*The 46th International Conference on Software Engineering (ICSE 2024)*

# Beyond a Joke: Dead Code Elimination Can Delete Live Code

**Haoxin Tu**, Lingxiao Jiang, Debin Gao (Singapore Management University)
He Jiang (Dalian University of Technology)

18/04/2024, Lisbon

## Background: Dead Code Elimination

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  - A fundamental compiler optimization technique that removes dead code (e.g., unreachable or reachable but whose results are unused) in the program

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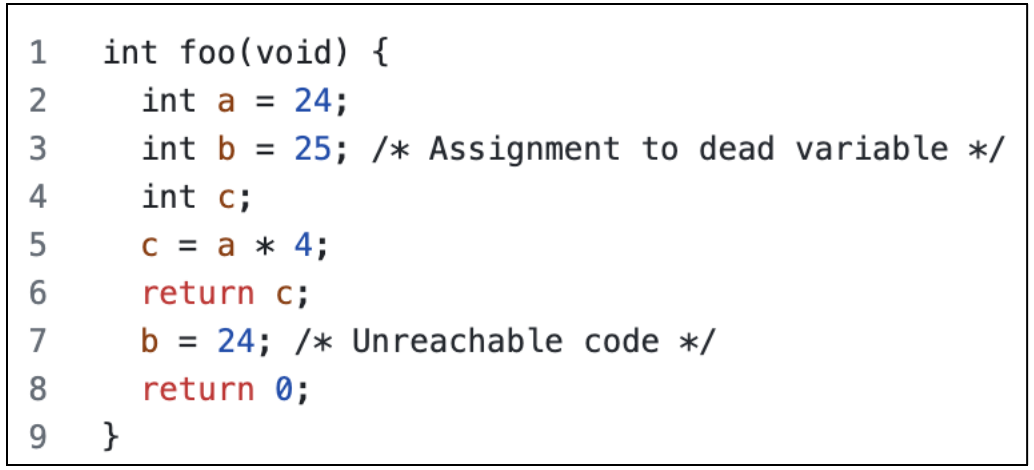

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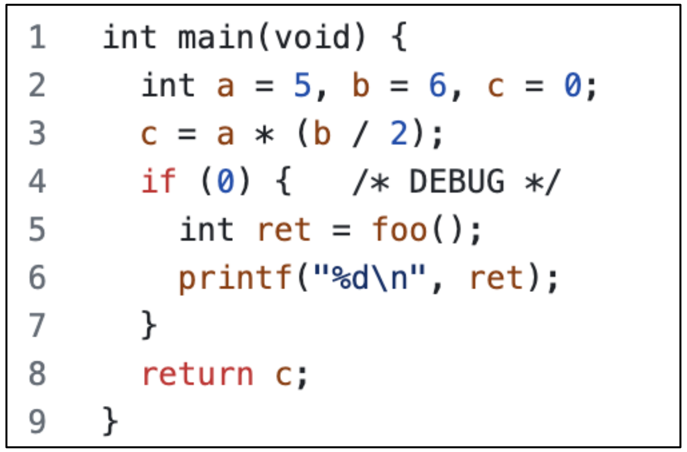

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Examples are cited from https://en.wikipedia.org/wiki/Dead-code_elimination#Examples

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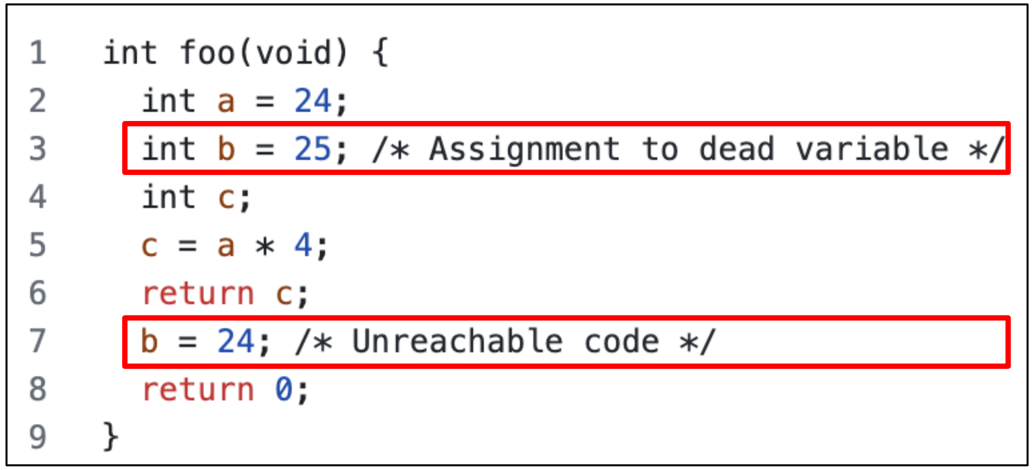

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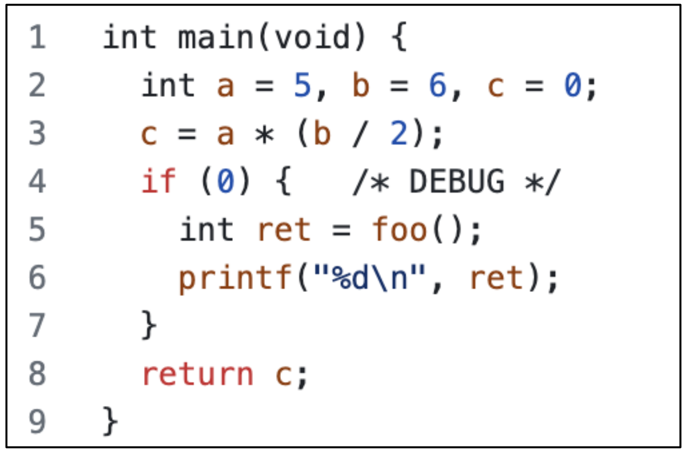

