Fuzzing the Solidity Compiler

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- Security engineer, Solidity team
- Semantic testing of Solidity compiler

Find security-critical bugs in the compiler before it is shipped

tl;dr:

- Threat model: Incorrect code generation
- Randomly generated valid Solidity (yul) programs test compiler
- Found 10 bugs using semantic fuzzing
- Continuous fuzzing for early bug discovery

Introduction

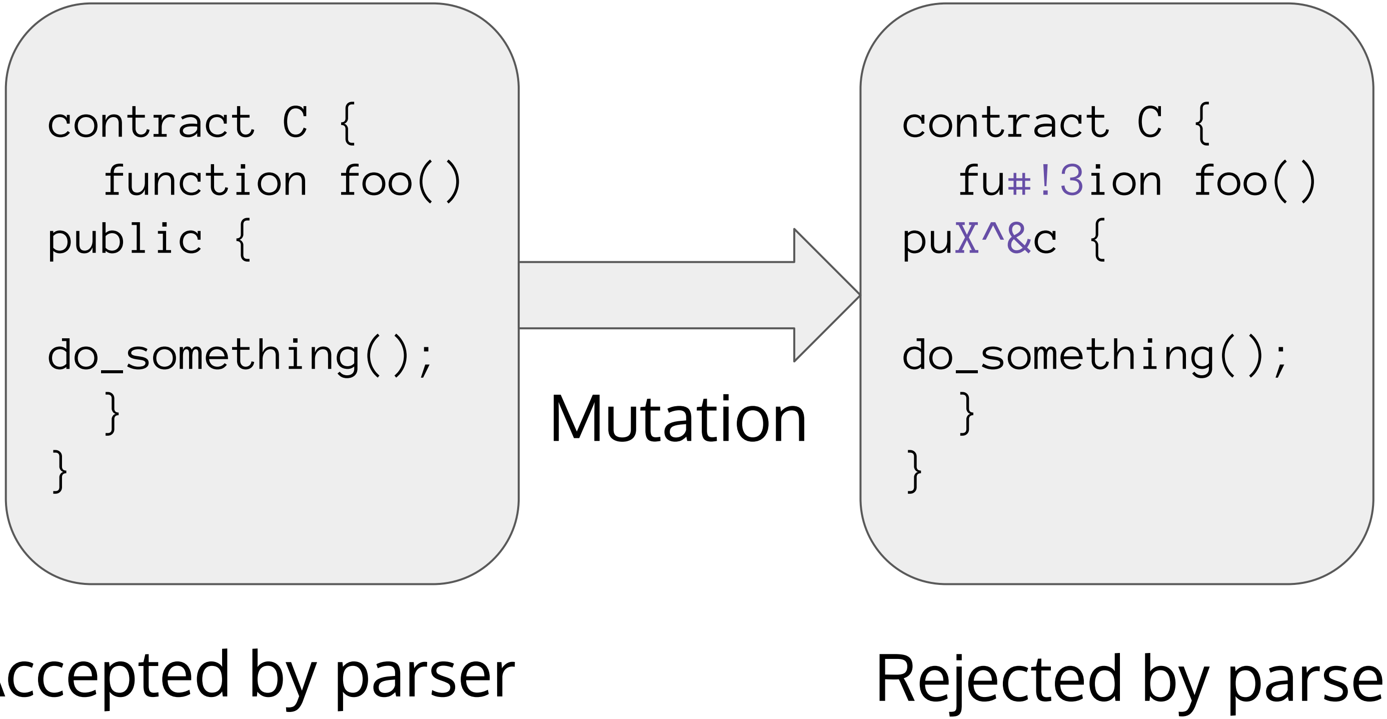
Threat model

- Compiler user (programmer) is not malicious
- Bugs introduced by the optimizer

Fuzz testing in a nutshell

```
while not ctrl + c
do
    input=gen_input()
    runProgram(input)
done
```

Limitation of random fuzzing



```
contract C {
  function foo()
public {

do_something();
  }
}
```

```
contract C {
  fu#!3ion foo()
puX^&c {

do_something();
  }
}
```

Fuzzing a compiler requires generating valid programs…

… generating a valid program requires structure awareness

Approach

Write a specification

Specification written in protobuf language

```
message Block {
  repeated Statement stmts;
}
...
message program {
  repeated Block blocks;
}
```

Full spec:
https://github.com/ethereum/solidity/blob/develop/test/tools/ossfuzz/yulProto.proto

