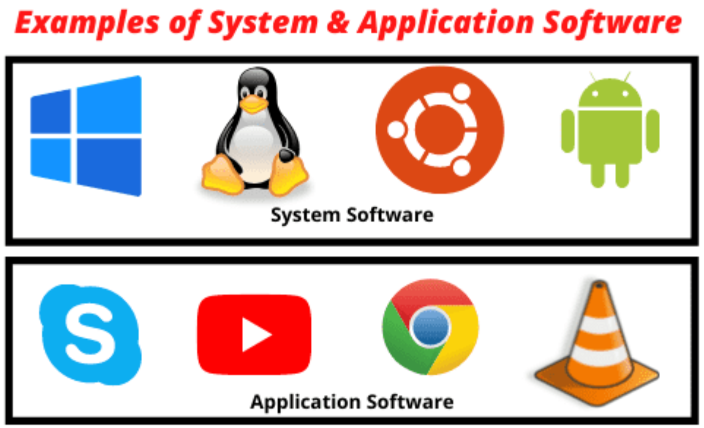


- **Q: How to improve the quality of software?**

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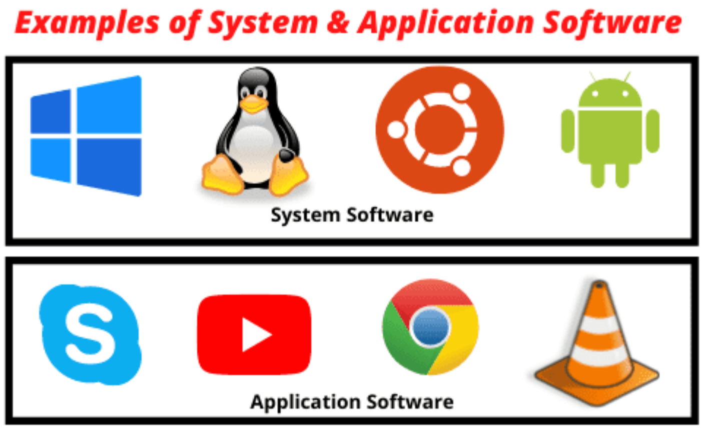


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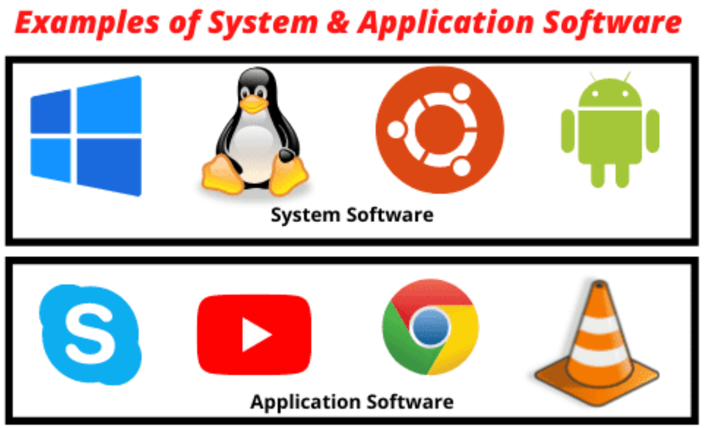


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(Symbolic Execution)

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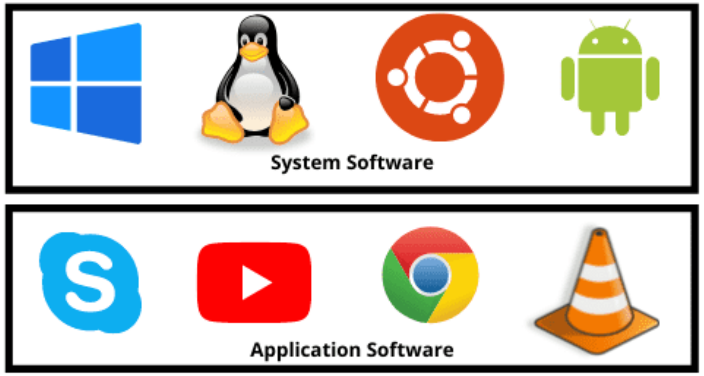


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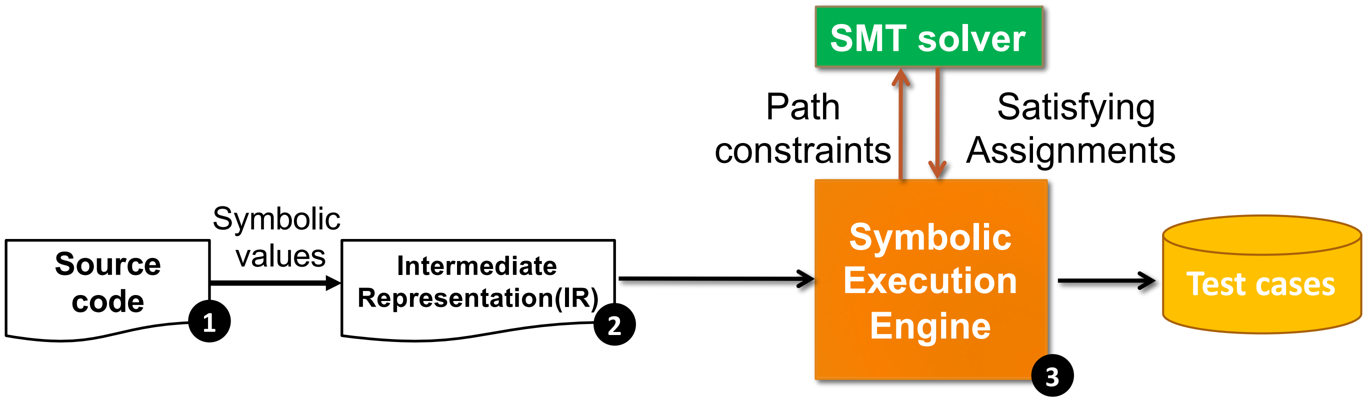


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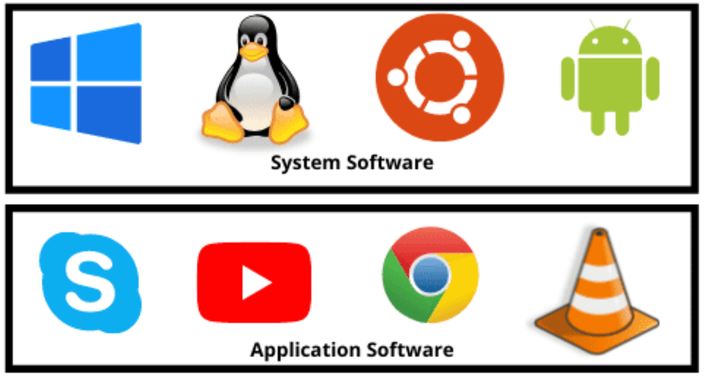