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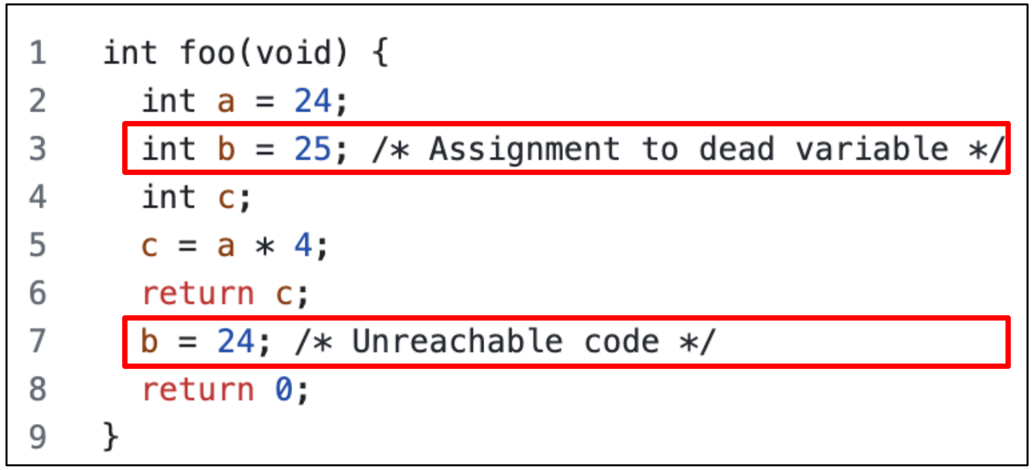

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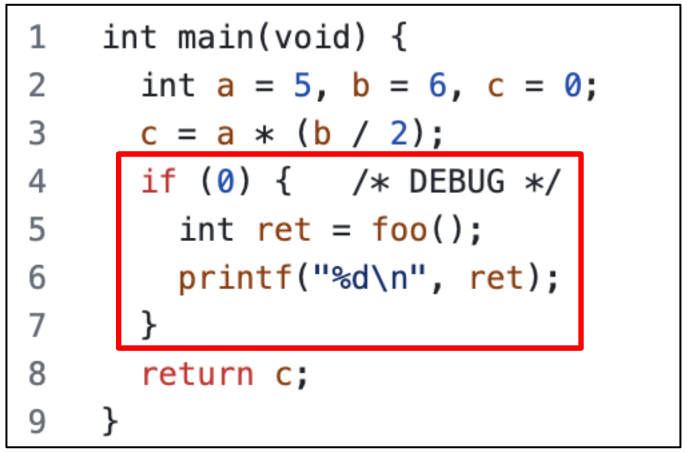

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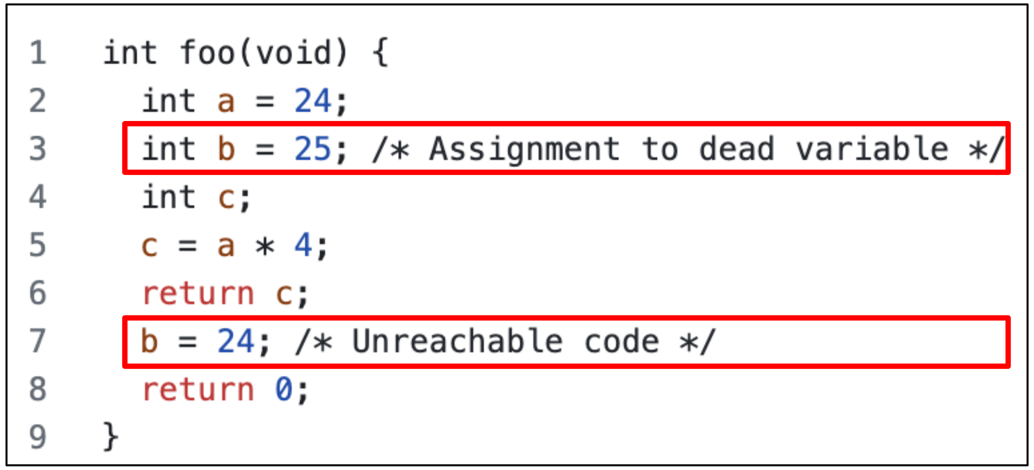

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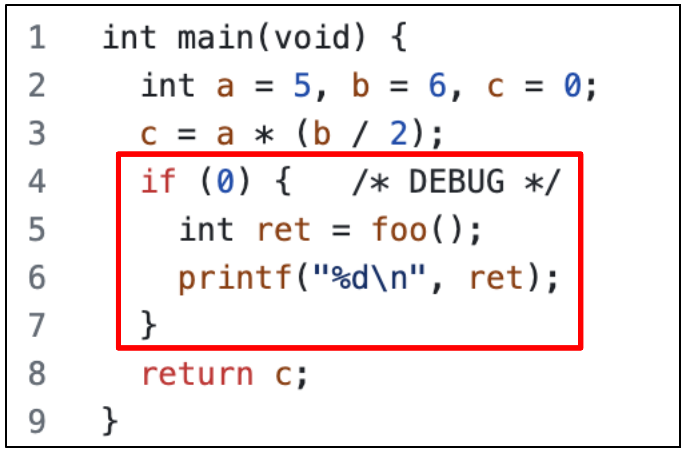

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- ➢ Benefits of DCE: produce ***smaller*** or ***faster*** executables
  - • Many other applications and languages (Java, Go, and Rust, etc.)