Input generation

- Input generated and mutated by libprotobuf-mutator
- Each input is a tree

```
blocks { stmts { ifstmt { condition {
binaryOp { eq { op1: varref{id: 0} op2: 0}
} } } } }
```

Input conversion

- Converter is source-to-source translator
- Input: protobuf serialization format
- Output: yul program

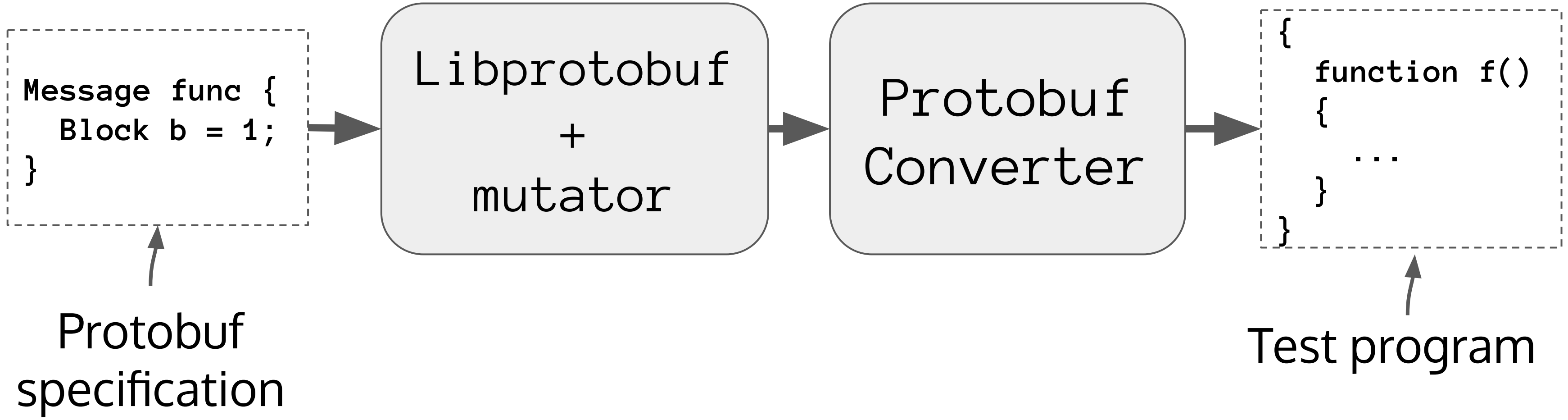
Example

```
blocks { stmts { ifstmt { condition {
binaryOp { eq { op1: varref{id: 0} op2: 0}
} } } } }
```

$\Downarrow$ Conversion

```
if x_0 == 0
```

Test program generation



```
Message func {
  Block b = 1;
}
```

```
{
  function f()
  {
    ...
  }
}
```