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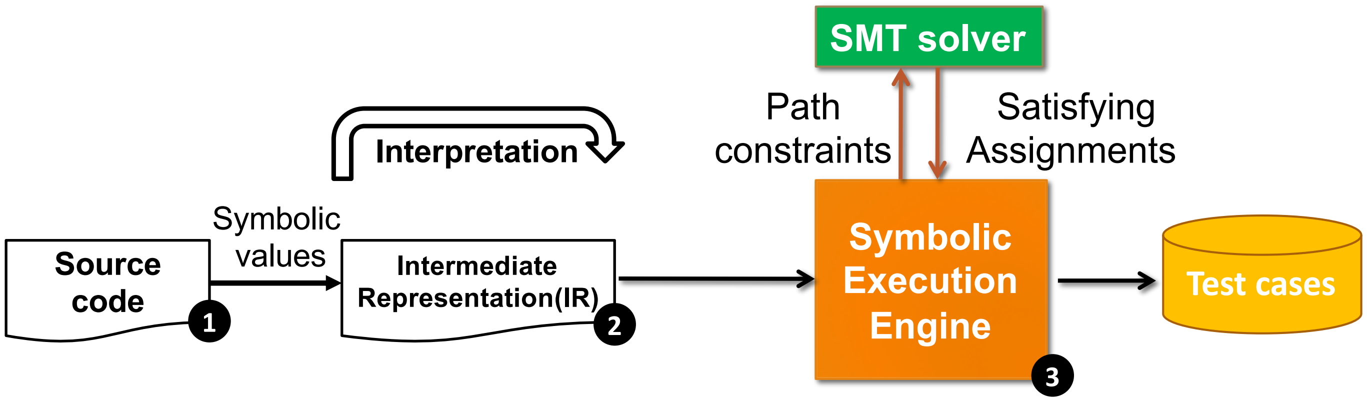


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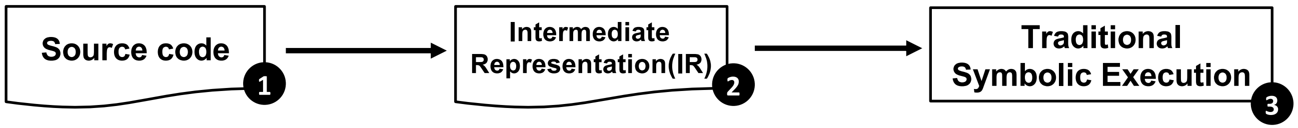
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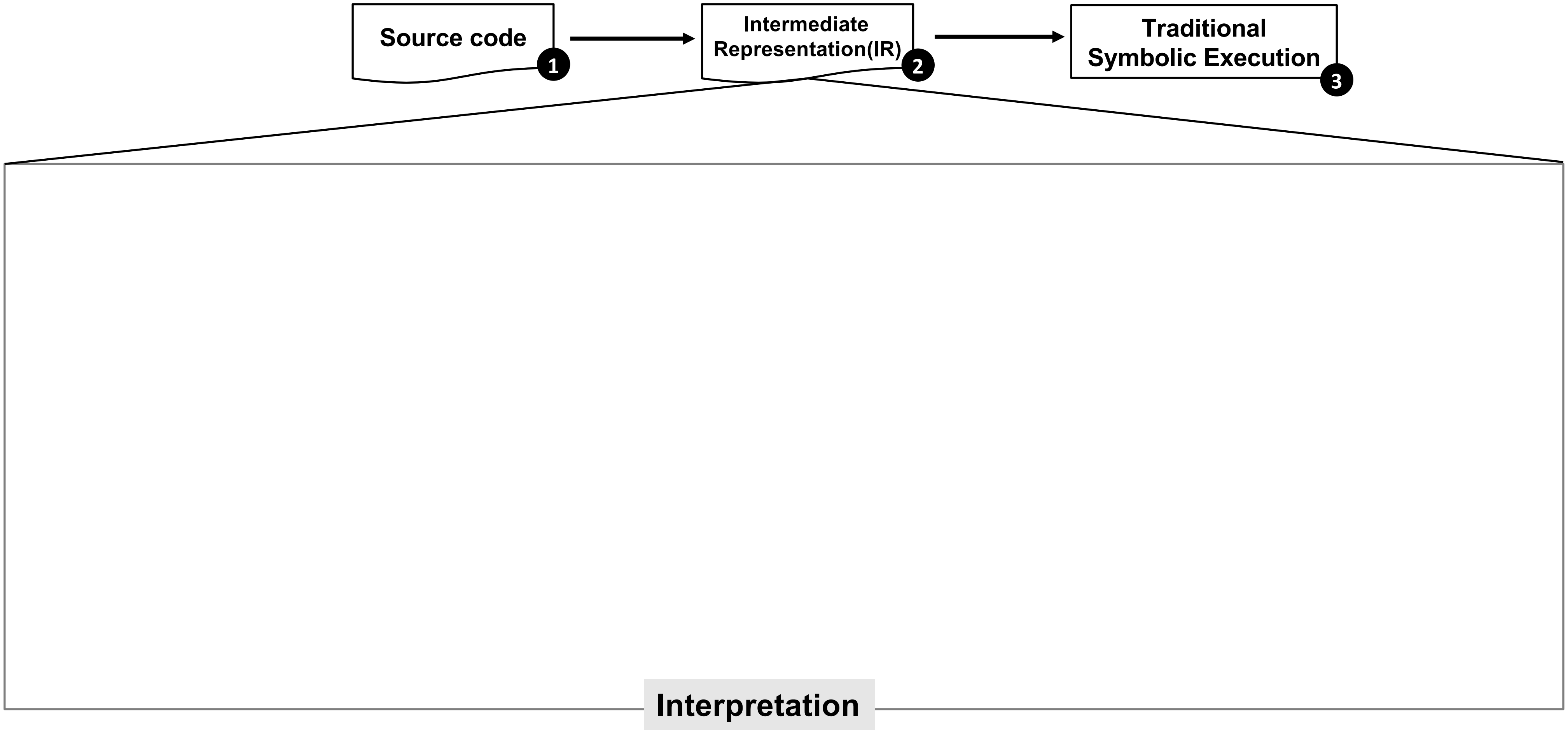
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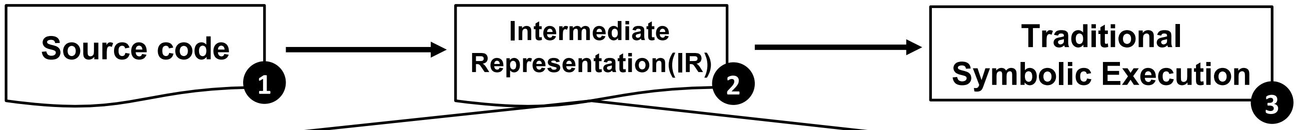


## (1) Observation

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

```
Elapsed: 01:00:04
KLEE: done: explored paths = 125017
KLEE: done: avg. constructs per query = 74
KLEE: done: total queries = 8859
KLEE: done: valid queries = 6226
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KLEE: done: query cex = 8859