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void g() { if (a == 0x99)     f();   }

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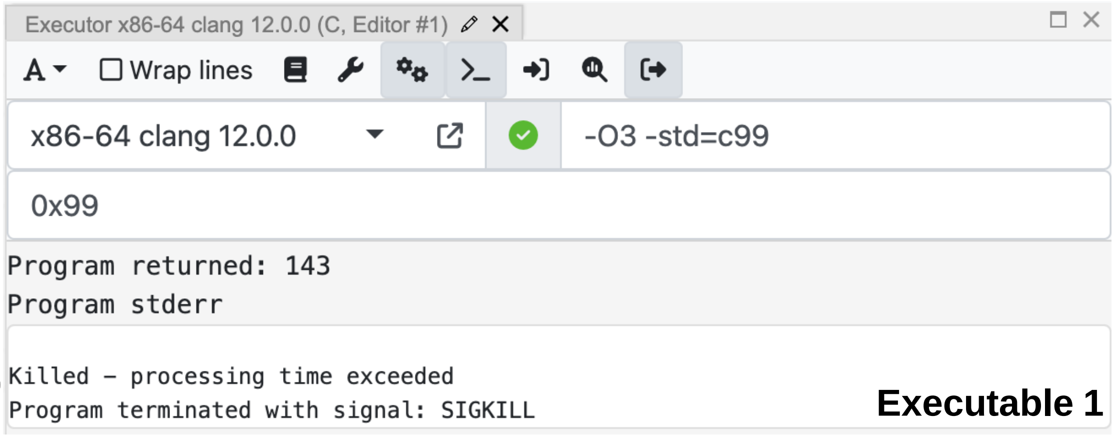

x86-64 clang 12.0.0 -O3 -std=c99

**(Input)** 0x99

```
Program returned: 143
Program stderr
```

**(Output)**

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Killed - processing time exceeded
Program terminated with signal: SIGKILL
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**Executable 1**

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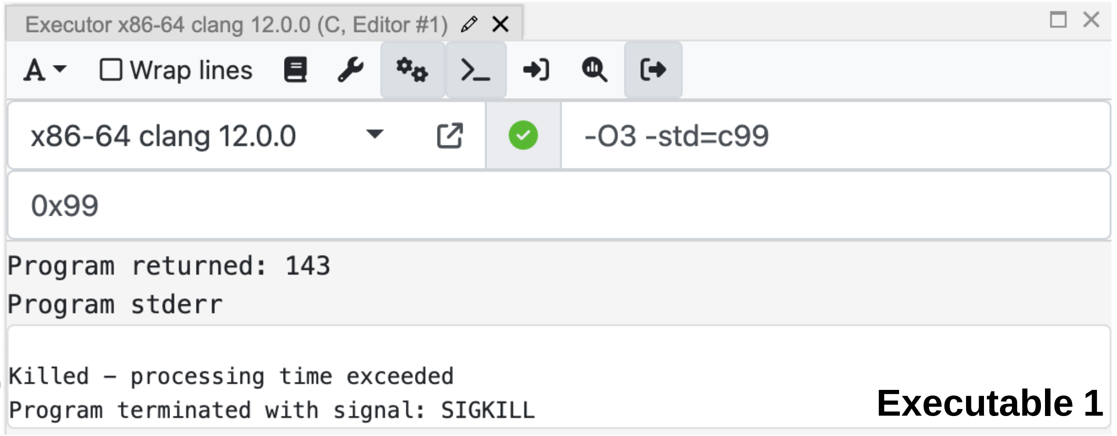

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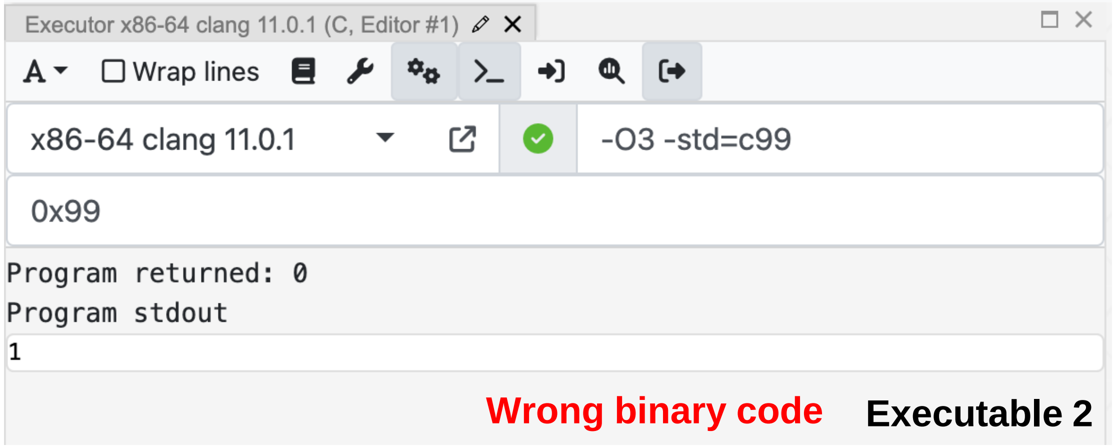

