DSpot: how developers can amplify existing test cases.

Benjamin DANGLOT

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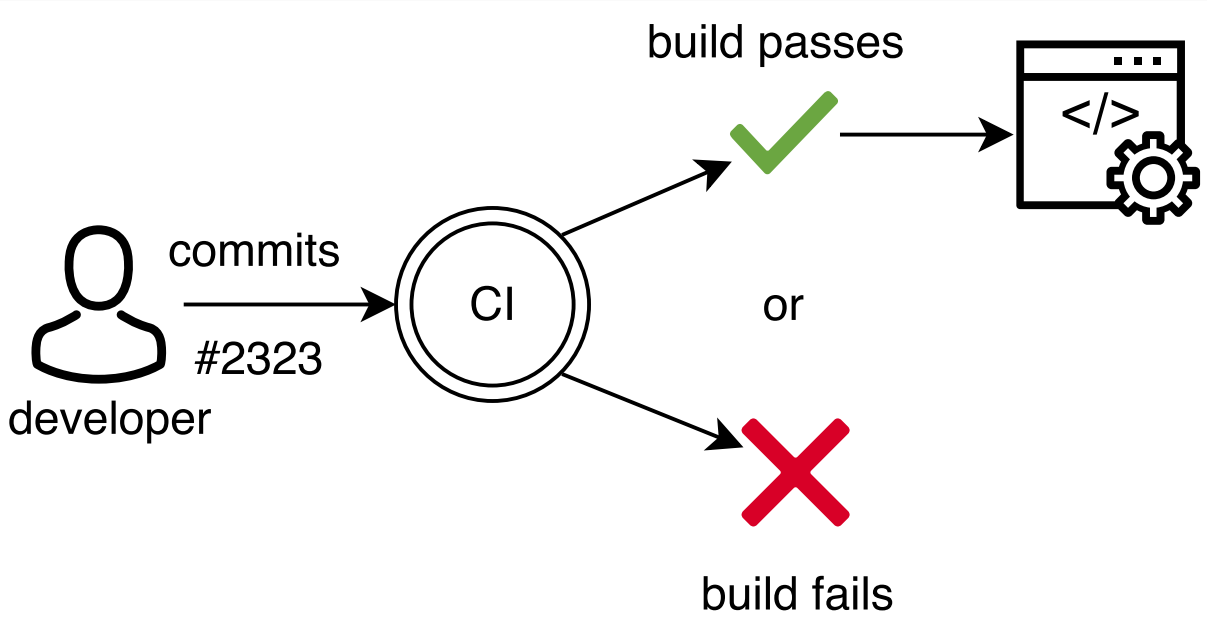
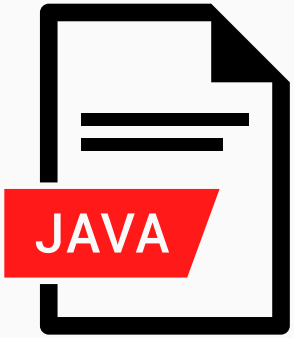
Demo

Use case example



DSpot

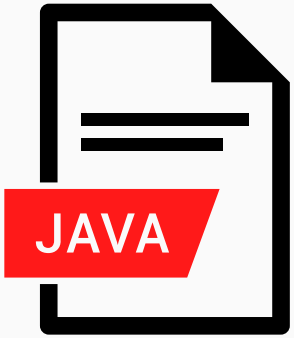
DSpot: Principle



Program

Test suite

DSpot: Principle



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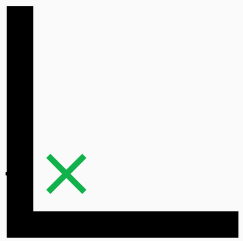
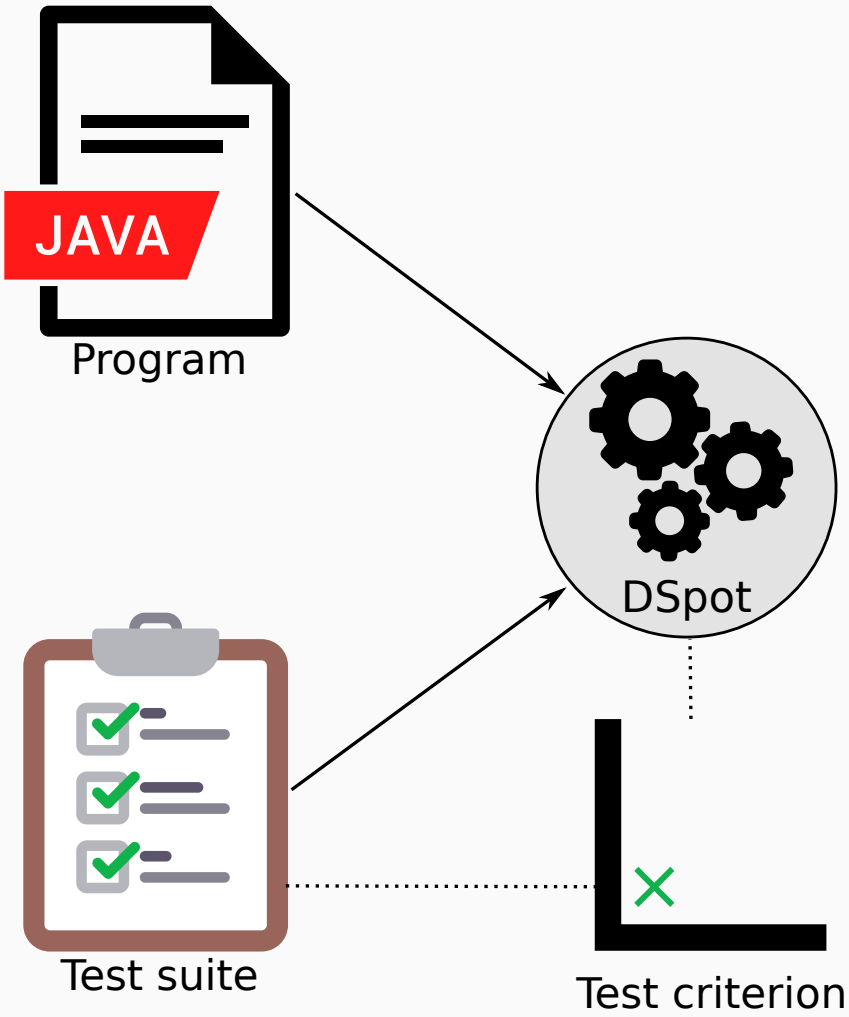
Test suite



Test criterion

DSpot: Principle



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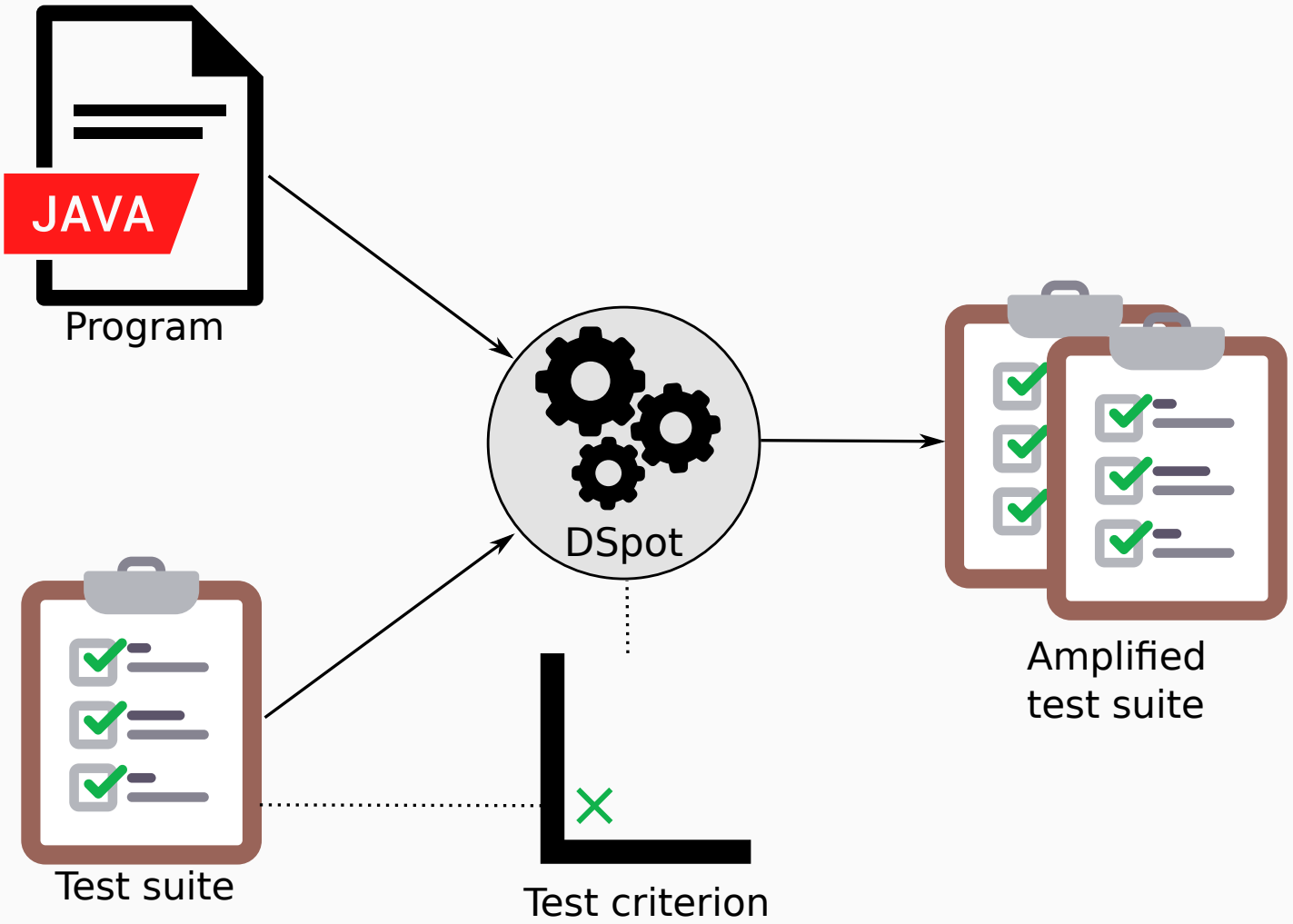