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KLEE: done: completed paths = 125017
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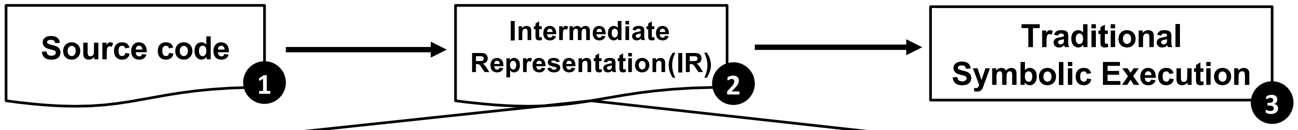


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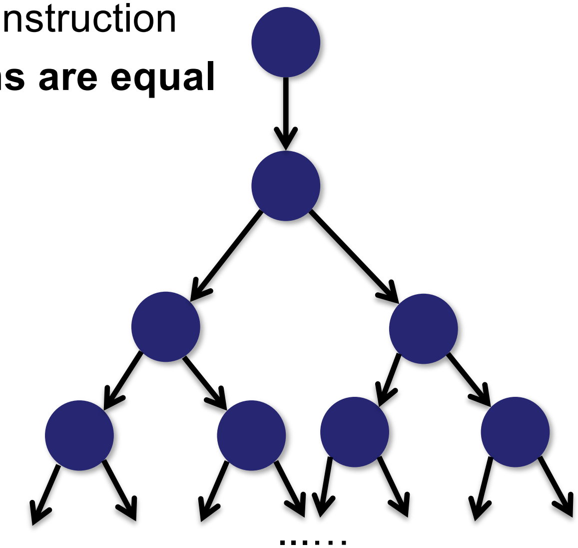
## (2) Overheads in current symbolic execution

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

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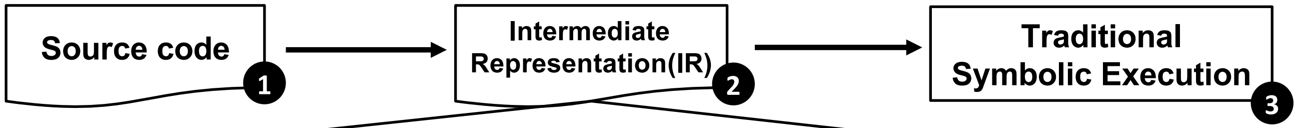


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**Can we reduce the overheads of interpreted instructions for faster symbolic execution?**

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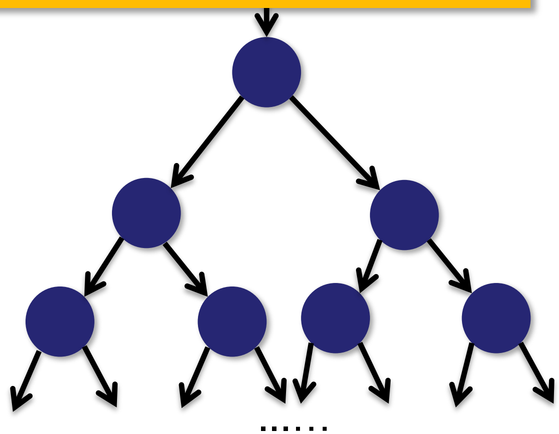


