Testing, Fuzzing, & Symbolic Execution

Software Testing

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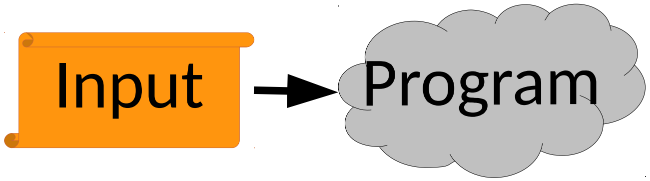

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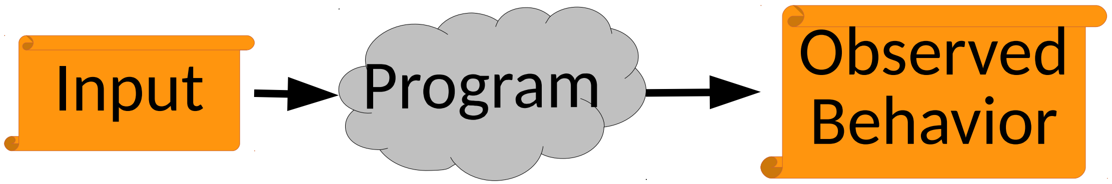

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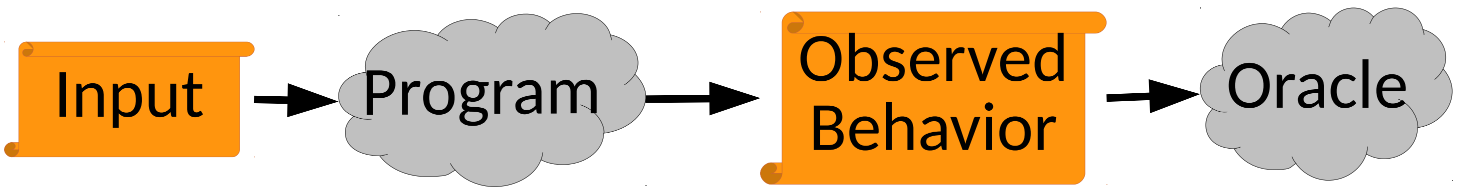

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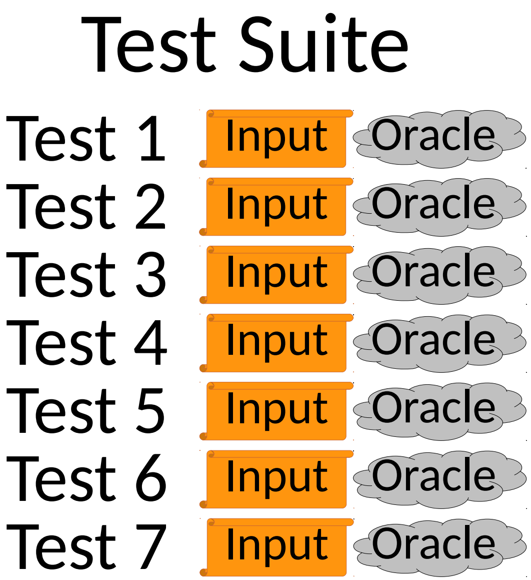

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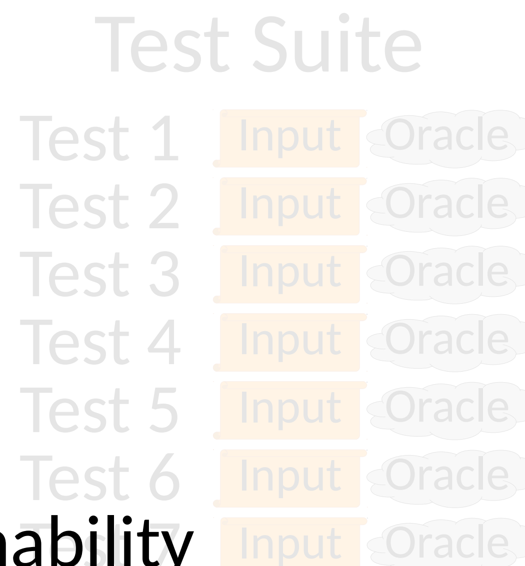

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- Metrics
  - Statement Coverage

Is each statement executed by at least one test in the test suite?

```
def my_lovely_fun(a,b,c):
  if (a && b) || c:
    …
  else:
    …
  print('awesome')
```

$$\text{score} = \frac{\text{\# covered}}{\text{\# statements}}$$

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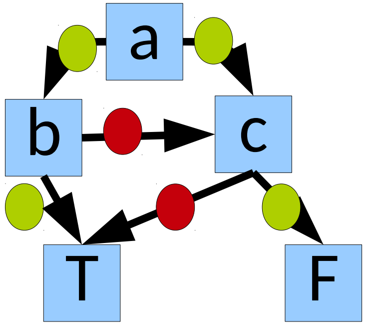

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def my_lovely_fun(a,b,c):
   if (a & b) | c:
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More common in safety critical systems where full coverage may be required.

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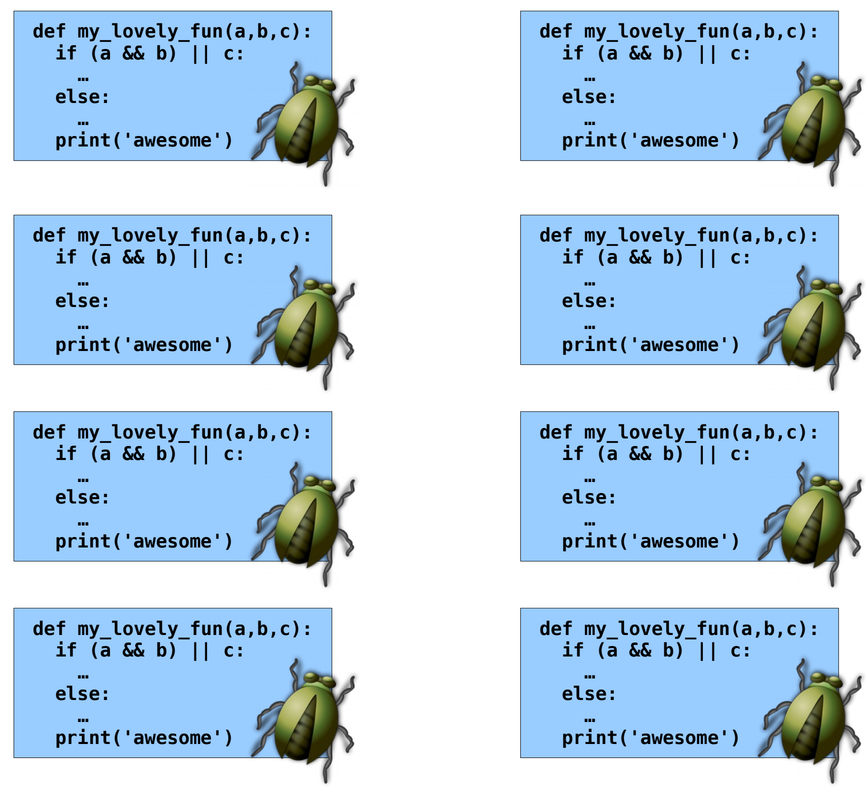