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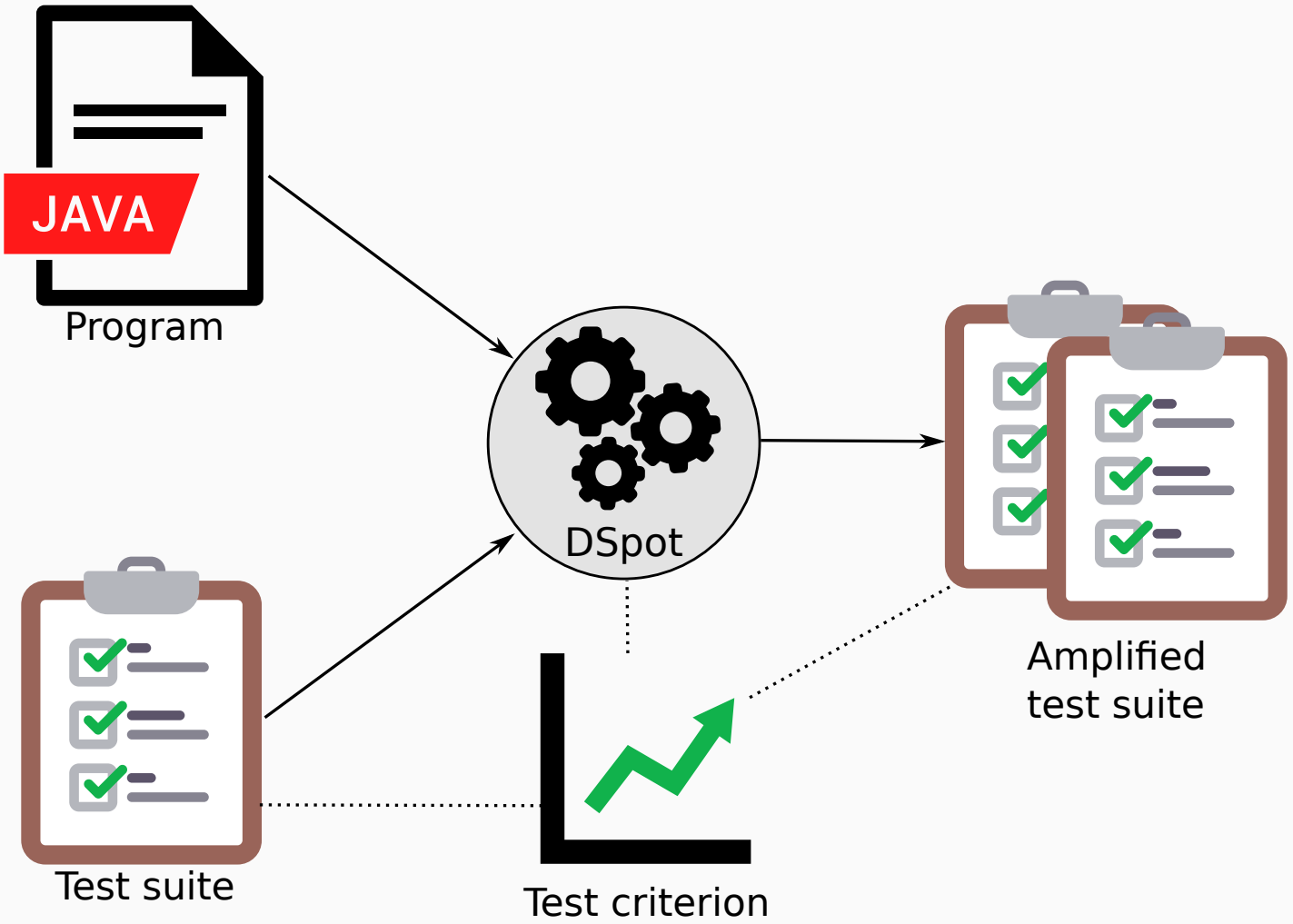

Test Example

```
@Test
public void test() {
    Tacos tacos = new Tacos();
    Benjamin benjamin = new Benjamin();
    benjamin.eat(tacos);
    assertFalse(benjamin.isHungry());
}
```

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In blue, the input of the test

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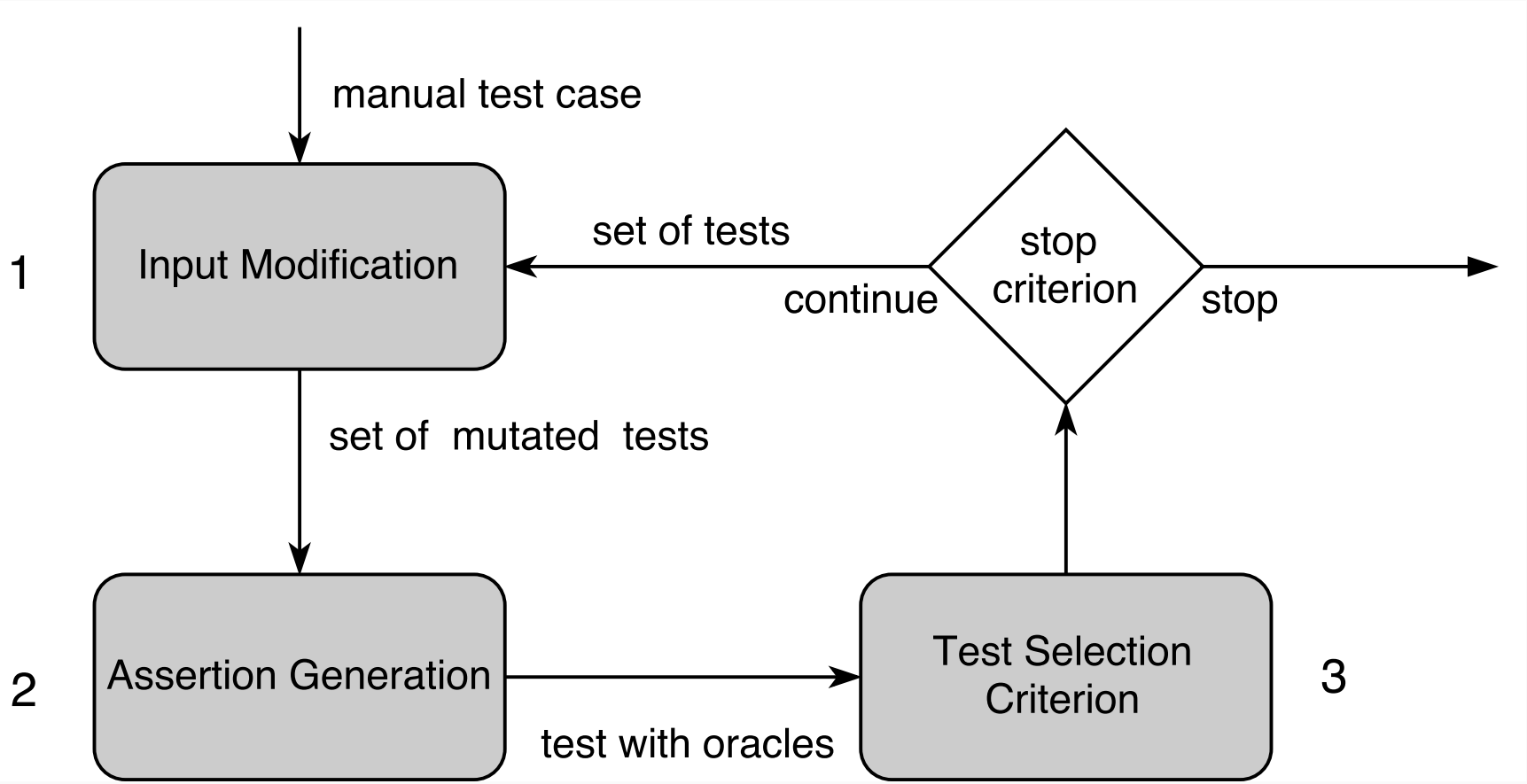
}
```

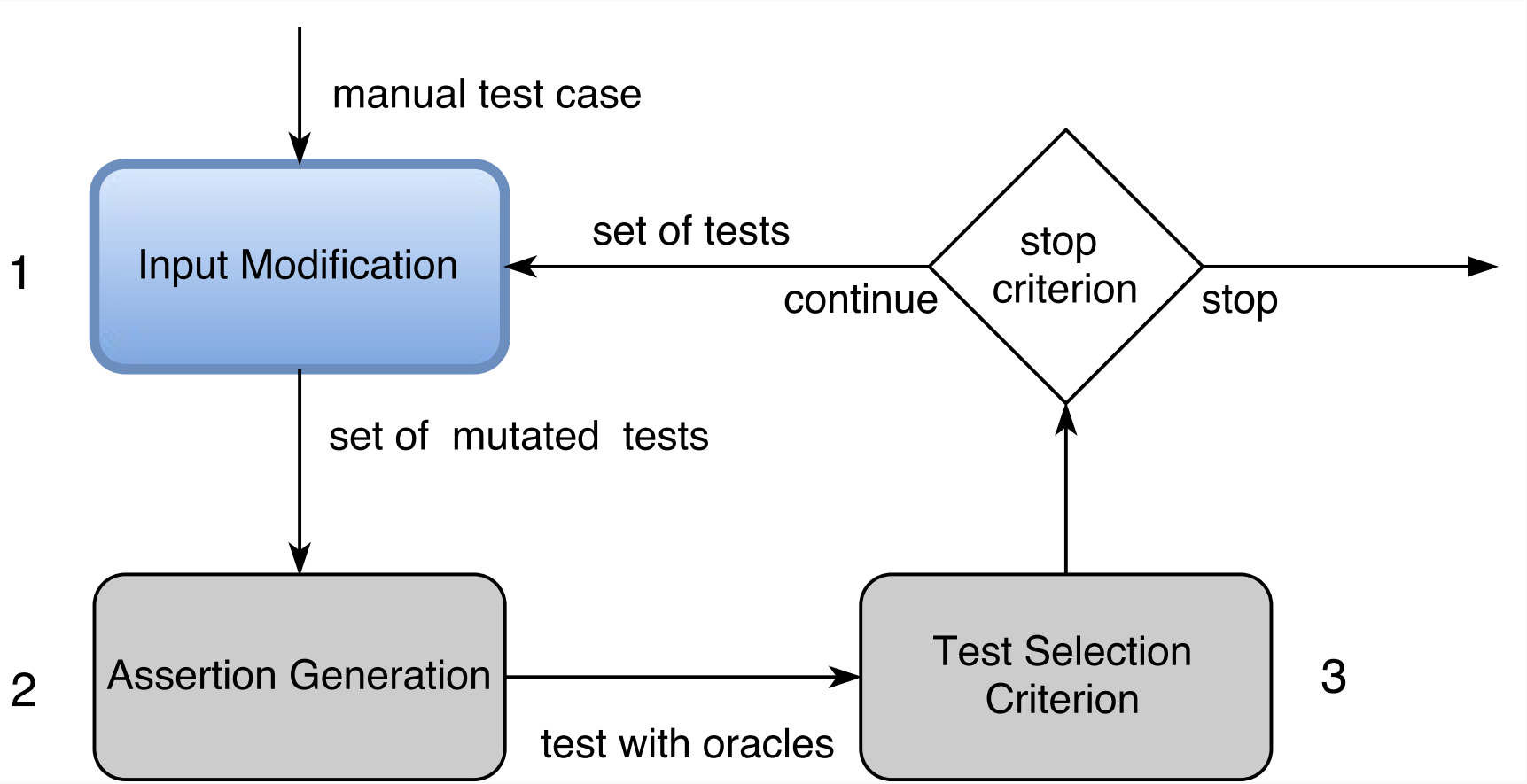
In blue, the input of the test

In green, an oracle of the test to verify the current behavior

How DSpot works?



DSpot: 1. Input Modification



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Modifies the input to create new state of the program

DSpot: 1. Input Modification

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@Test
public void test() {
    Tacos tacos = new Tacos();
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```

Remove method call

Removes a method call to create a new state of the program

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public void test() {
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public void test() {
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    Benjamin benjamin = new Benjamin();

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}
```