Executor x86-64 clang 11.0.1 (C, Editor #1)

x86-64 clang 11.0.1 -O3 -std=c99

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```
Program returned: 0
Program stdout
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**Wrong binary code** **Executable 2**

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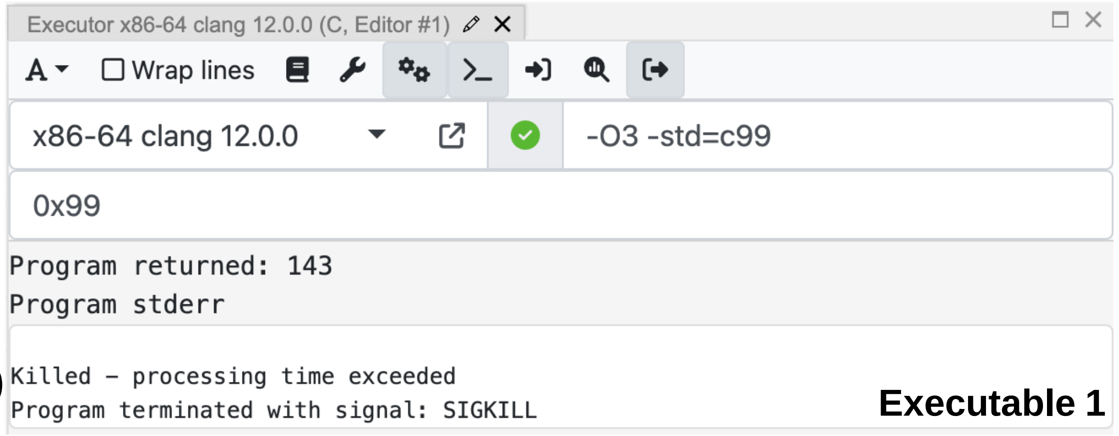

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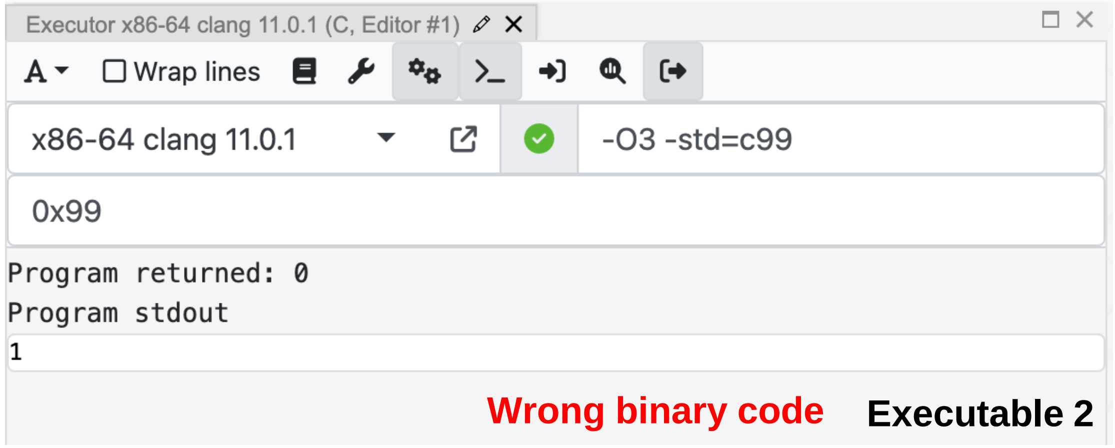

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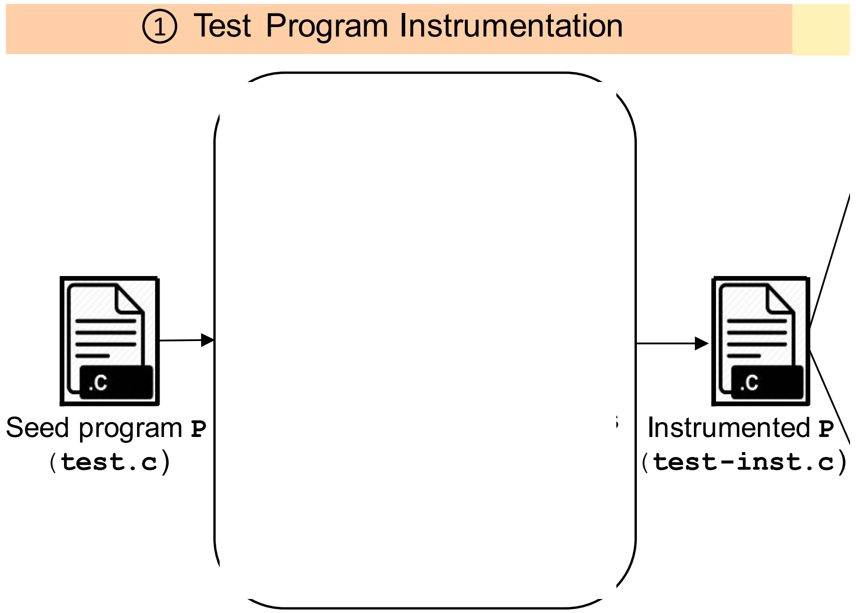