**Interpretation**

# Solution – FastKLEE (1/2)

[1] Ccured: George C. Necula, Jeremy Condit, Matthew Harren, Scott McPeak, and Westley Weimer. 2005. **CCured: type-safe retrofitting of legacy software**. ACM Trans. Program. Lang. Syst. 27, 3 (May 2005), 477–526.

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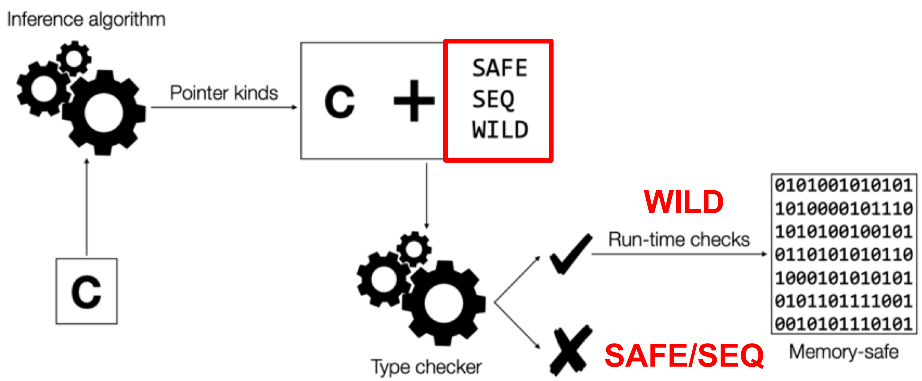


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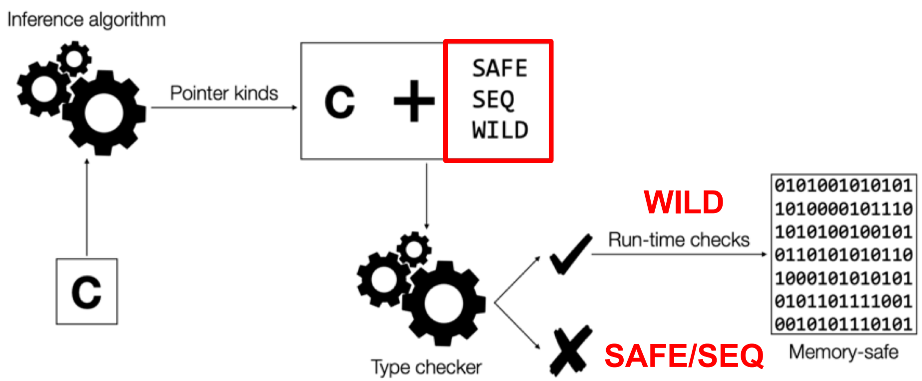
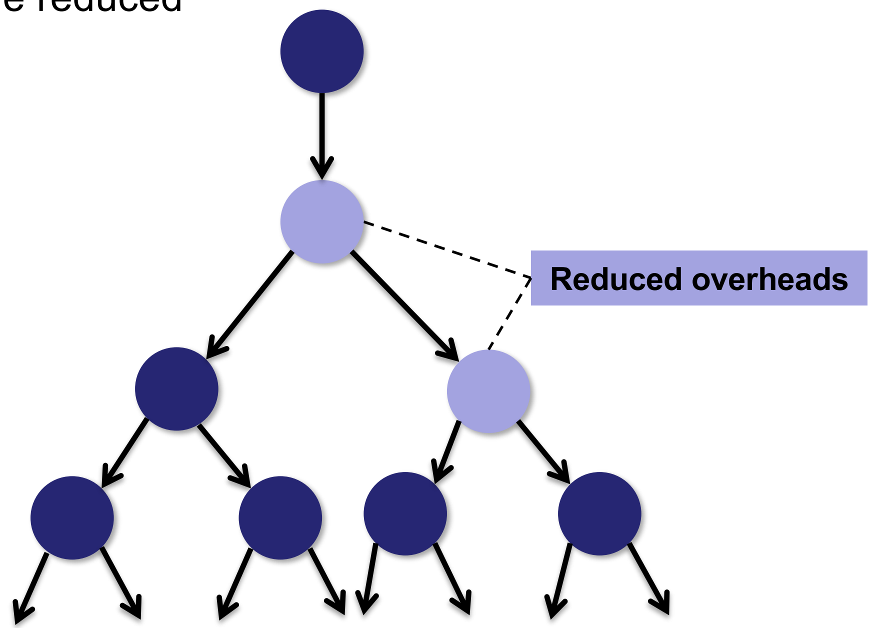



- **Advantage: overheads in FastKLEE**
  – Interpretation overheads for some instructions are reduced

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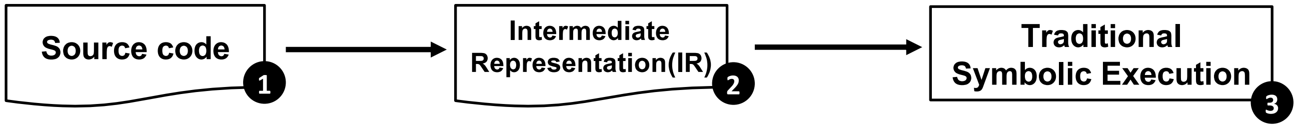