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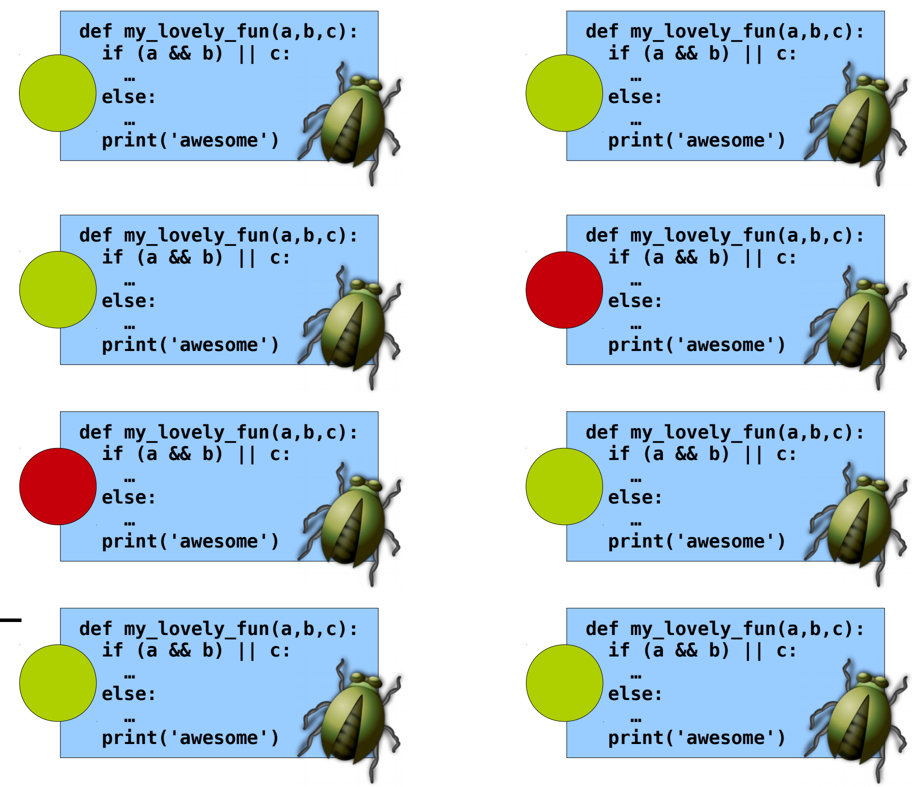

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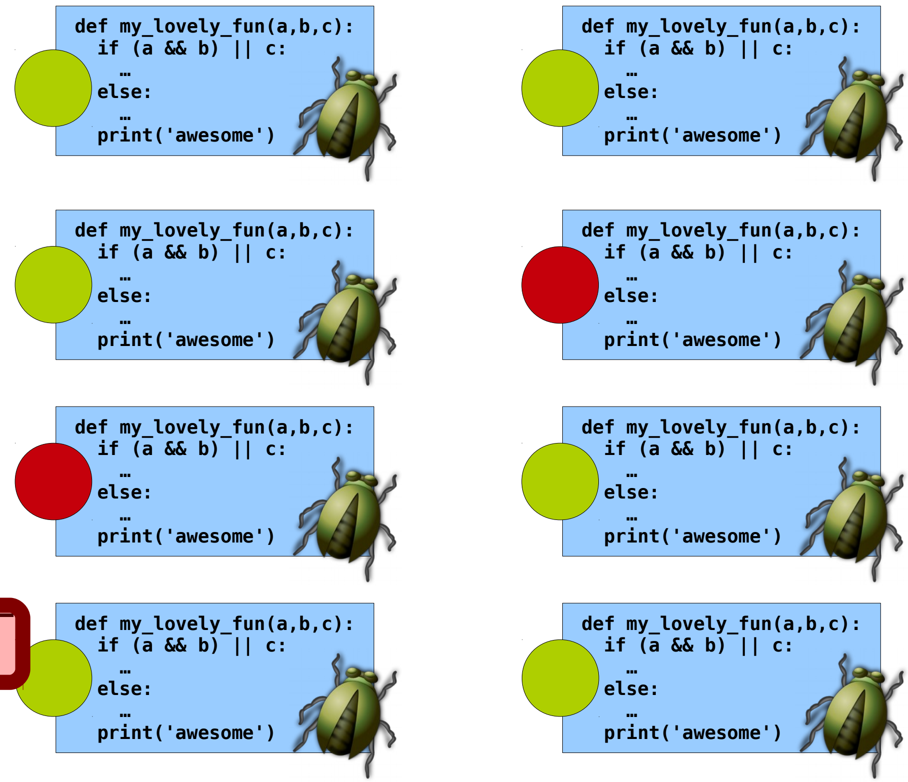

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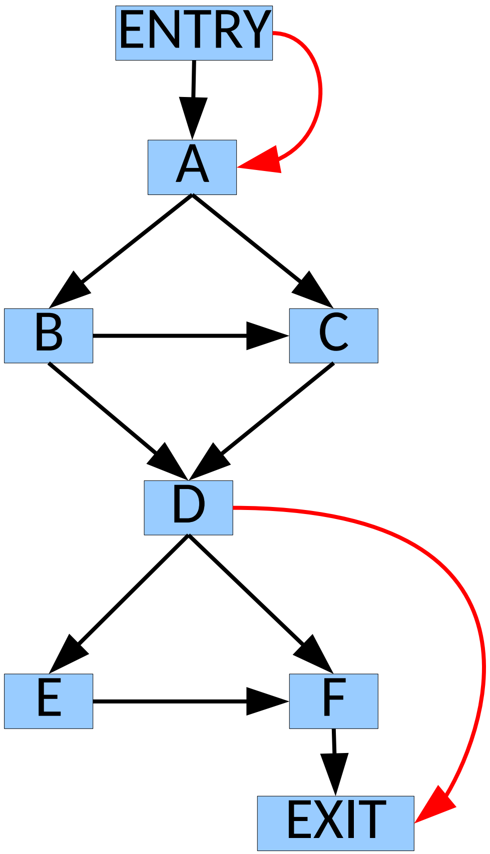

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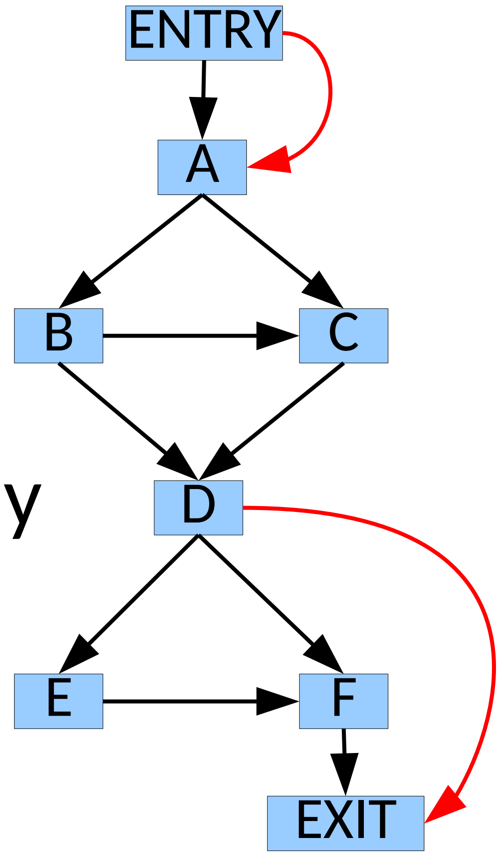
Can apply EPP!



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BUT reducing test suites for St, Br, MC/DC coverage decrease defect detection!