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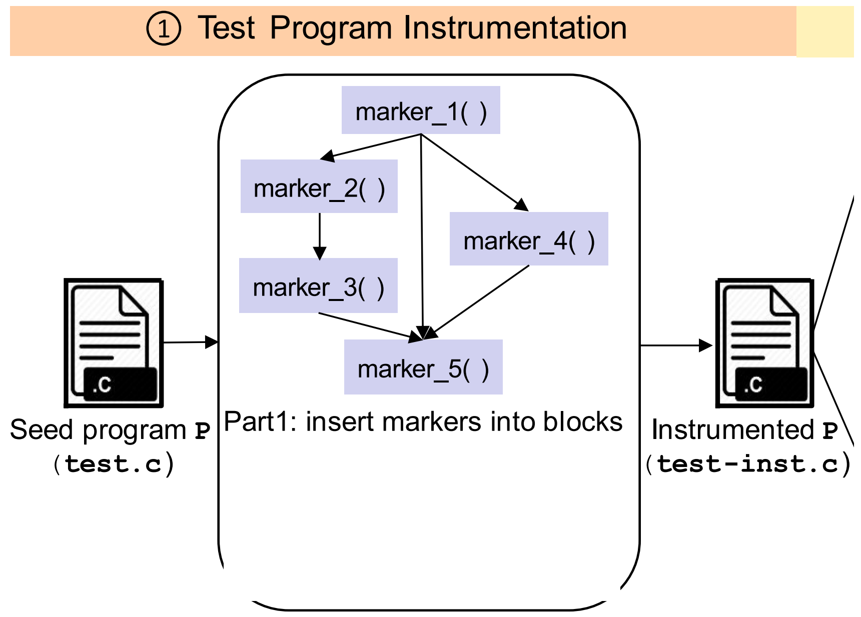

**The marker function:**

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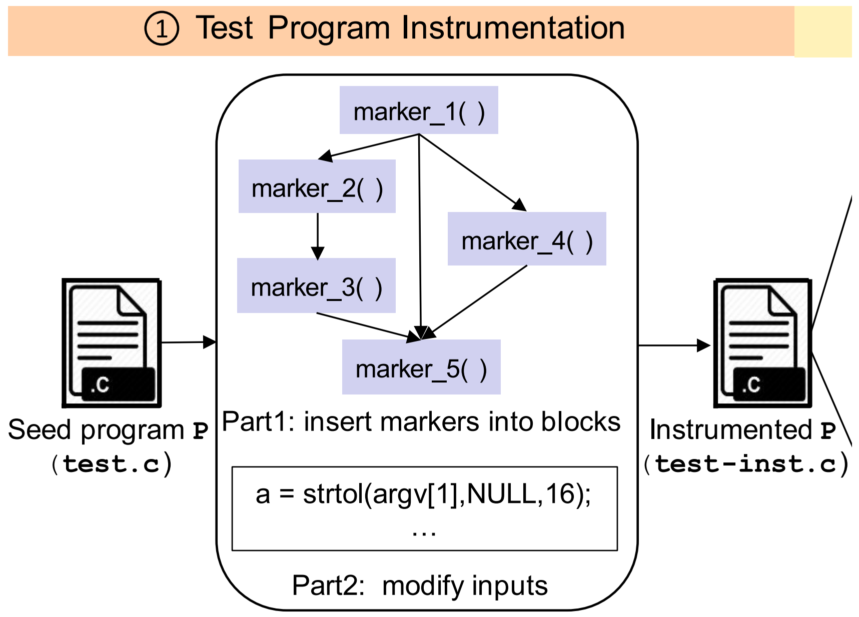

① Test Program Instrumentation
marker_1( )
marker_2( )
marker_3( )
marker_4( )
marker_5( )
.C
Seed program P (test.c)
Part1: insert markers into blocks
a = strtol(argv[1],NULL,16);
…
Part2: modify inputs
Instrumented P (test-inst.c)