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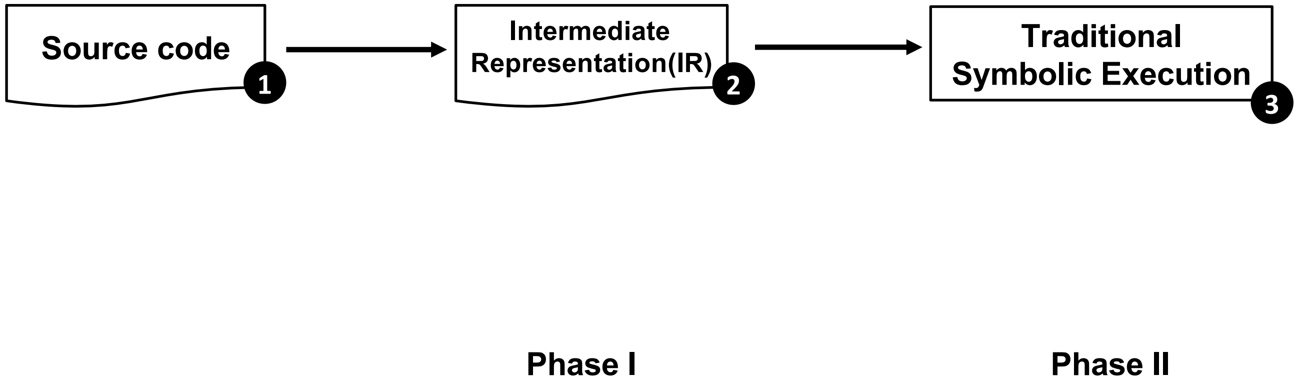

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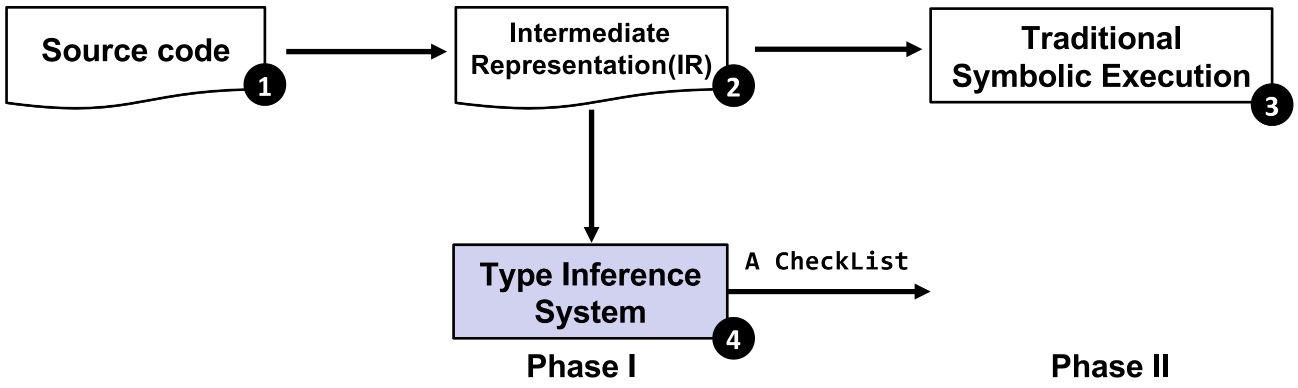


❹ • **Phase I**: Introduce a **Type Inference System** to classify memory-related instruction types

– ***Unsafe*** memory instructions will be stored in **CheckList**

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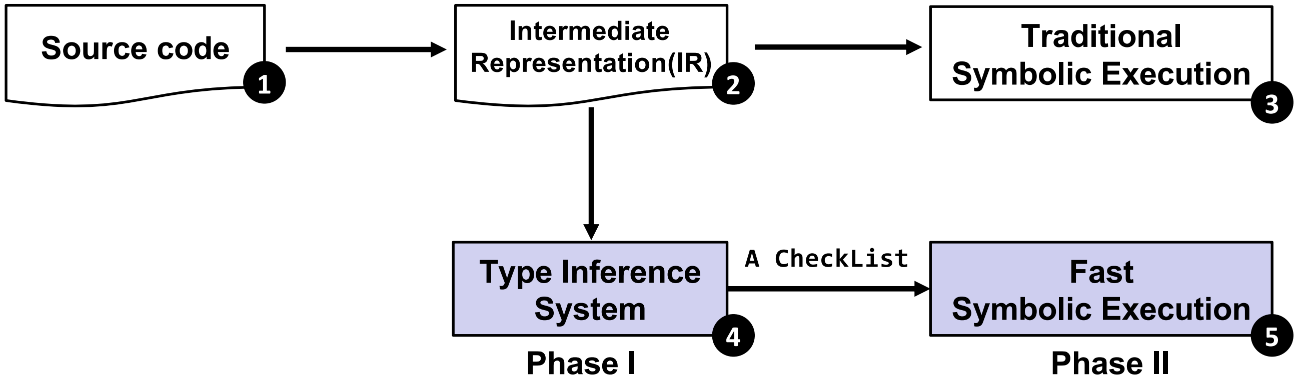


❹ • **Phase I**: Introduce a **Type Inference System** to classify memory-related instruction types
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❺ • **Phase II**: Conduct **Customized Memory Operation** in Fast symbolic execution