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for i in inputModel:
    test = findRepresentative(i)
    check_test(test)
```

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  - Black Box – Treat the program as opaque / unknown

    e.g. specification based, naive fuzzing,
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  - Black Box – Treat the program as opaque / unknown
  - White Box – Program structure & semantics can be used

e.g. symbolic execution, call chain synthesis, white box fuzzing, boundary value analysis, ...

Generating Oracles

?

Generating Oracles

- Likely invariants?
- Careful variable selection & monitoring?
- Differential Testing
- Metamorphic Testing

A very open (hard) problem.

Interesting Problems

- Random Testing
- Test Suite Adequacy
- Test Suite Minimization
- Test Generation
- Oracle Generation
- Test Maintenance
- Performance Testing
- Field Testing
- Power Testing
- Test Prioritization
- …

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Test generation techniques have also proven to be critical in security research.

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It was distressingly effective at finding buffer overflows (25%-33% of programs).

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     - Modify an existing test suite
     - Seeing a resurgance via *AFL* & *libFuzzer*

Symbolic Execution

Cadar & Sen, 2013

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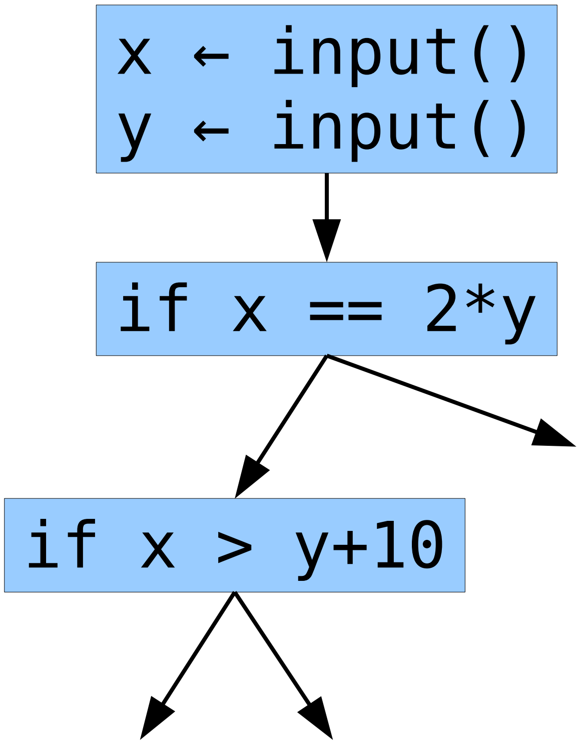

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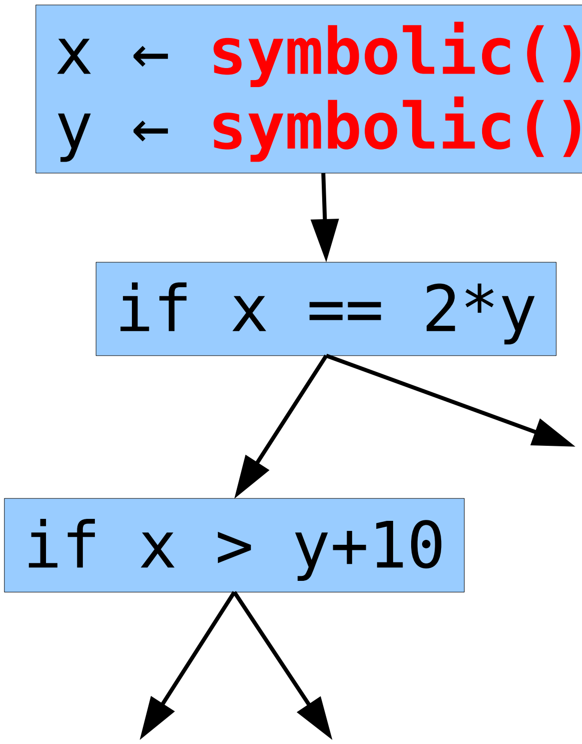

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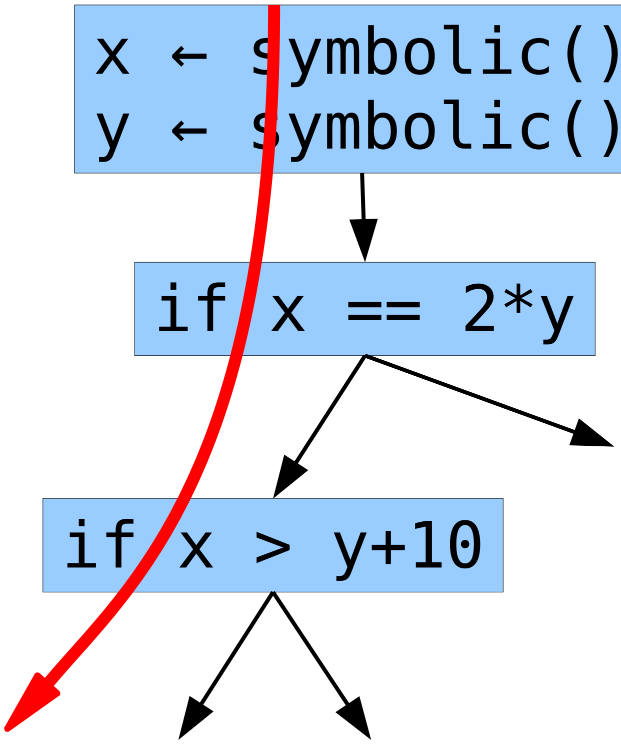

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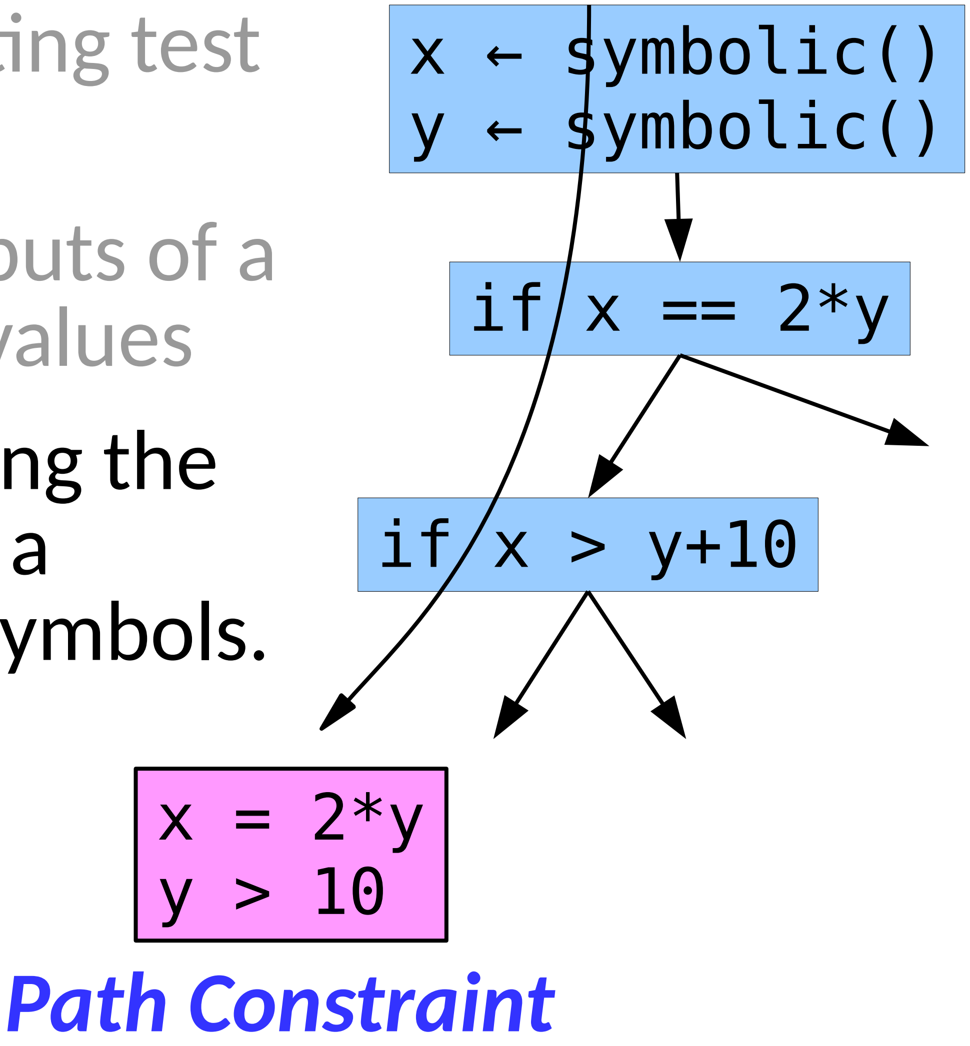

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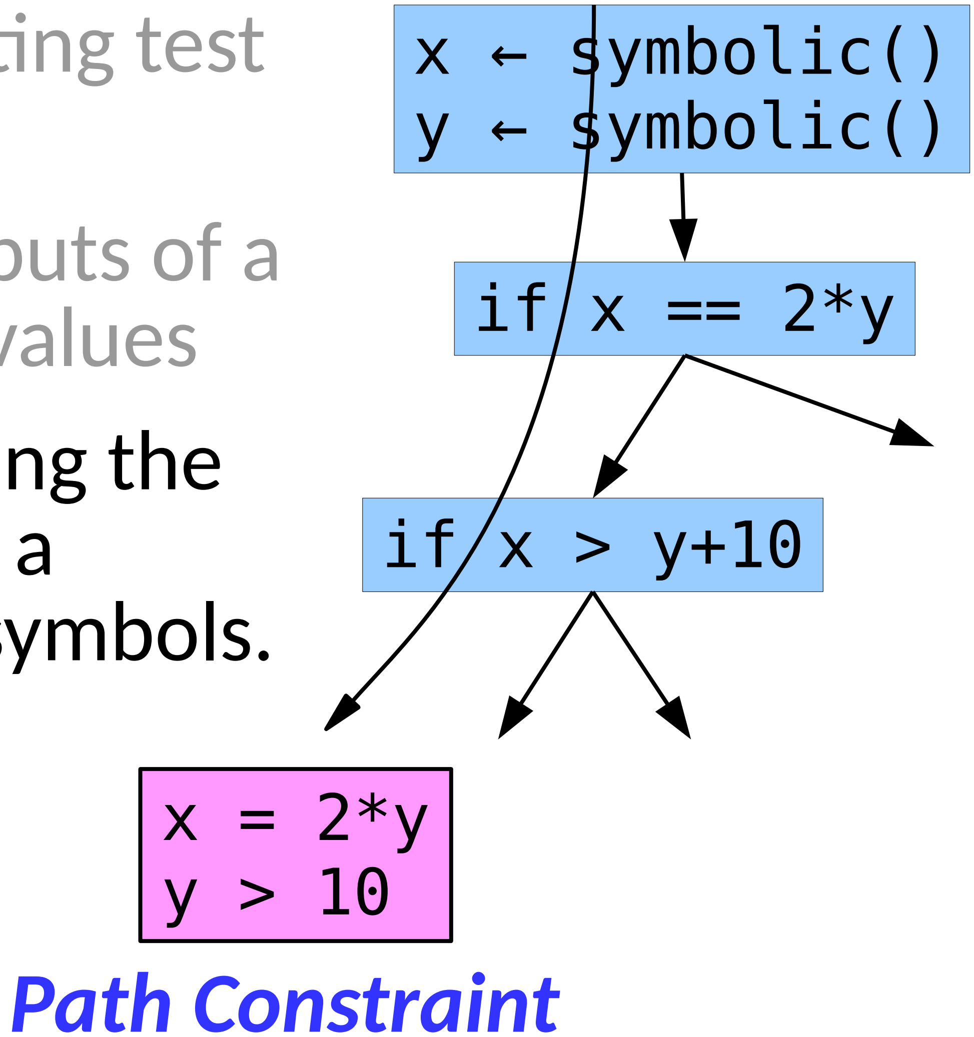

A path constraint represents all executions along that path

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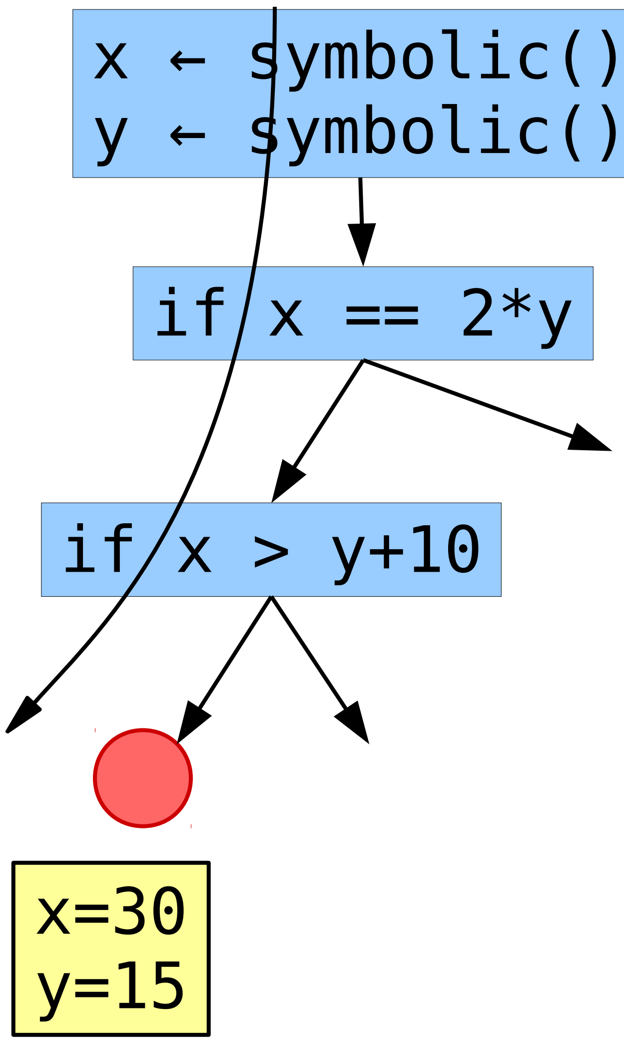