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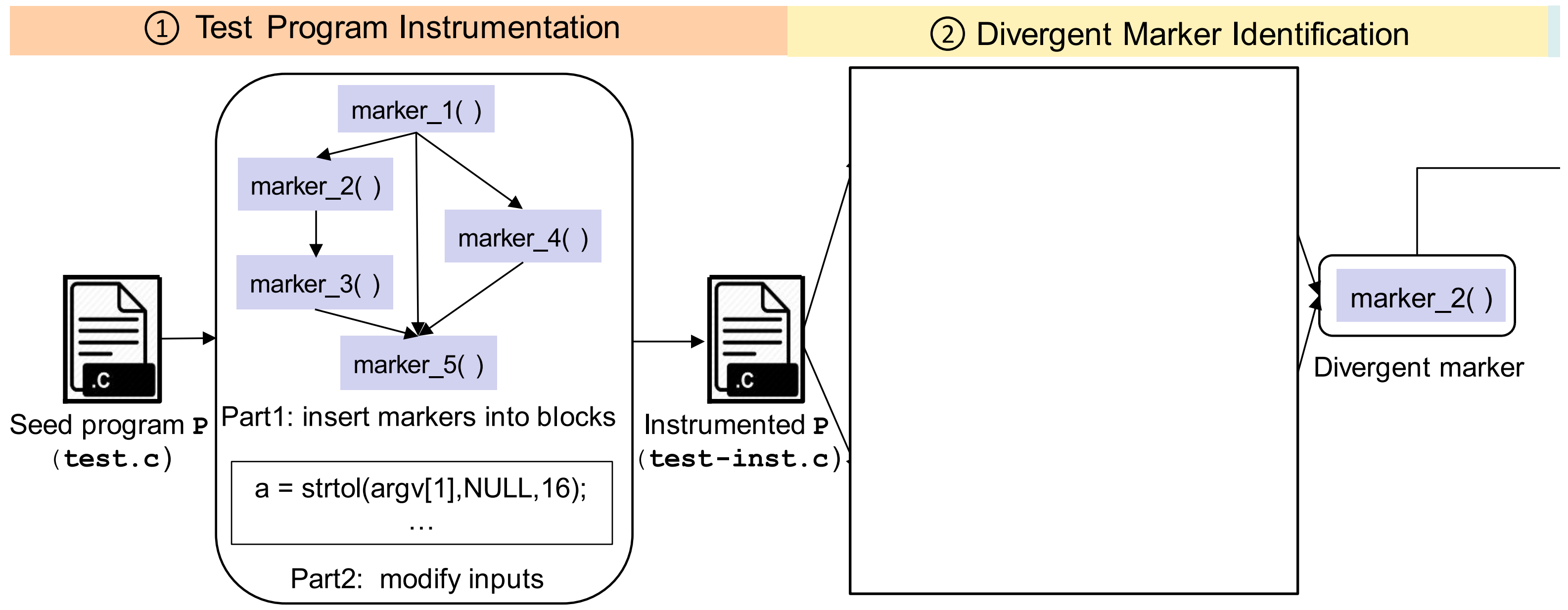

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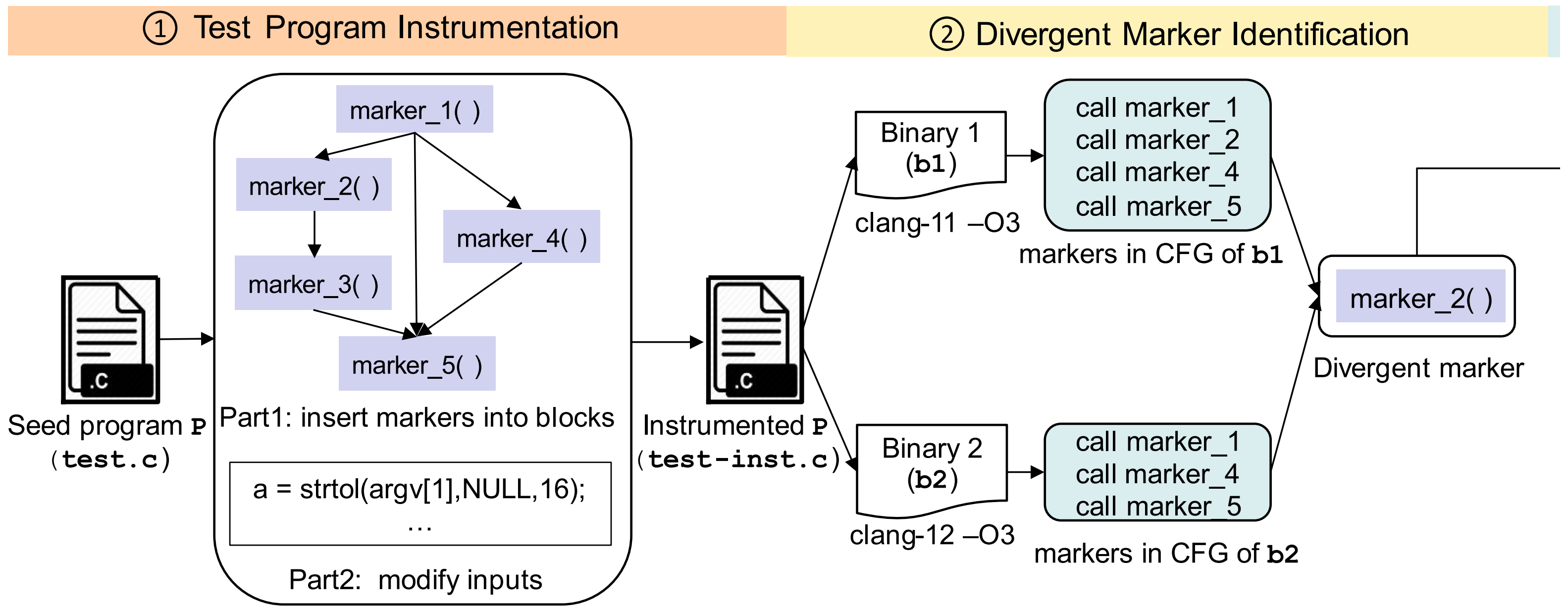