  – Only perform checking for ***Unsafe*** memory instructions during interpretation

# Tool demonstration

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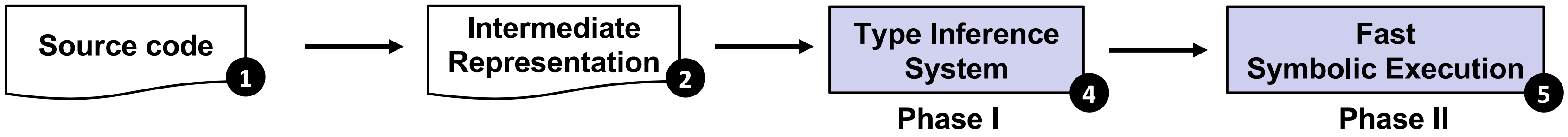


- **Impementation**
  - KLEE [1] and Ccured [2]

Installation of FastKLEE

Full video demo: https://youtu.be/fjV_a3kt-mo

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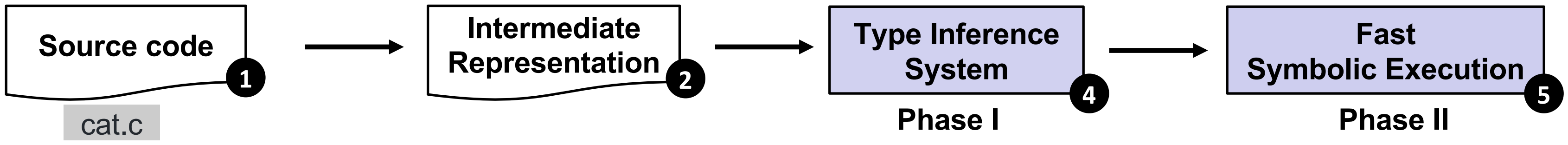


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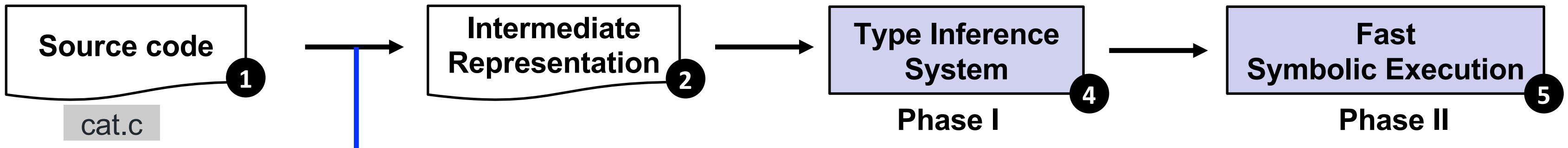


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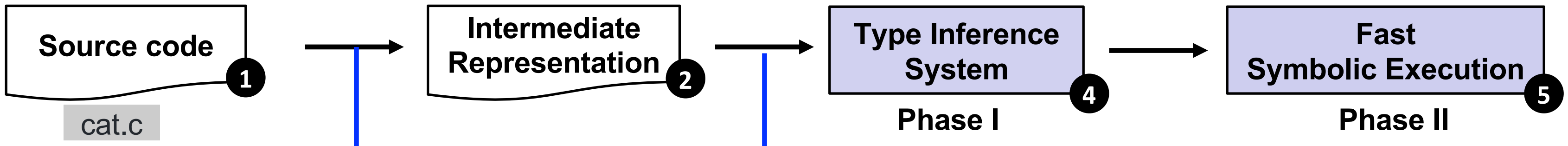