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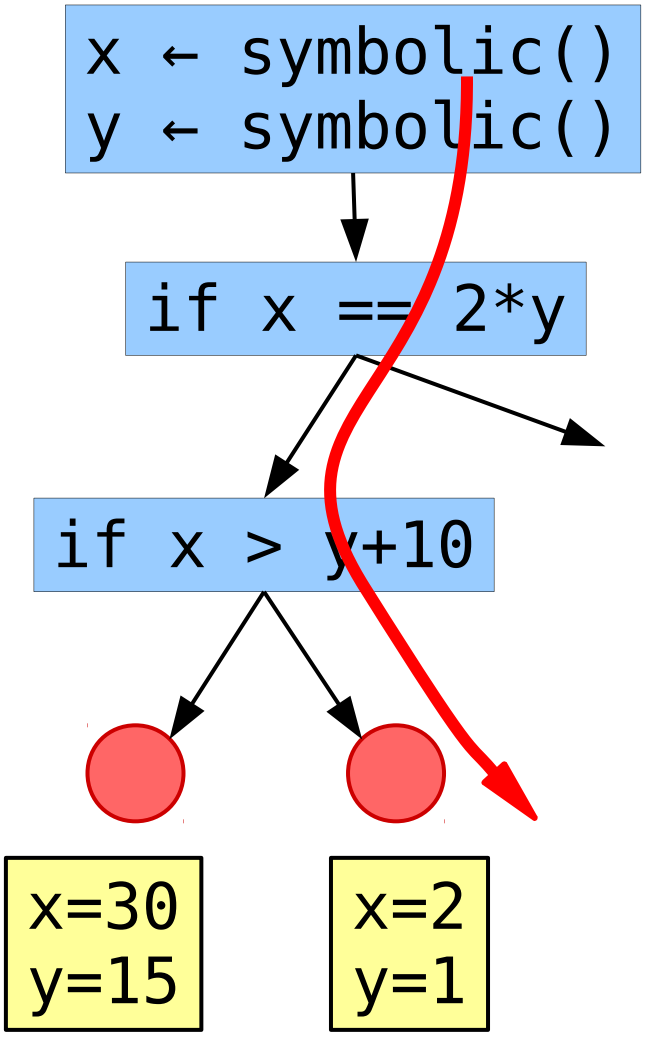

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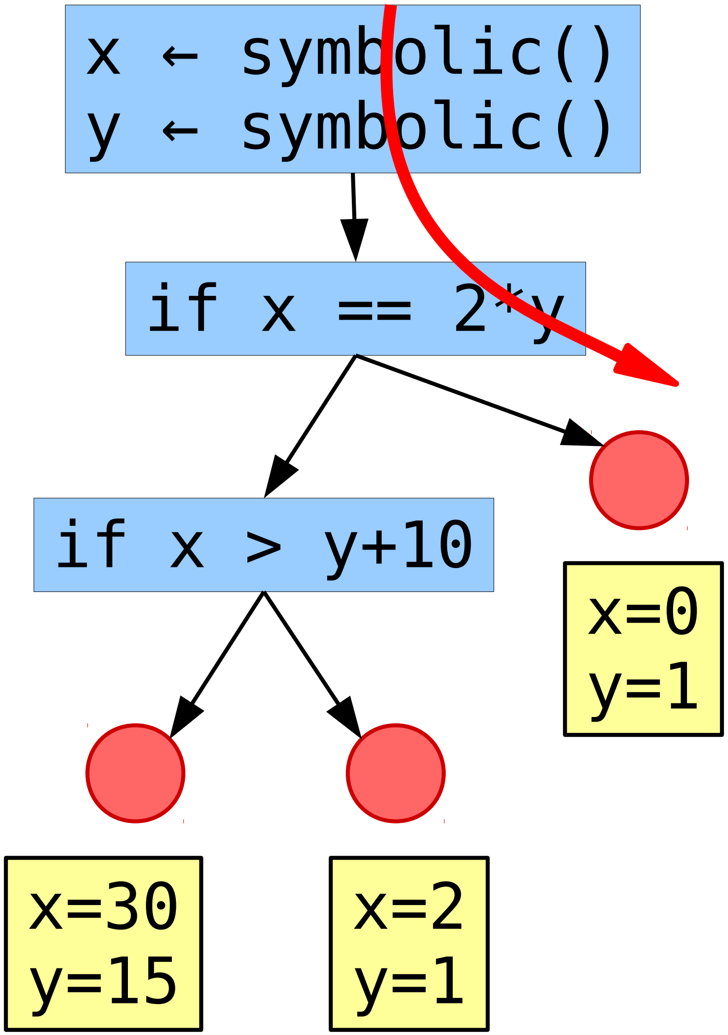

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Try it online:
http://www.rise4fun.com/Z3/tutorial/

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What is the intuitive meaning?

Exploring the Execution Tree

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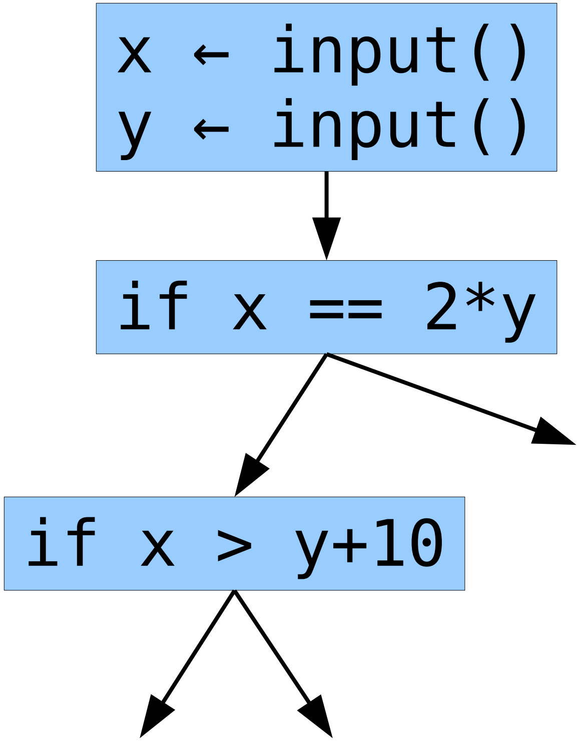
Cadar & Sen, 2013



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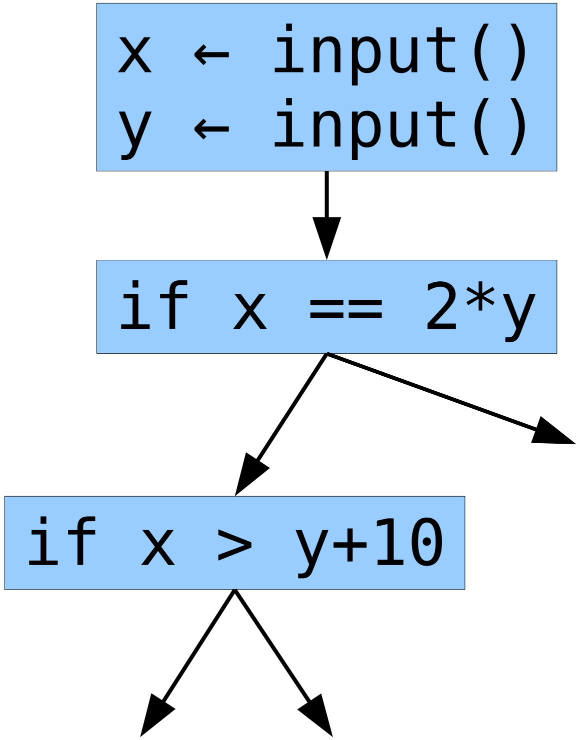

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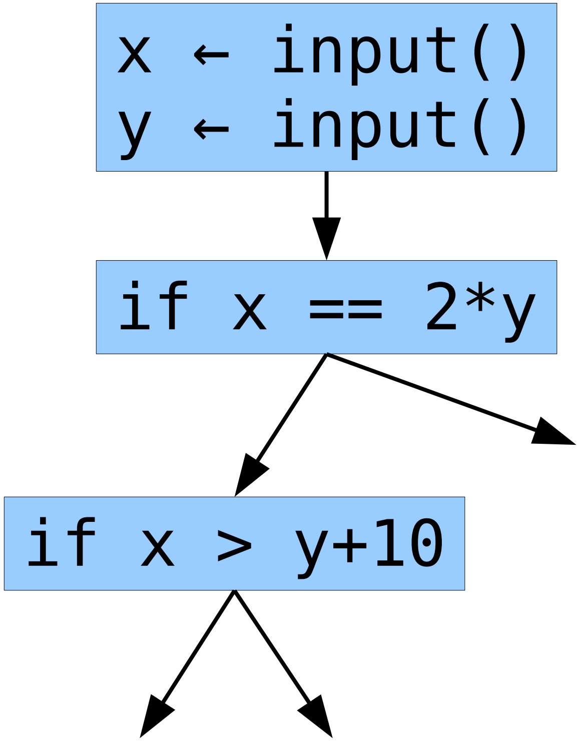