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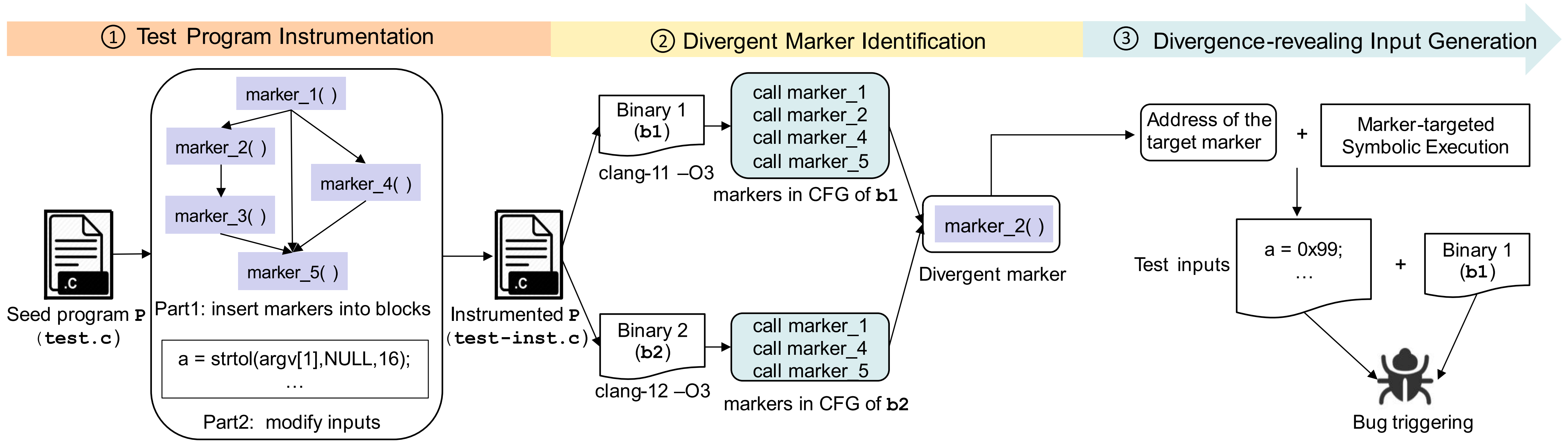

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  - Benchmark
    - **10,000** seed program from Csmith
  - Subjects
    - GCC and LLVM
  - Running setting
    - four scenarios under “–O3”

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  - Number of divergent markers
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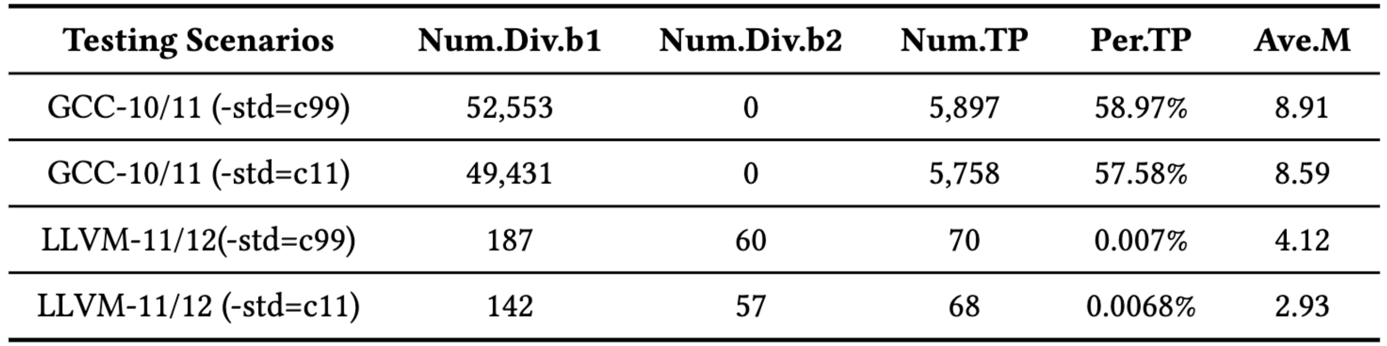

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|---|---|---|---|---|---|
| GCC-10/11 (-std=c99) | 52,553 | 0 | 5,897 | 58.97% | 8.91 |
| GCC-10/11 (-std=c11) | 49,431 | 0 | 5,758 | 57.58% | 8.59 |
| LLVM-11/12(-std=c99) | 187 | 60 | 70 | 0.007% | 4.12 |
| LLVM-11/12 (-std=c11) | 142 | 57 | 68 | 0.0068% | 2.93 |

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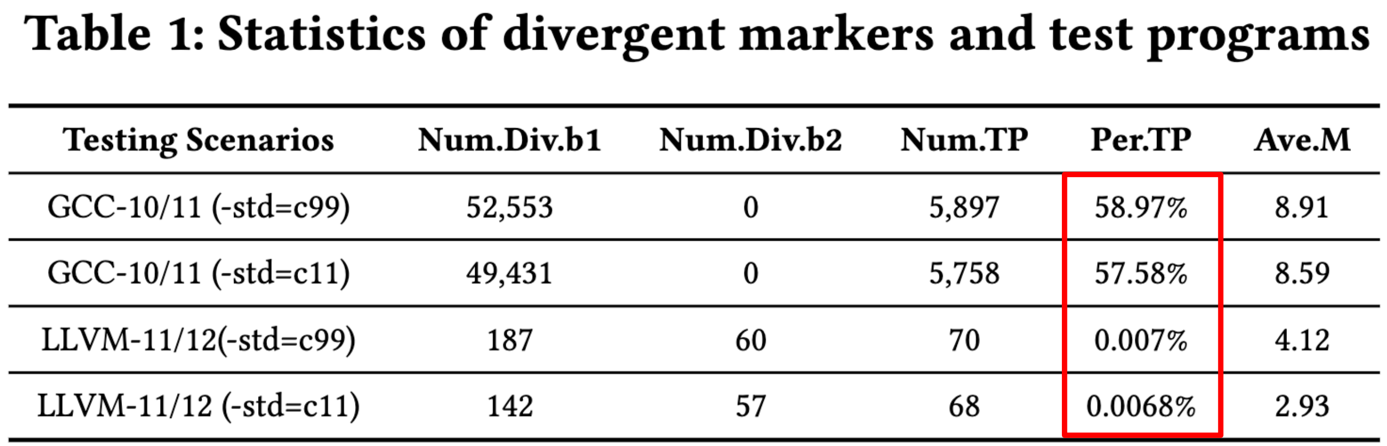