Removes a method call to create a new state of the program

Before:

benjamin.isHungry() → *false*

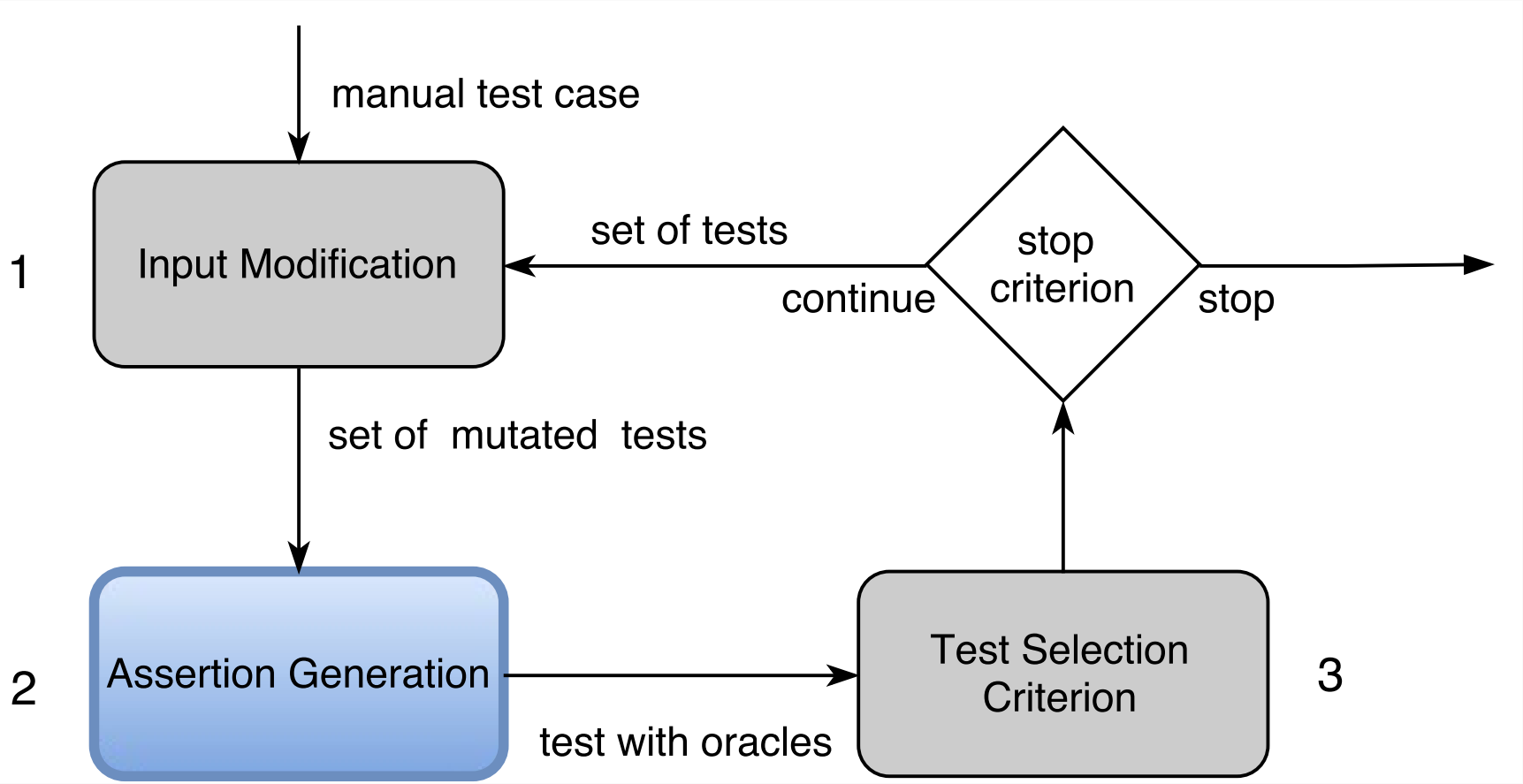
benjamin.isHappy() → *true*

After:

benjamin.isHungry() → *true*

benjamin.isHappy() → *false*

DSpot: 2. Assertion Generation



DSpot: 2. Assertion Generation

1. Remove existing assertions
2. Instrument the test
3. Run Instrumented test to collect values
4. Generate assertions based on values collected

DSpot: 2. Assertion Generation

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@Test
public void test() {
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A. Removes existing assertions

DSpot: 2. Assertion Generation

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public void test() {
    Tacos tacos = new Tacos();
    Benjamin benjamin = new Benjamin();

    benjamin.isHungry();
}
```

assertion removed

A. Removes existing assertions

DSpot: 2. Assertion Generation

```java
@Test
public void test() {
    Tacos tacos = new Tacos();
    Benjamin benjamin = new Benjamin();

    benjamin.isHungry();
}
```

B. Instruments the code to gather new values

DSpot: 2. Assertion Generation

```java
@Test
public void test() {
    Tacos tacos = new Tacos();
    Benjamin benjamin = new Benjamin();

    benjamin.isHungry();
    Log.log(benjamin, id: "benjamin");
}
```

B. Instruments the code to gather new values

DSpot: 2. Assertion Generation

```java
@Test
public void test() {
    Tacos tacos = new Tacos();
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C. Runs the instrumented test and obtains observations

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C. Runs the instrumented test and obtains observations

Observations:

$benjamin.isHungry() \rightarrow true$

$benjamin.isHappy() \rightarrow false$

DSpot: 2. Assertion Generation

```java
@Test
public void test() {
    Tacos tacos = new Tacos();
    Benjamin benjamin = new Benjamin();

    assertTrue(benjamin.isHungry());
    assertFalse(benjamin.isHappy());
}
```

D. Generates new assertions based on observations

Observations:

benjamin.isHungry() → *true*

benjamin.isHappy() → *false*

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public void test() {
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benjamin.isHungry() → *true*

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DSpot: Amplification of Test Results

```java
@Test
public void test() {
    Tacos tacos = new Tacos();
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    benjamin.eat(tacos);
    assertFalse(benjamin.isHungry());
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Original test

```java
@Test
public void test() {
    Tacos tacos = new Tacos();
    Benjamin benjamin = new Benjamin();

    assertTrue(benjamin.isHungry());
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Amplified test

DSpot: Amplification of Test Results

```java
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public void test() {
    Tacos tacos = new Tacos();
    Benjamin benjamin = new Benjamin();
    benjamin.eat(tacos);
    assertFalse(benjamin.isHungry());
}
```