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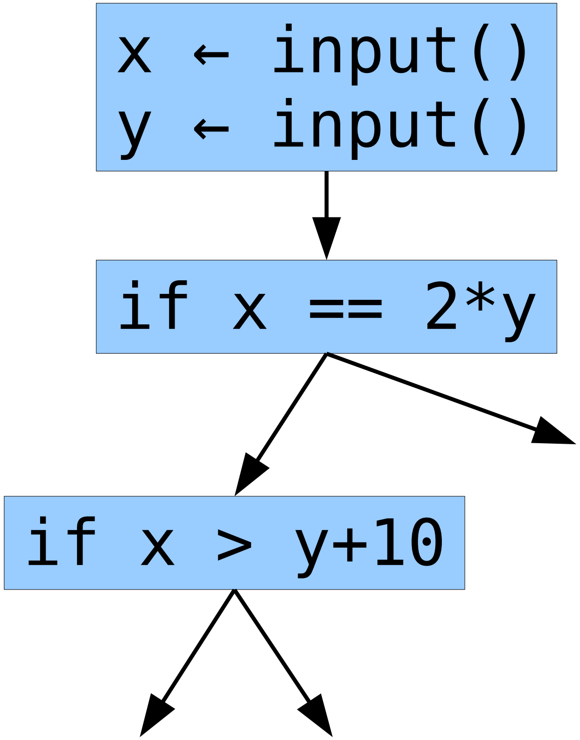

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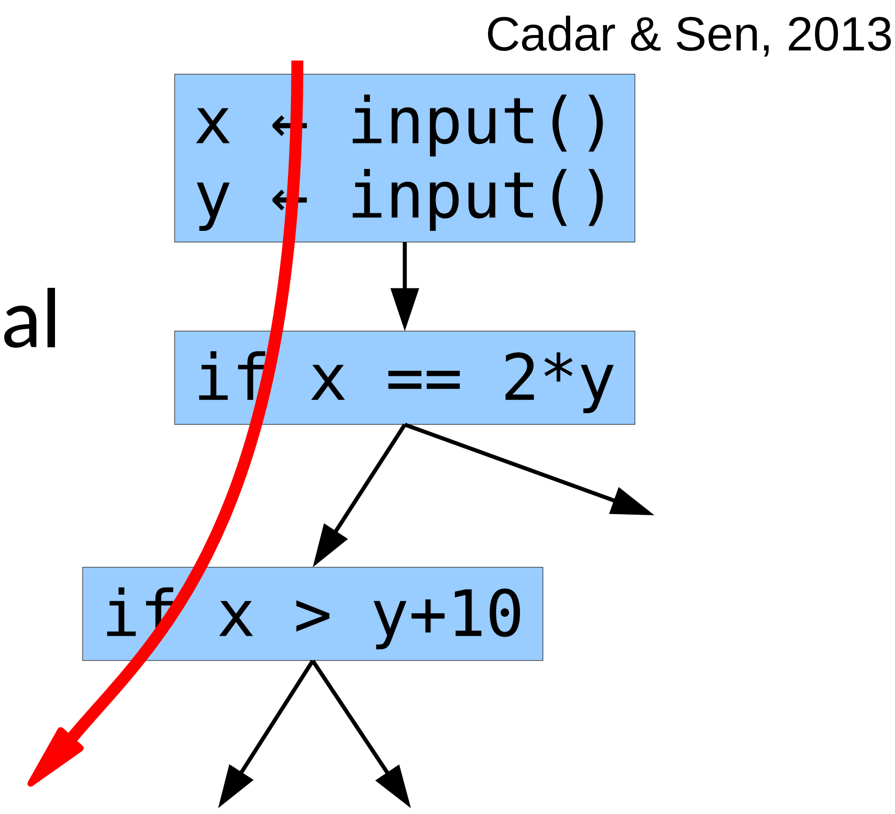

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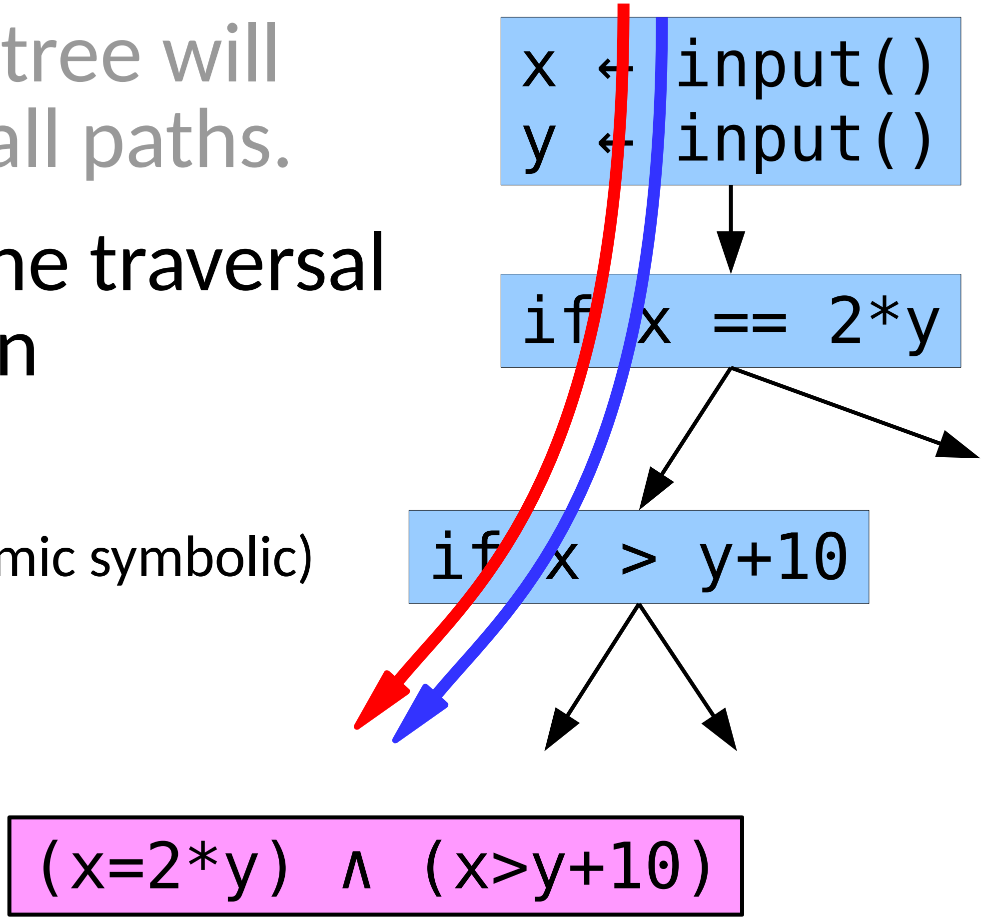

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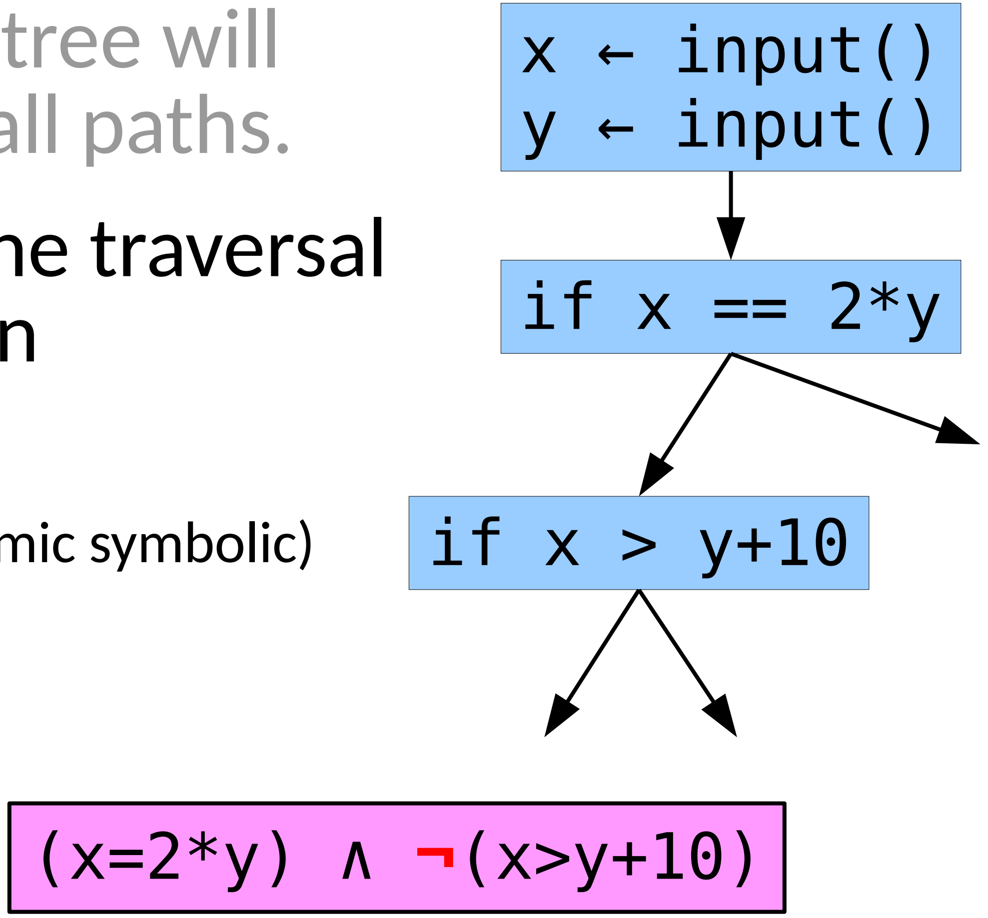

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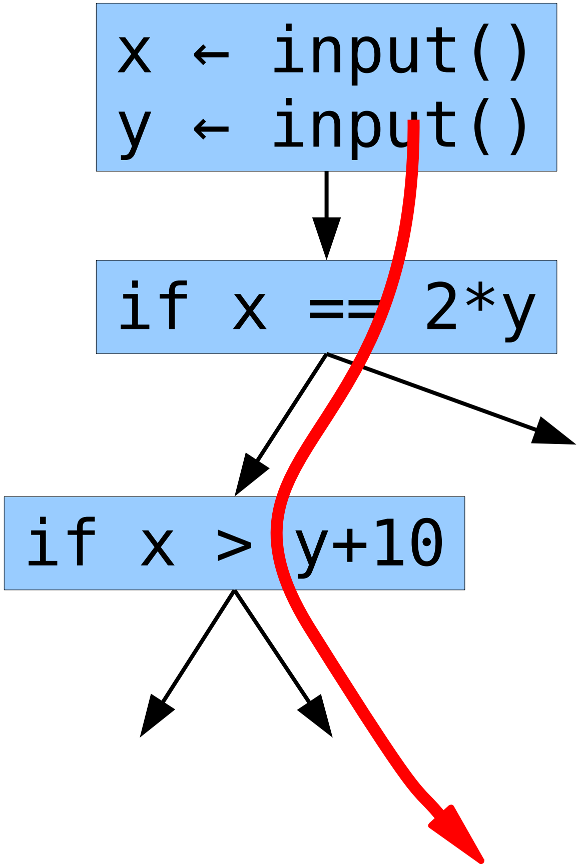

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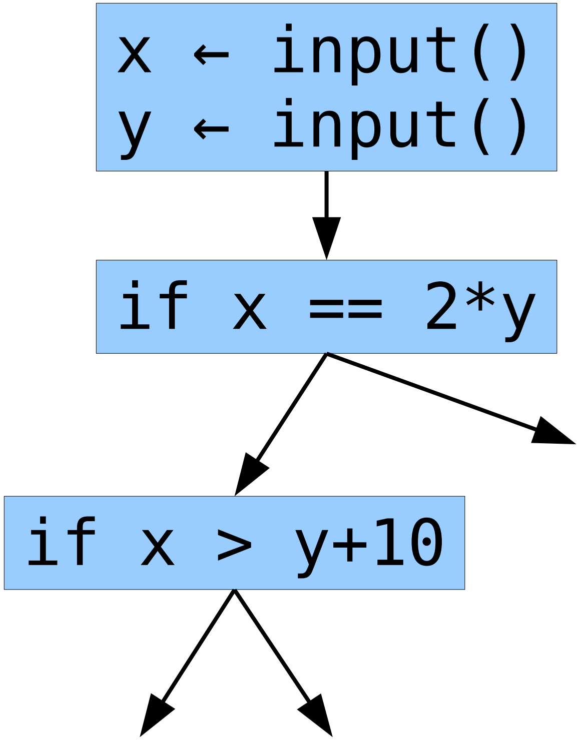

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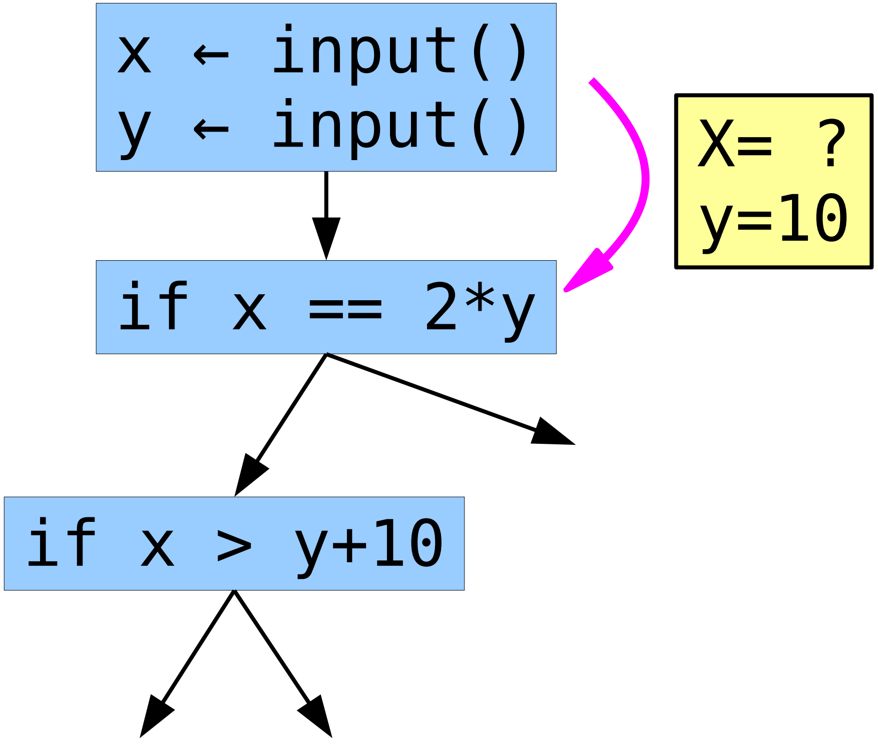