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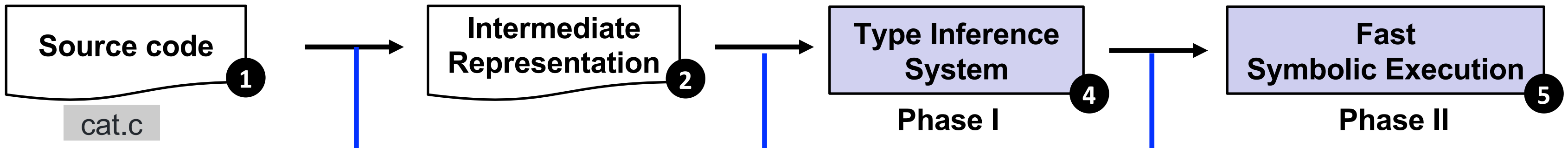


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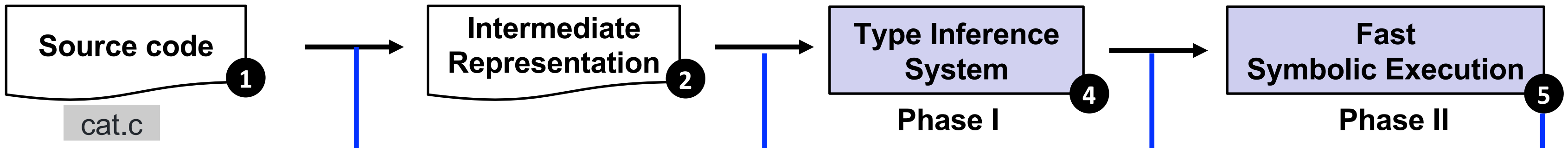


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```

**4. Conduct faster symbolic execution**

```
$ fastklee [options] ./cat.bc --sym-args 0 1
10  --sym-args 0 2 2  --sym-files 1 8
```

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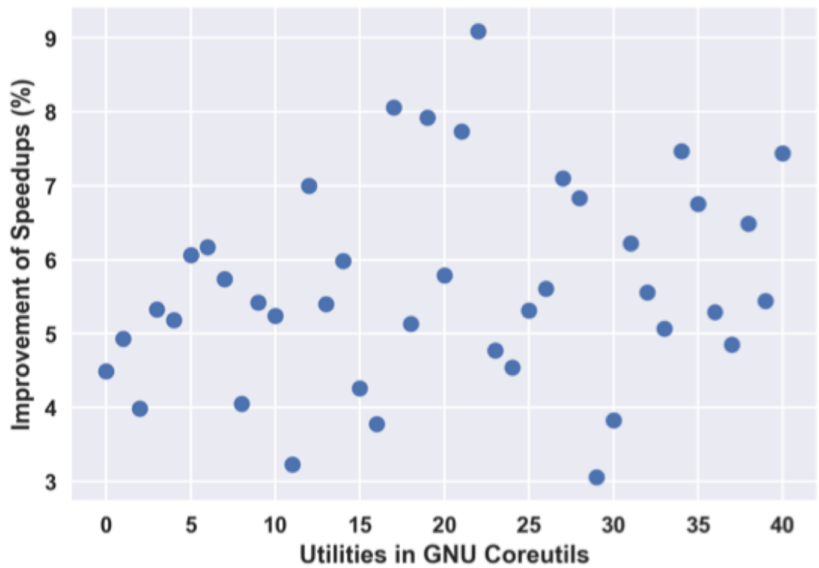


**Figure 2: Scatter plot of the improvement in speedups**

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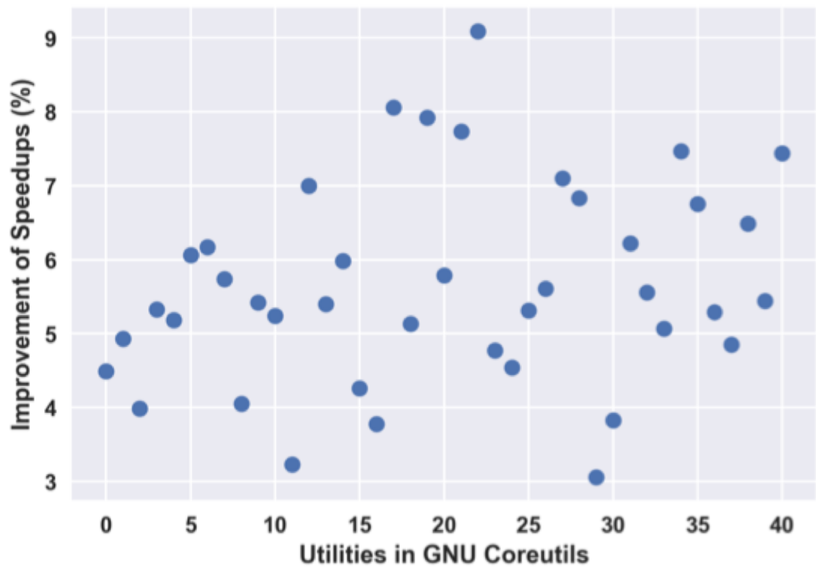
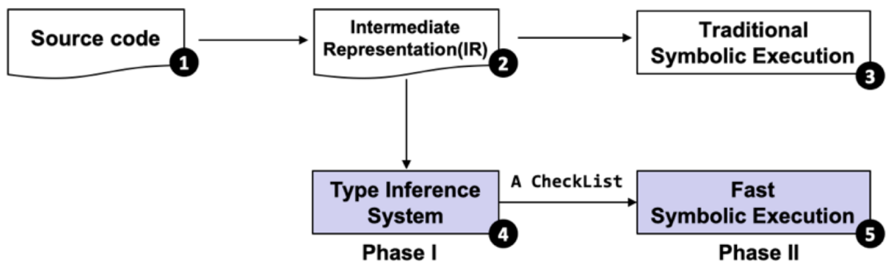