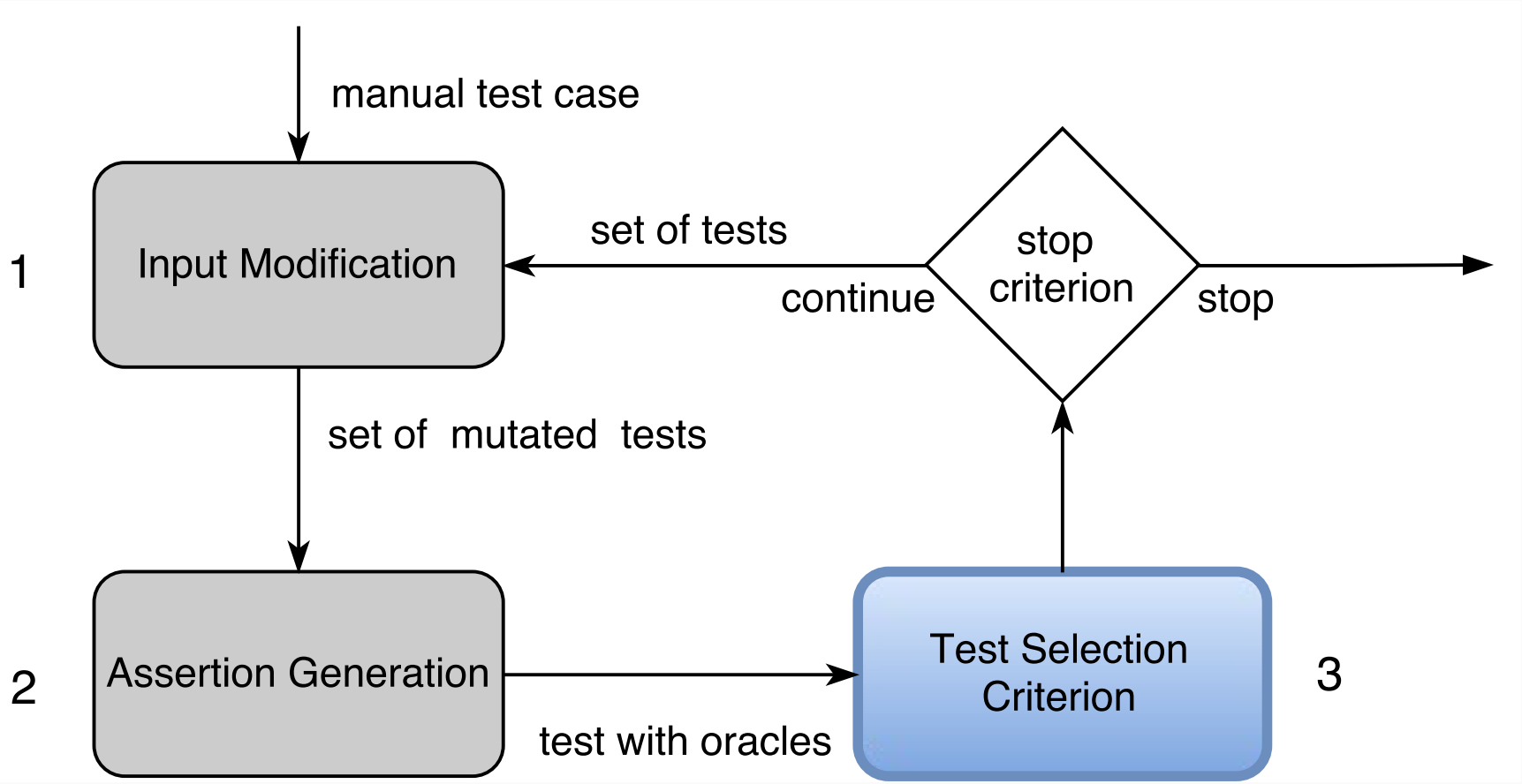
Original test

```java
@Test
public void test() {
    Tacos tacos = new Tacos();
    Benjamin benjamin = new Benjamin();
    →Method call removed
    assertTrue(benjamin.isHungry());
    assertFalse(benjamin.isHappy());
}
```

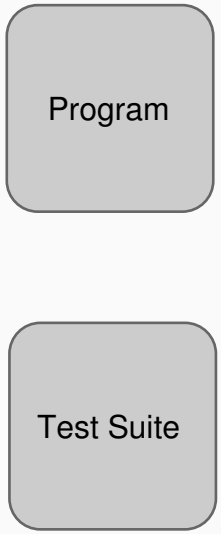
Assertion Generated

Amplified test

DSpot: 3. Test Selection

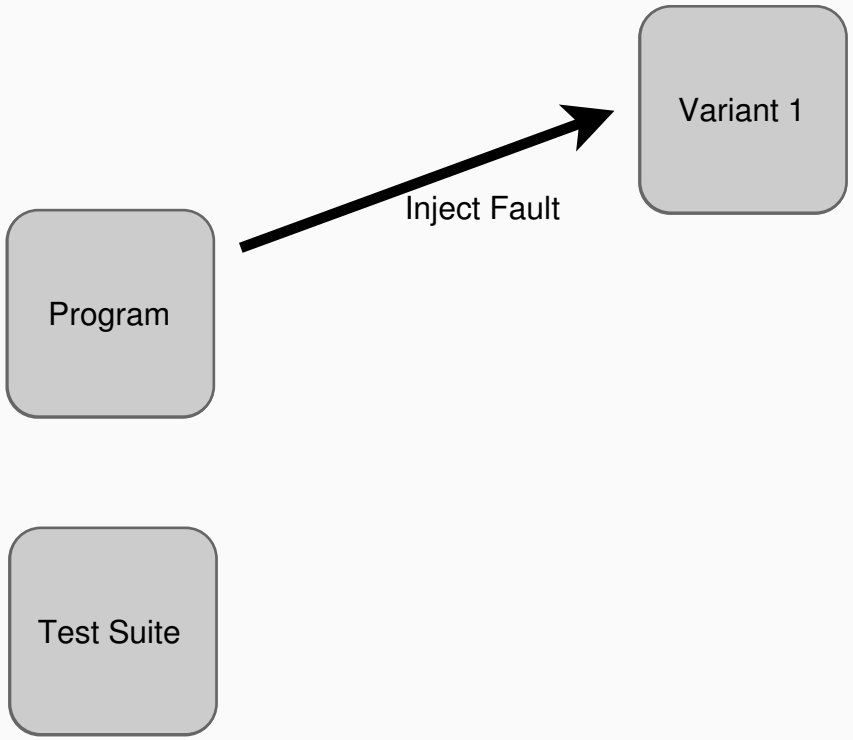


Pre-Requisite: Mutation Analysis



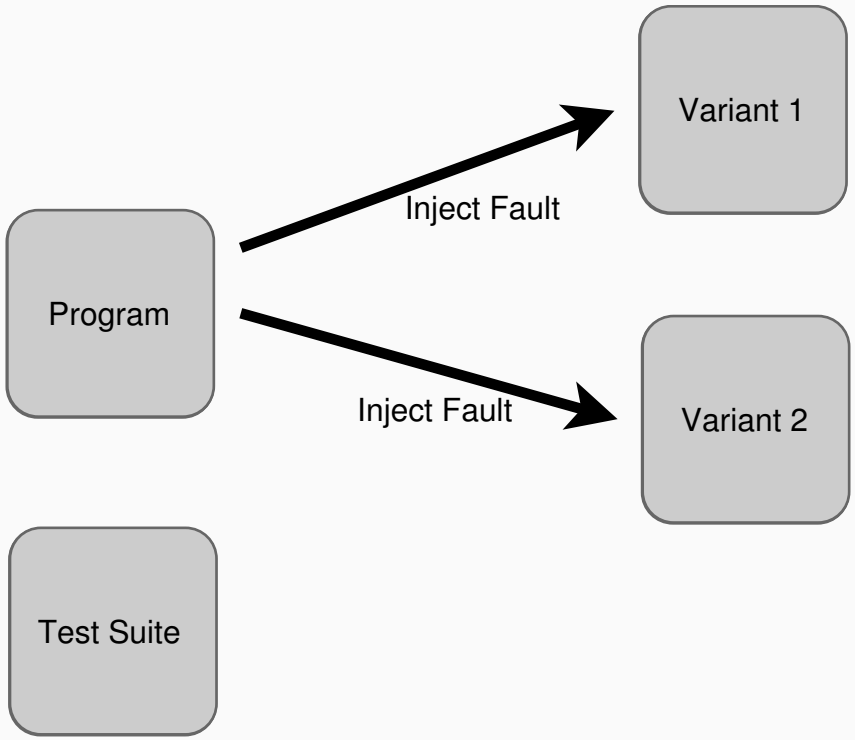
The mutation analysis computes the **mutation score**, a measure of the efficiency of tests

Mutation Analysis



First, creates variants of program by injecting faults

Mutation Analysis



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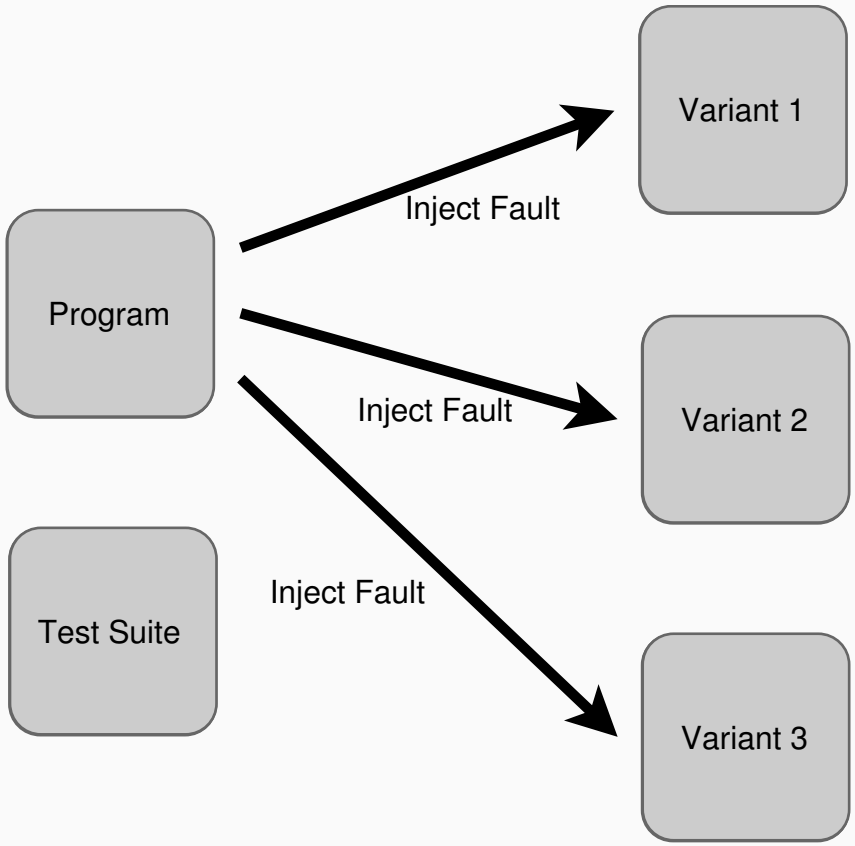