Cadar & Sen, 2013



Exploring the Execution Tree

- The possible paths of a program form an ***execution tree***.
- Traversing the tree will yield tests for all paths.
- Mechanizing the traversal yields two main approaches
  - Concolic (dynamic sy
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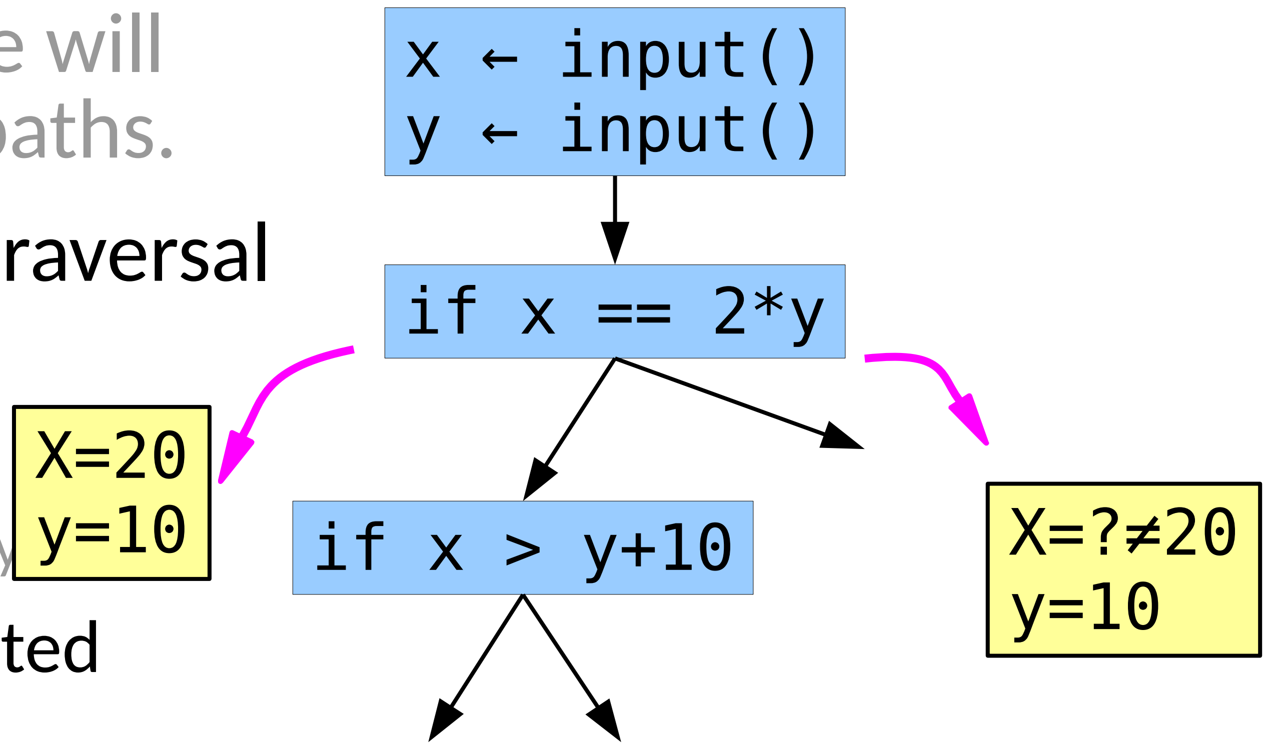

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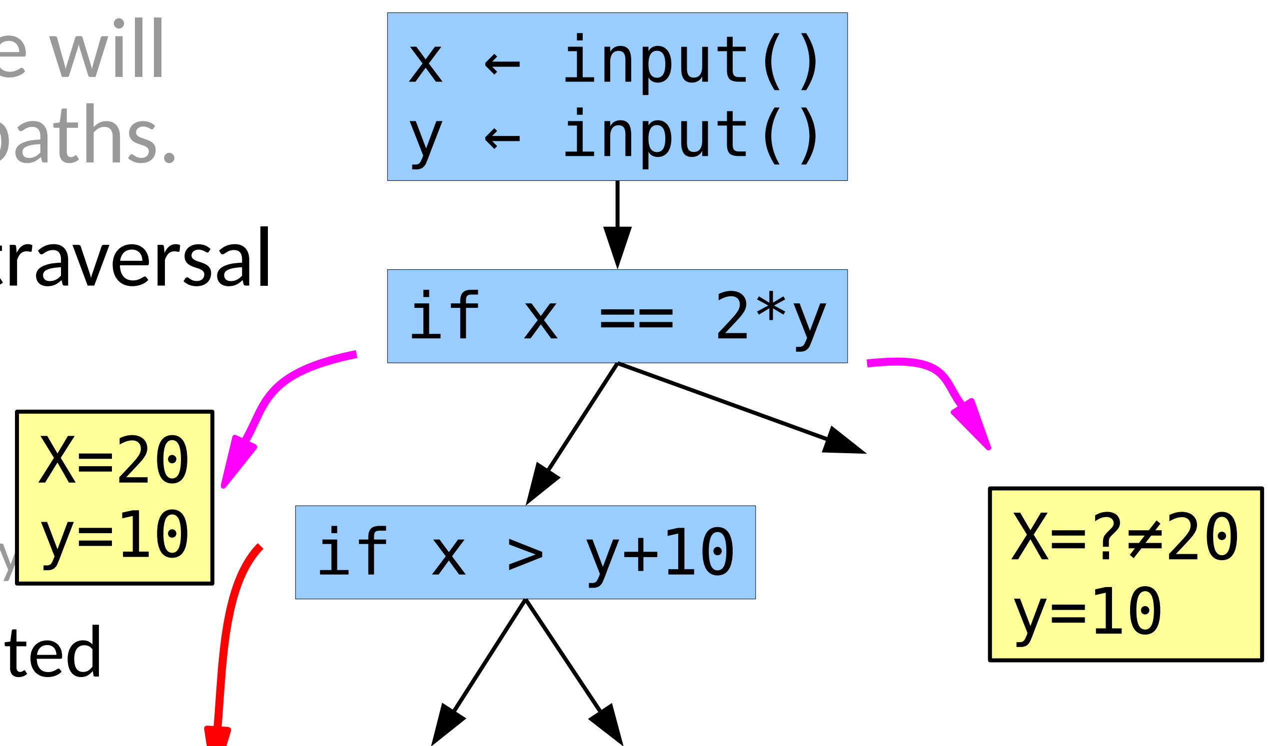

Execution on this side is concrete from this point on.

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Try it out:
1) https://github.com/klee/klee
2) Symbolic PathFinder
3) http://research.microsoft.com/Pex/
4) http://angr.io/