Correctness testing requires encoding expectation somehow

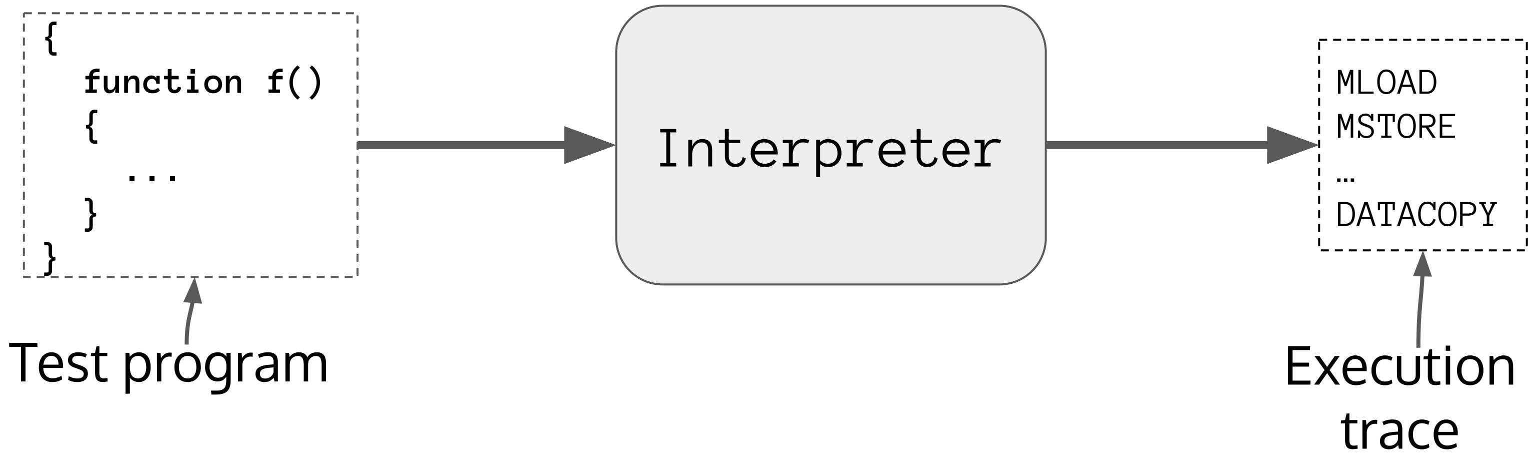
Differential fuzzing

- Track side-effects of execution
- Run program
- Run optimized program
- Compare side-effects

Yul interpreter

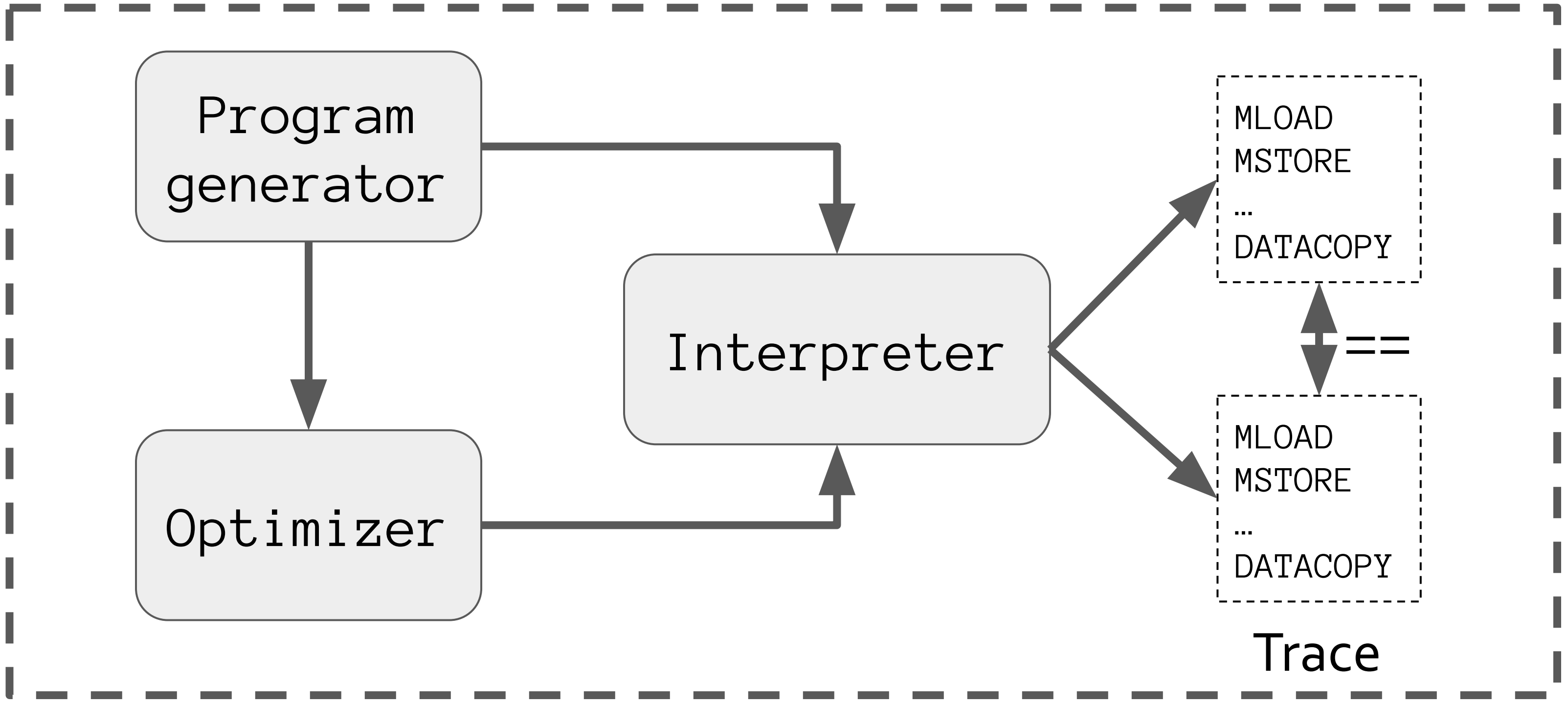
- Interprets arbitrary yul program
- Outputs side-effects as a trace (string)