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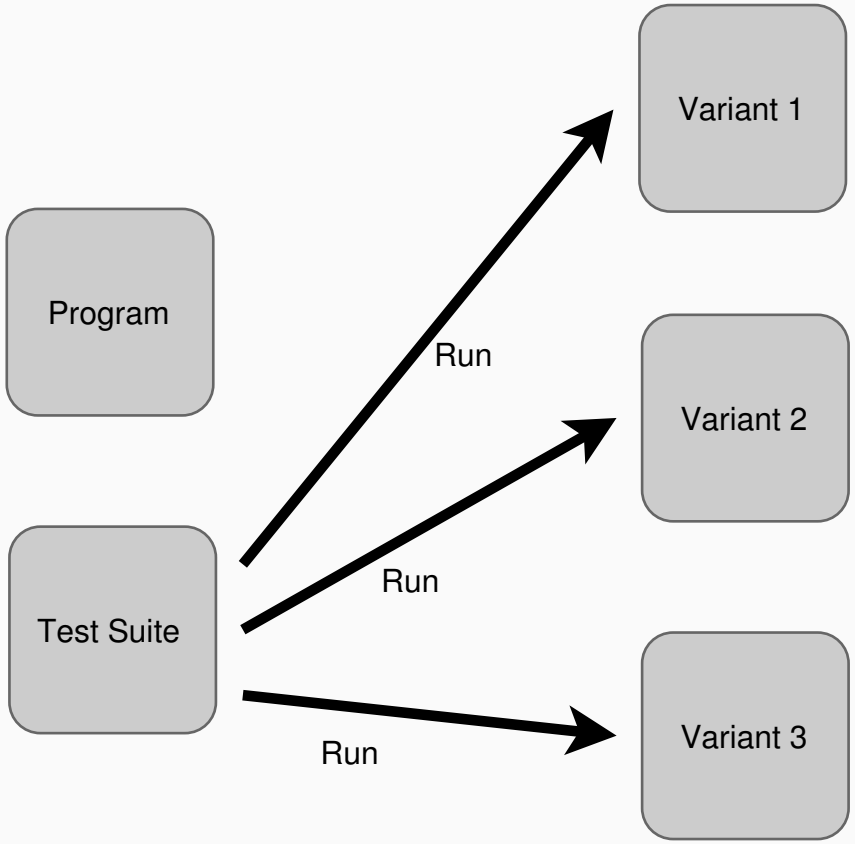
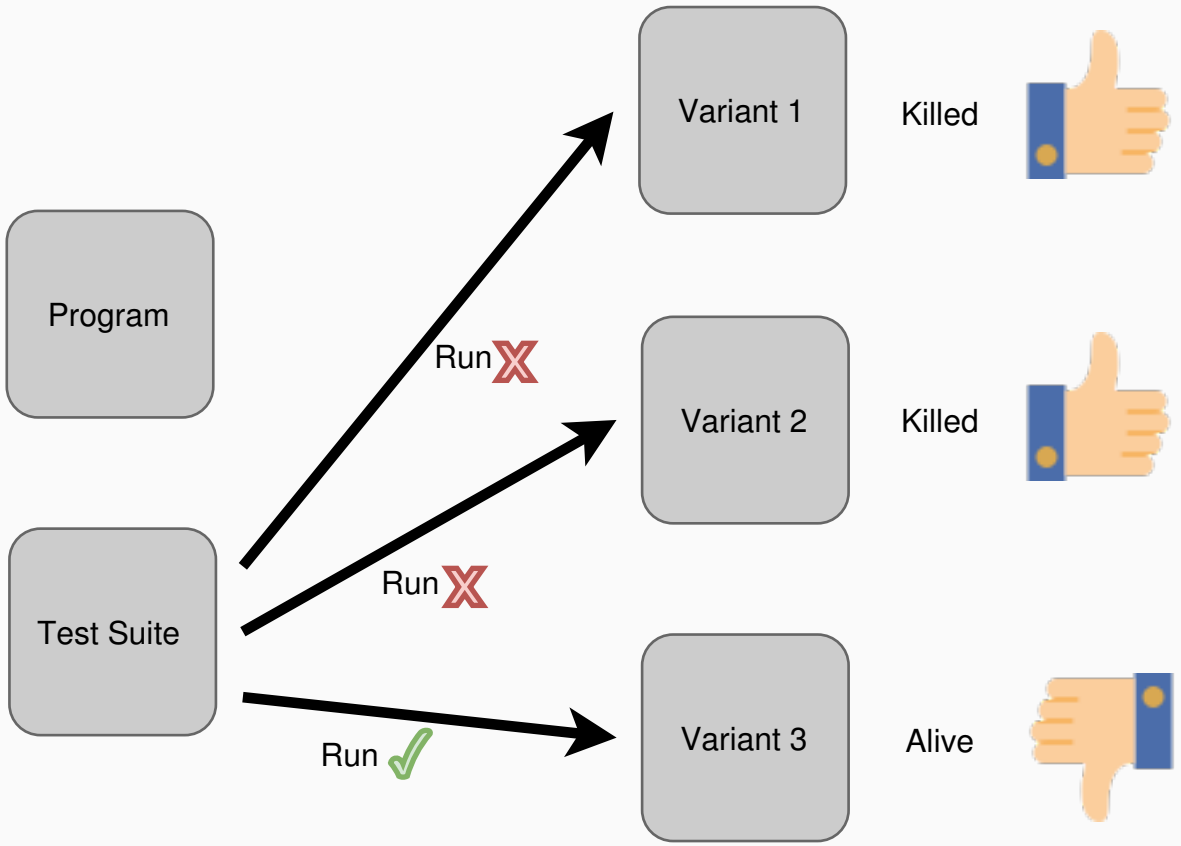


Then, runs tests against each variant

Mutation Analysis

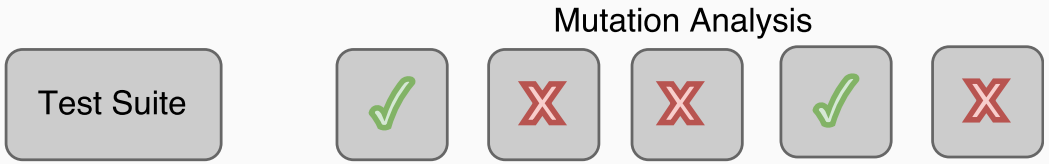


Failing test $\Leftrightarrow$ mutant killed $\Leftrightarrow$ behavior variation detected

Selection Of Test Using Mutation Analysis

✓ test passes <=> mutant remains alive

✗ test fails <=> mutant is killed



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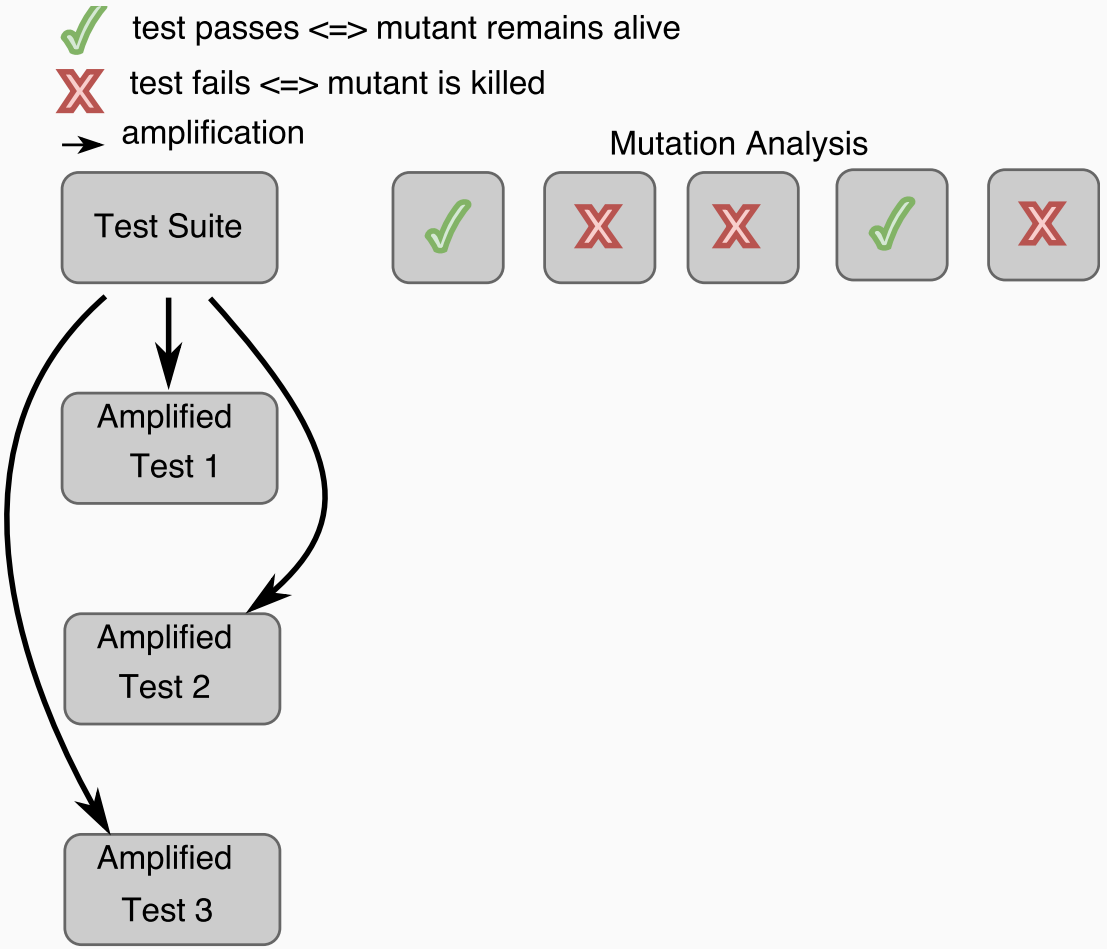