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- **Summary**
  - Found many divergent portions indicating erroneously deleted live code (i.e., wrong compiler optimization opportunities)
  - Detected ***Two*** miscompilation bugs in LLVM compilers

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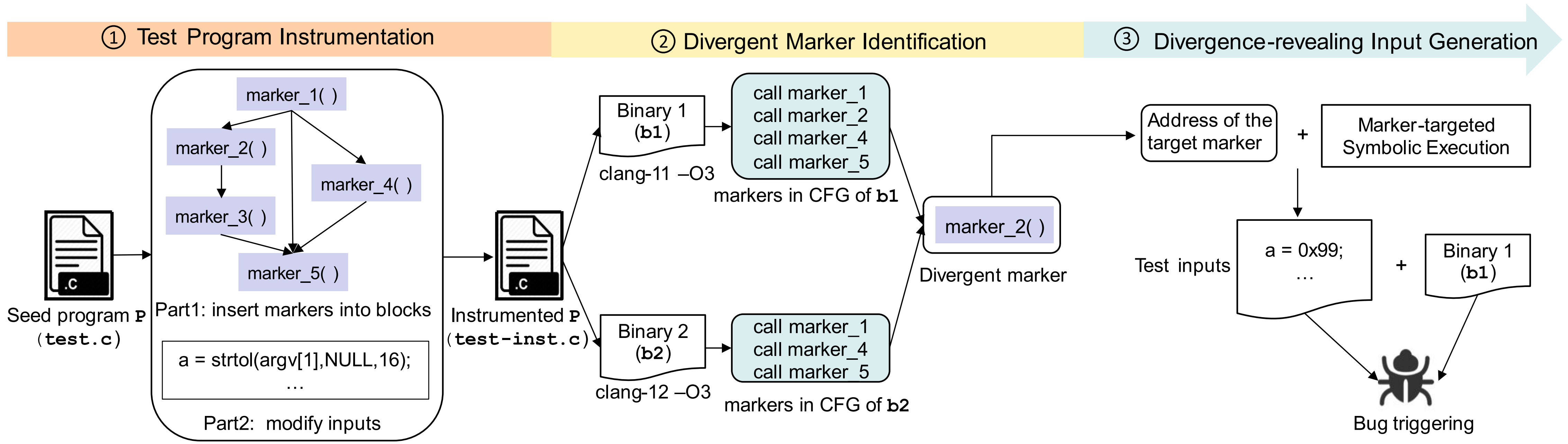

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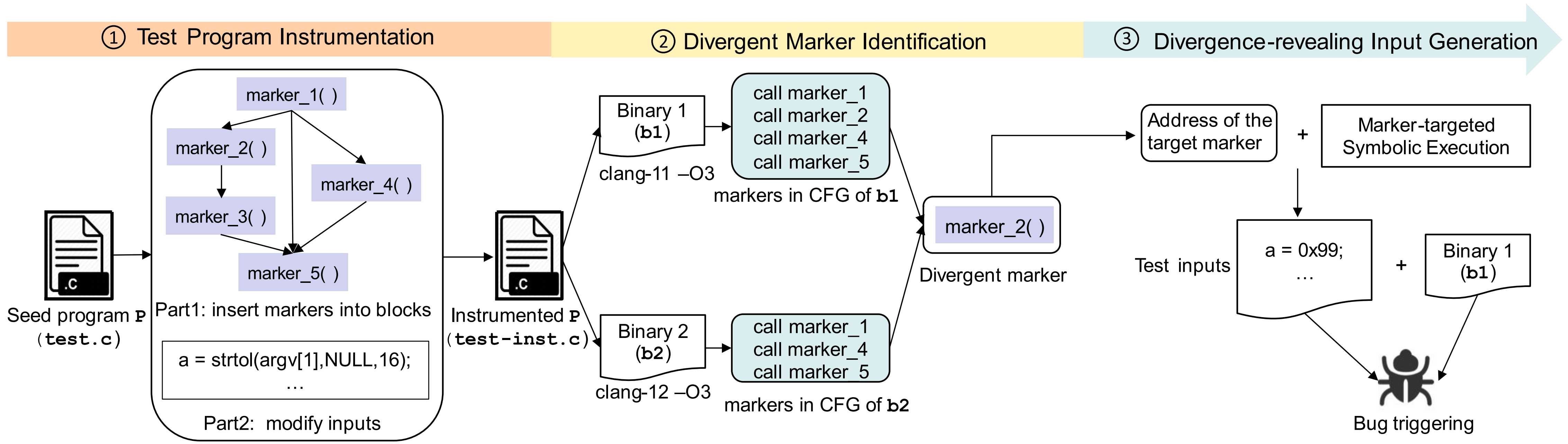

- **Future work**
  - Utilize more fine-grained binary analysis to identify fine-grained divergent portions in **Part 1**
  - Improve the efficiency of **Part 3**
    - efficient path exploration

**Paper**

**Code**

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# Thank you & Questions?

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