Yul interpreter

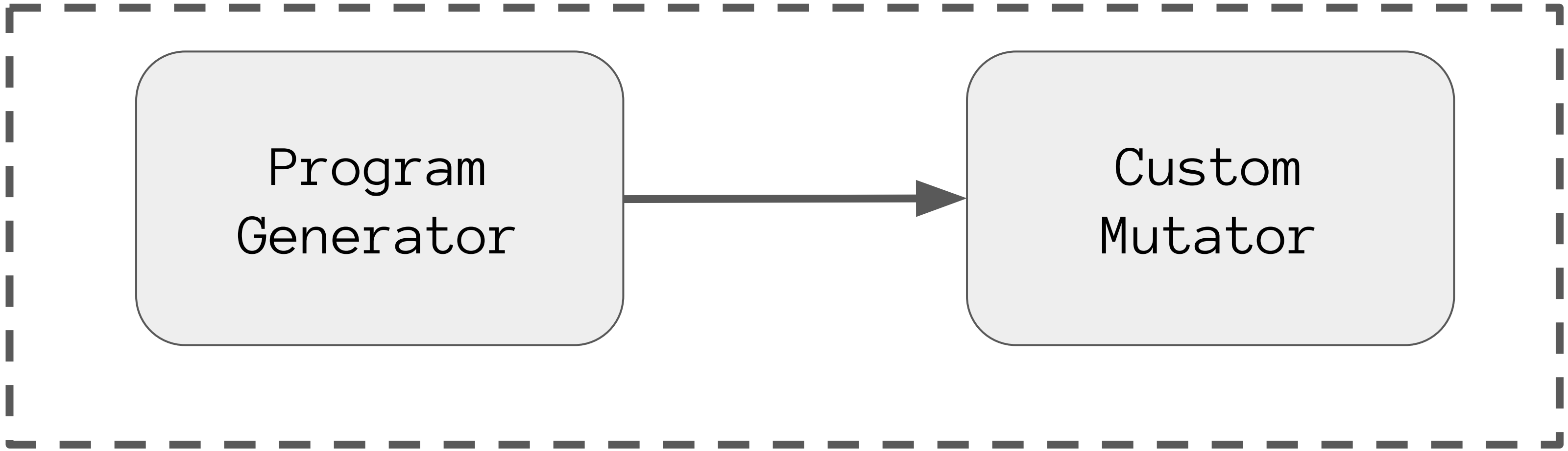


```
{
  function f()
  {
    ...
  }
}
```