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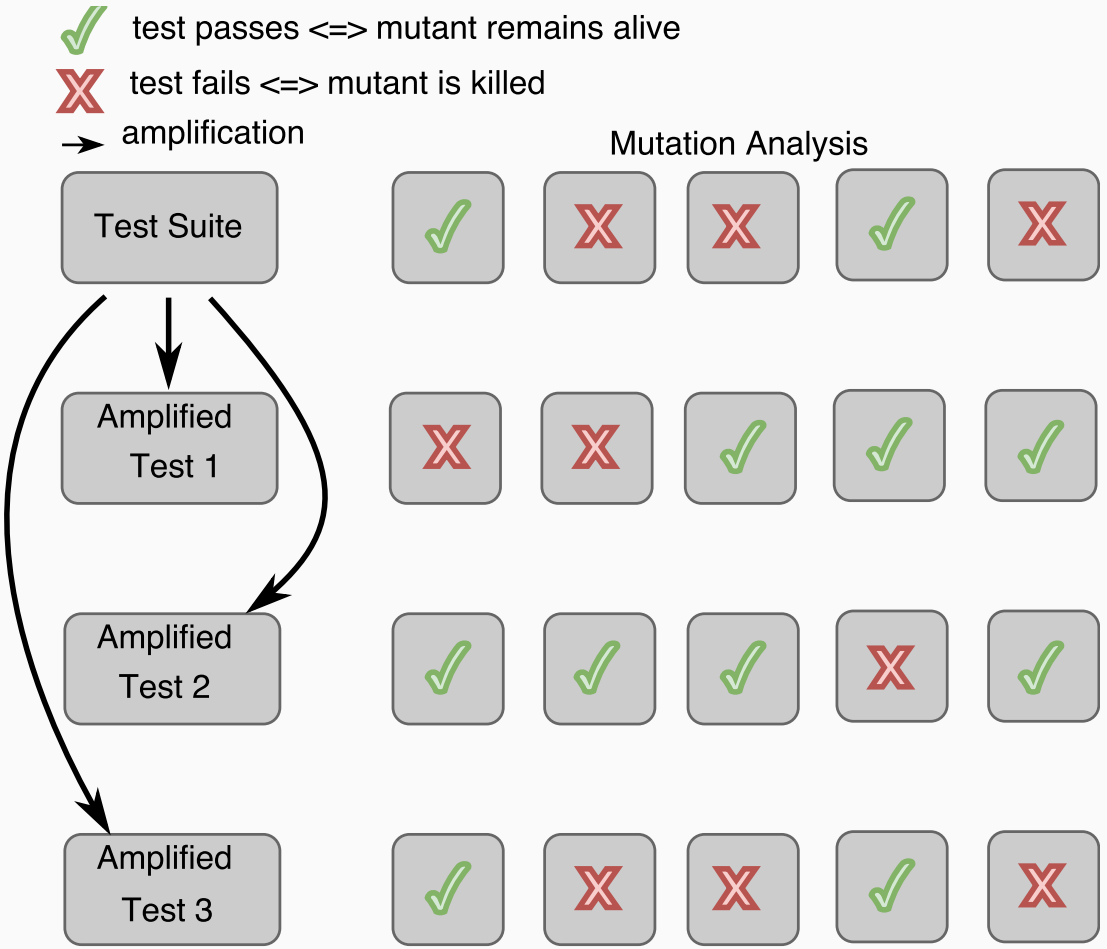

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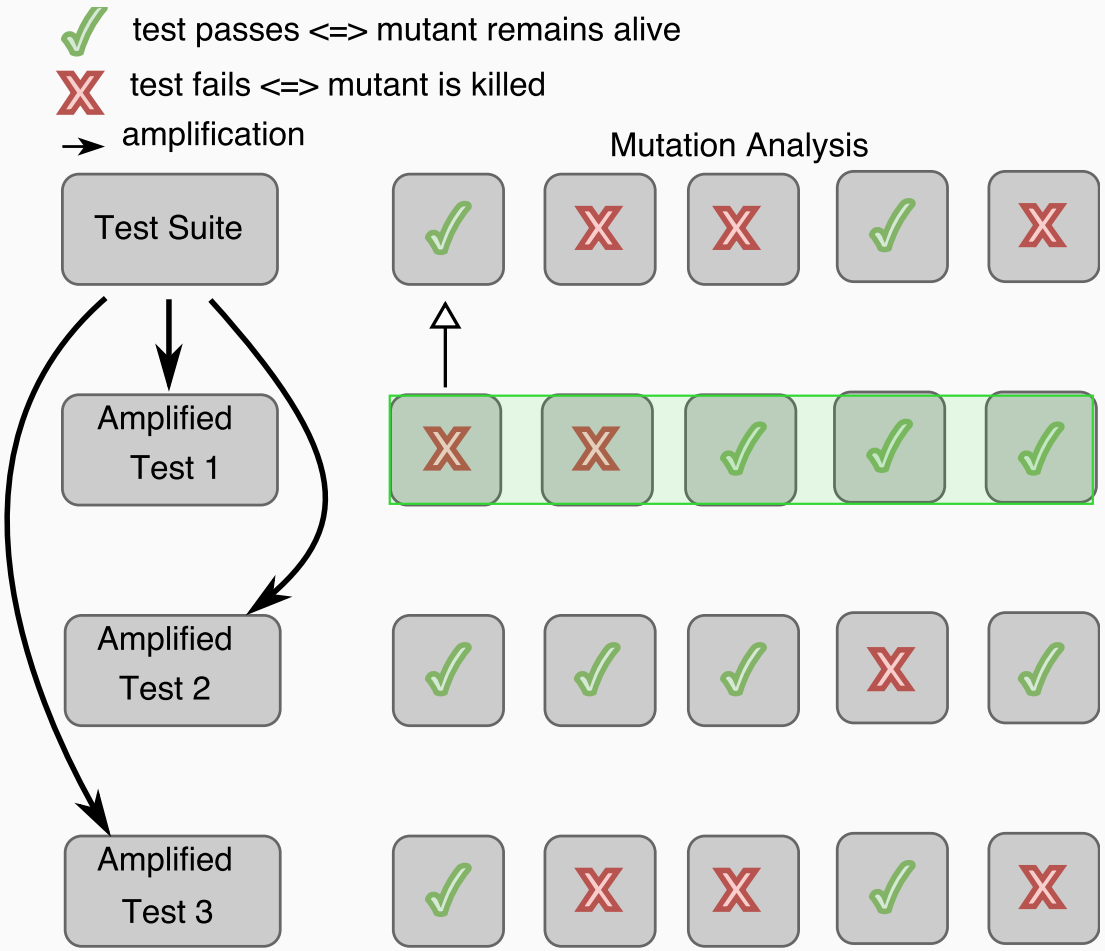
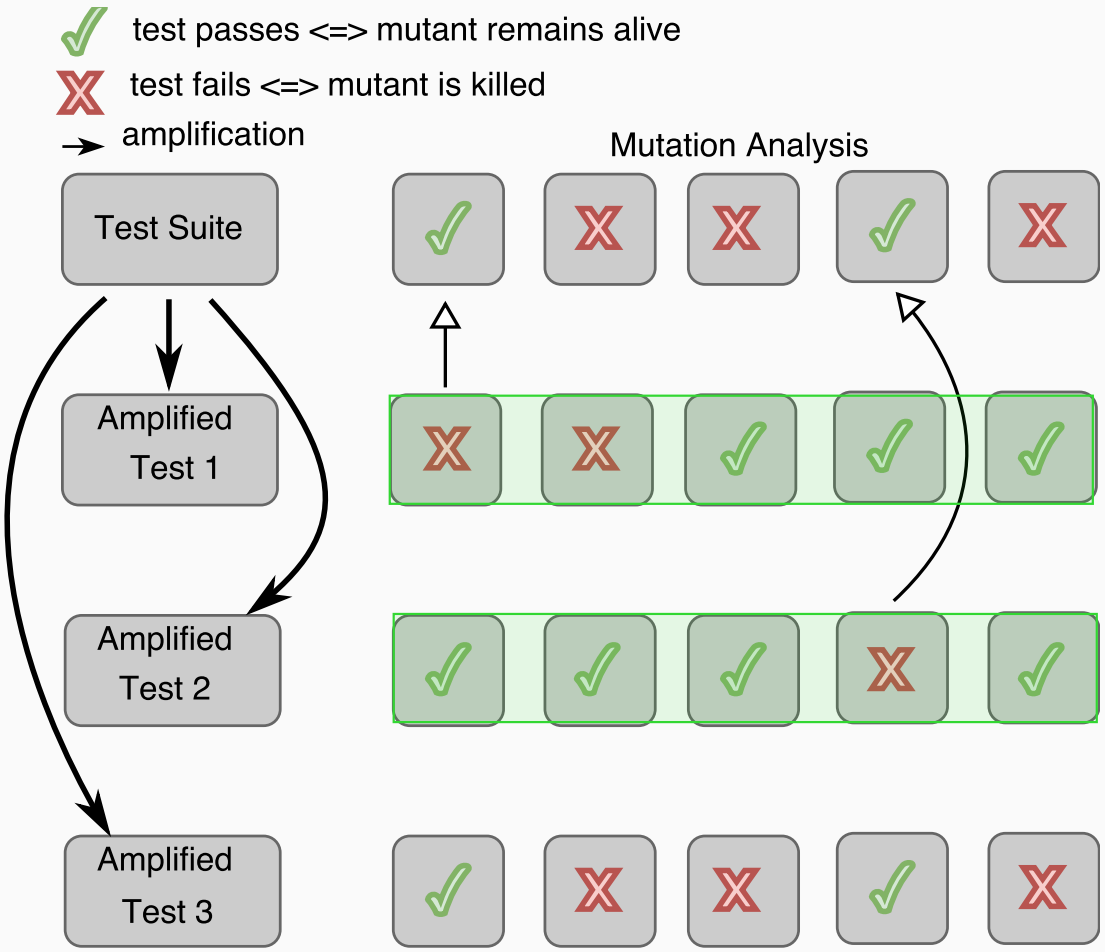