**Figure 2: Scatter plot of the improvement in speedups**

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

# Conclusion

- **Contribution**
  - We present **FastKLEE**, which reduces the interpretation overheads for faster symbolic execution



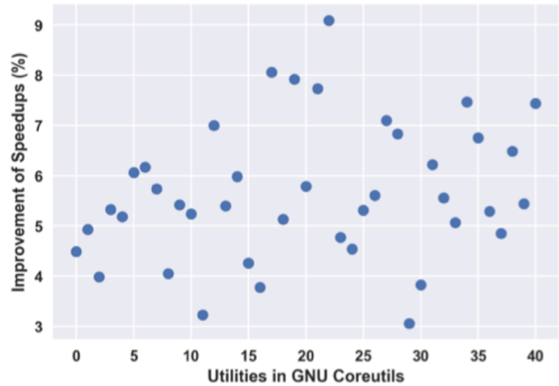




**Figure 2: Scatter plot of the improvement in speedups**

- **Future work**
  - Use FastKLEE to explore more **valuable** execution paths in software systems
    - valuable: vulnerable and exploitable

Code: https://github.com/haoxintu/FastKLEE
Video demo: https://youtu.be/fjV_a3kt-mo
Email: haoxintu.2020@phdcs.smu.edu.sg
(Please feel free to pull requests or raise any questions if you have!)