Fuzzing Setup



Custom Fuzz Mutator

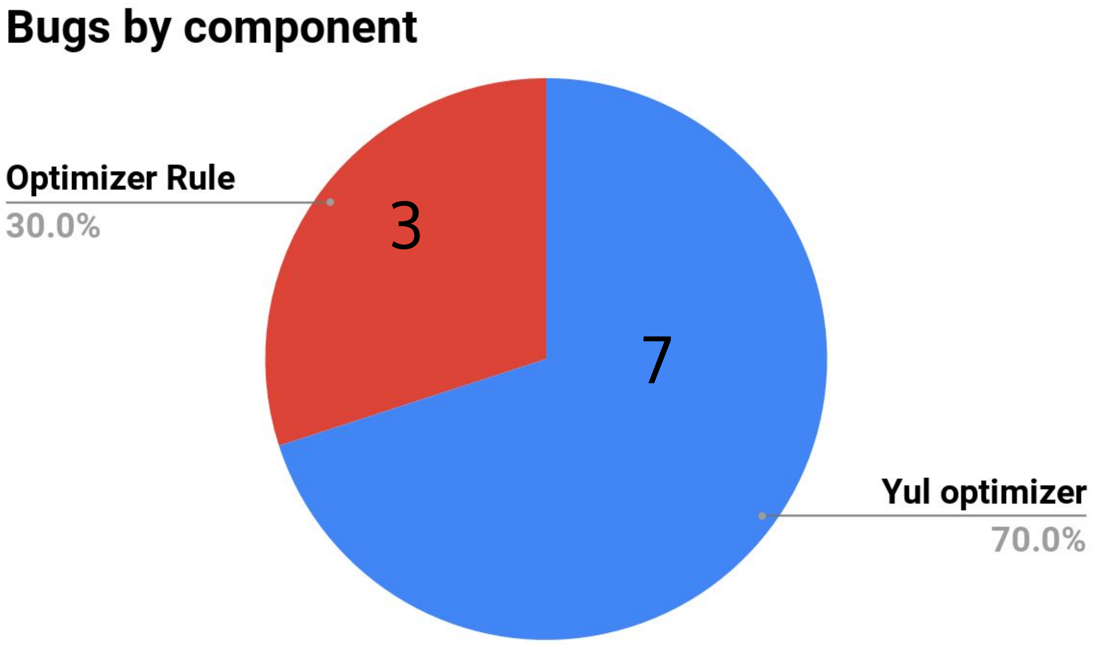


```
if x_0 == 0
```

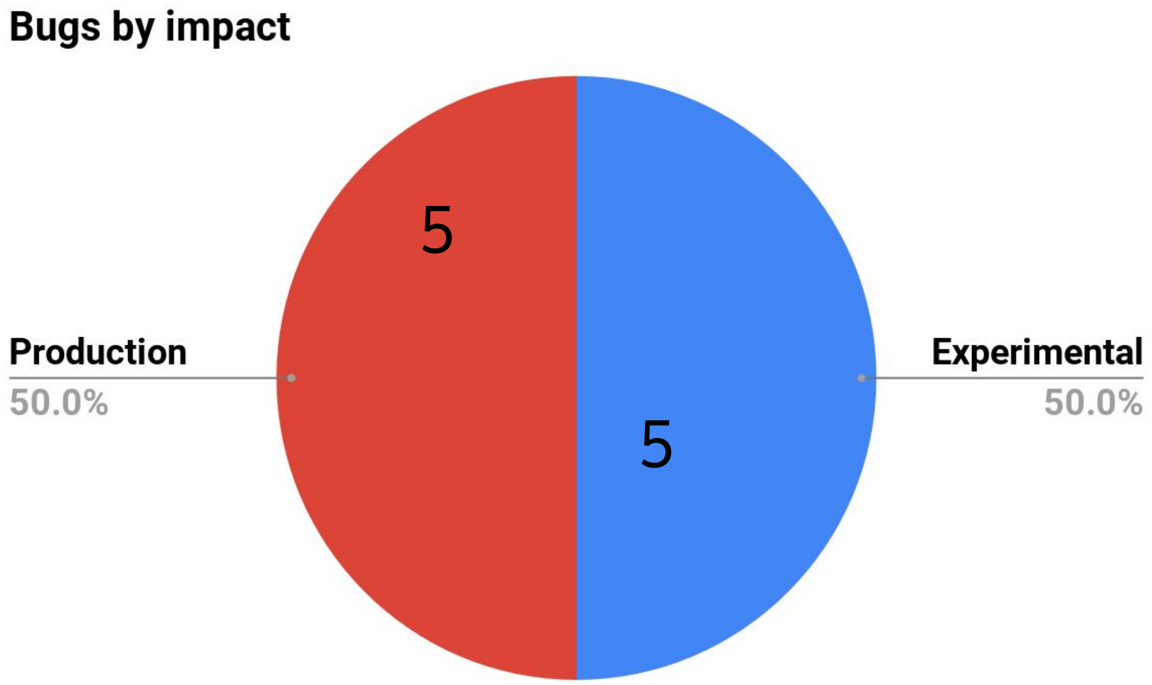
```
if x_0 != 0
```

Results

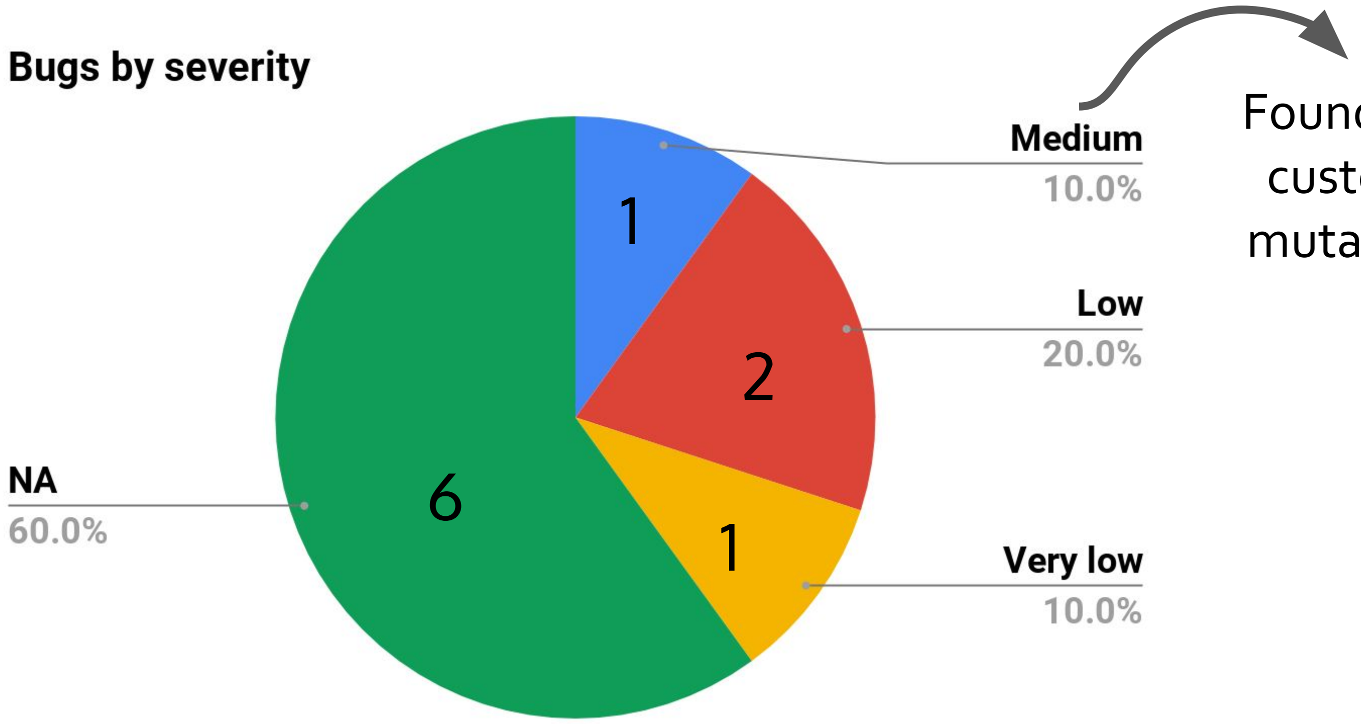
Bugs by component



Bugs by impact

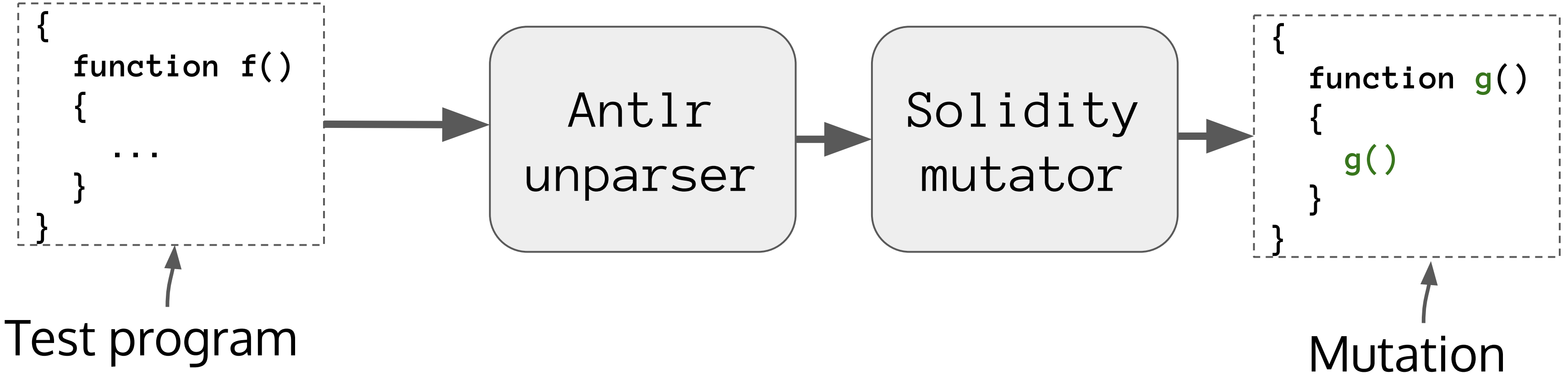


Bugs by severity



Current work

Antlr based custom mutator



```
{
  function f()
  {
    ...
  }
}
```

```
{
  function g()
  {
    g()
  }
}
```

Conclusion

Conclusion

- Continuous structure-aware fuzzing for early bug discovery
- Useful for testing optimizer and data en/decoding
- Decent assurance
    - Evidence that it works
    - No formal guarantees though

Thank you!

ethereum/solidity.git

gitter.im/ethereum/solidity-dev