Approach


test passes <=> mutant remains alive
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amplification
Mutation Analysis
Test Suite
Amplified Test 1
Amplified Test 2
Amplified Test 3

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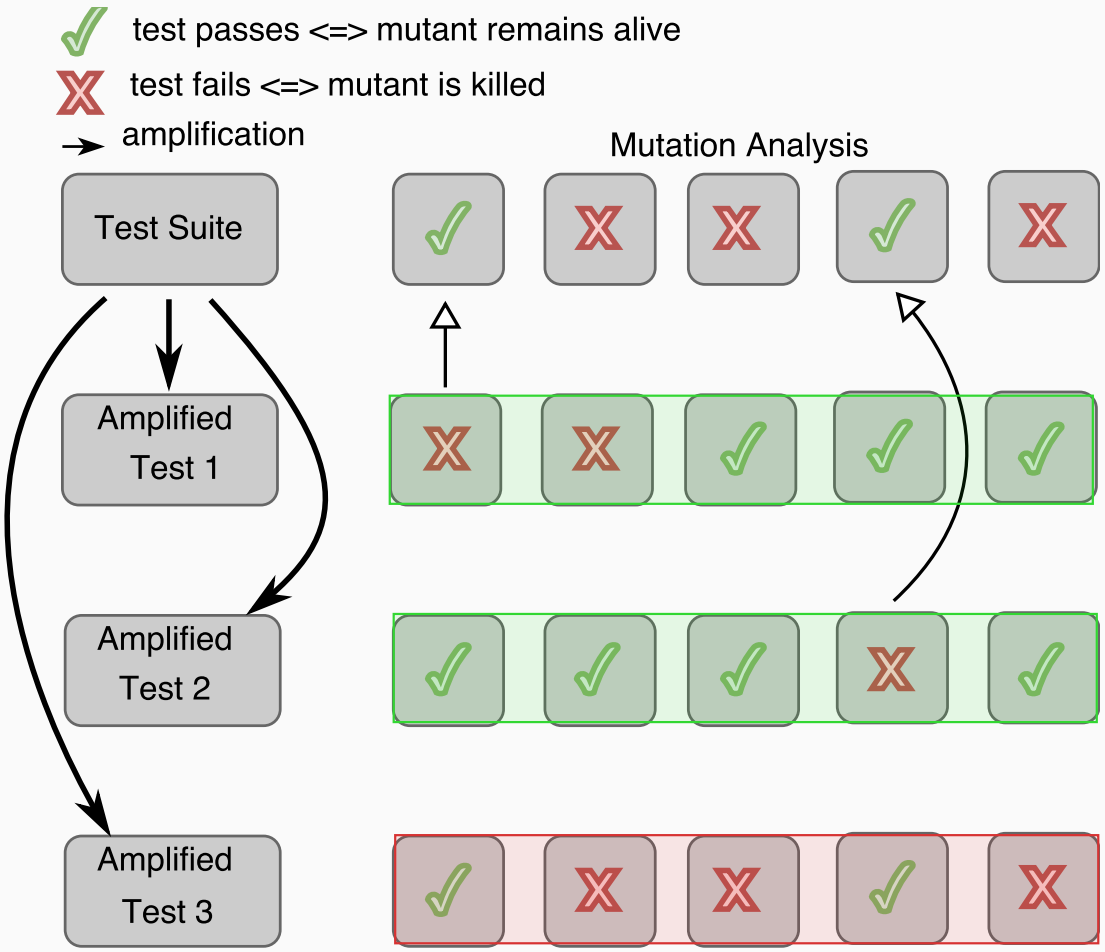

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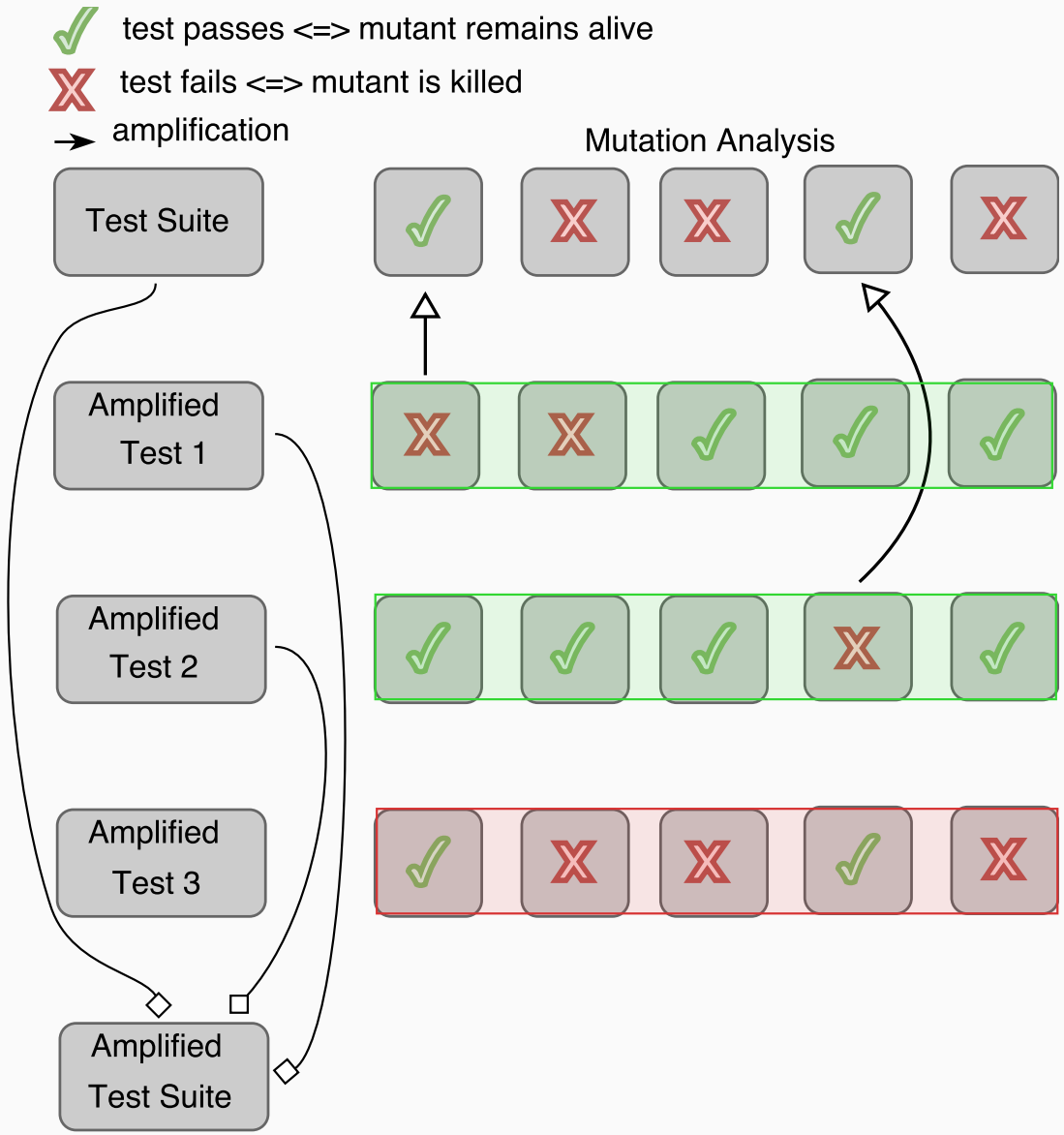

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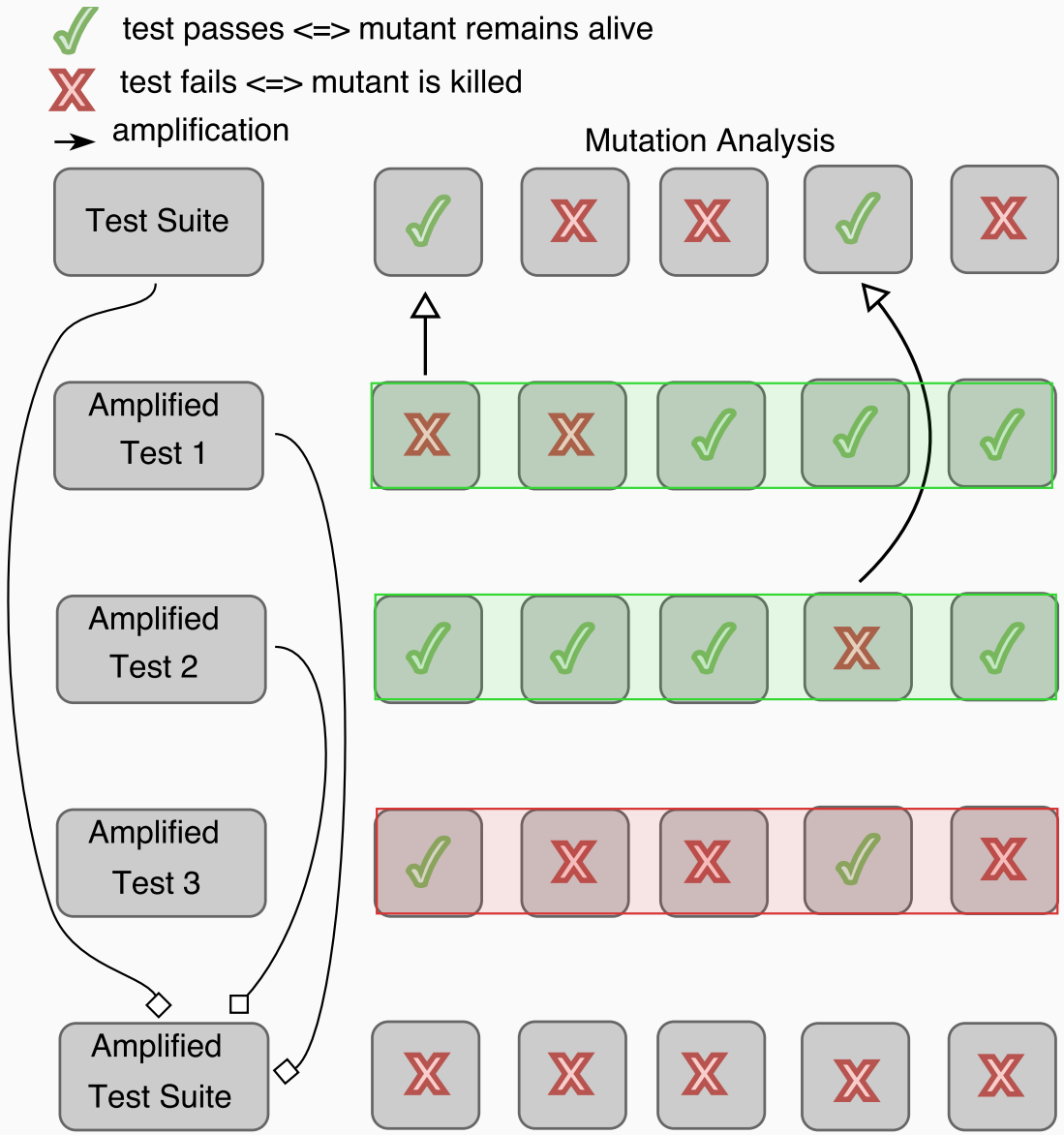
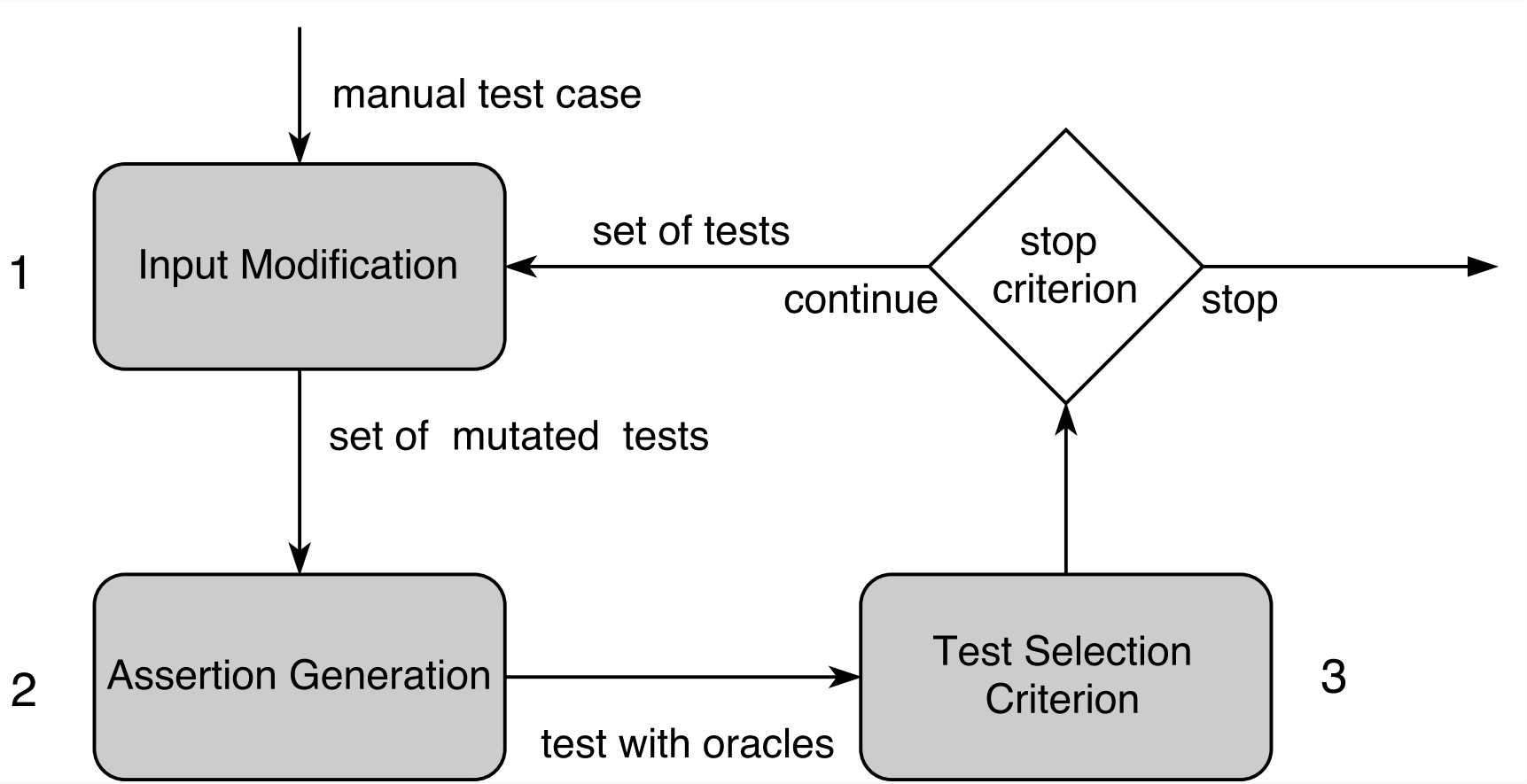


DSpot: iteration



Hands-on!

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- DSpot GitHub repository: `https://github.com/STAMP-project/dspot.git`
- Hands-on GitHub repository: `https://github.com/STAMP-project/dspot-hands-on.git`
- Using maven plugins (no manual downloading required)
- First, amplify a toy-project from STAMP-project repository (dhell)
- Then, amplify your own project!
- Bunch of scripts available on the hands-on repo

Toy-project to play with DSpot

- Clone: `git clone https://github.com/STAMP-project/dhell.git`
- Amplify:

```
mvn eu.stamp-project:dspot-maven:amplify-unit-tests \
    -DtargetOneTestClass \
    -Damplifiers=MethodAdd,MethodRemove \
    -Diteration=1 \
    -Dtest=eu.stamp_project.examples.dhell.HelloAppTest
```

- Output:

```
======= REPORT =======
PitMutantScoreSelector:
The original test suite kills 12 mutants
The amplification results with 1 new tests
it kills 2 more mutants
```

- Look output in `target/dspot/output/`.
- You should find some reports (.txt, .json), and the java file

On your own project

Amplify only assertions:

```
mvn eu.stamp-project:dspot-maven:amplify-unit-tests \
    -DtargetOneTestClass \
    -Dtest=your.TestClass
```

Amplify input: option -Damplifiers=amplifier1,amplifier2

```
mvn eu.stamp-project:dspot-maven:amplify-unit-tests \
    -DtargetOneTestClass \
    -Damplifiers=MethodAdd \
    -Diteration=1 \
    -Dtest=your.TestClass
```

values: MethodAdd, MethodRemove, AllLiteralAmplifiers, MethodGeneratorAmplifier, ReturnValueAmplifier

Backup hands-on

- Compute the original mutation score of class with:

```
mvn clean test -DskipTests \
    eu.stamp-project:pitmp-maven-plugin:descartes \
    -DoutputFormats=XML \
    -DtargetTests=your.TestClass \
    (-DtargetModules=myModule)
```

- Copy: `cp target/pit-reports/AAAAMMDDHHMM/mutations.xml ./mutations.xml`
- Amplify with `mutations.xml`:

```
mvn eu.stamp-project:dspot-maven:amplify-unit-tests \
    -Dpath-pit-result=mutations.xml \
    -Dtest=your.TestClass
```

```
mvn eu.stamp-project:dspot-maven:amplify-unit-tests \
    -Dpath-pit-result=mutations.xml \
    -Damplifiers=MethodAdd \
    -Dtest=your.TestClass
```

- Iterations: `-Diteration=<int>`, 1, 2, 3...
- Amplifiers: `-Damplifiers=<a1,a2,...an>`, MethodAdd, MethodRemove, TestDataMutator, MethodGeneratorAmplifier