Mutation Testing in Java

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https://github.com/wlk/mutation-testing-demo

How do you make sure your tests are any good?

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How do you make sure your tests are any good?

- Code Review
- TDD
- Code coverage
  - What does it really measure?
  - What does it prove?
  - Line/Statement/Branch coverage
  - Tests without assertions

https://github.com/wlk/mutation-testing-demo

Mutation Testing

- Technique to measure quality of tests
- Injects a fault into a system and uses our tests to find it
- Proposed in 1971 by Richard Lipton
- Competent programmer hypothesis
- Few new concepts:
  - Mutants
  - Mutation Operators
  - Generating Mutants
  - Mutation Coverage

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Mutation Testing - problems

- Forgotten for many years (only some academic work)
  - Performance problems
  - Lack of tooling
- Performance problem:
  - Test suite takes 5 minutes to run
  - 500 classes, 10 tests per class, testing each class takes 0.6s
  - Naive: 10 mutants per class gives 10 * 5 * 500 ~ **70 hours**
  - Fast: 10 * 0.6 * 500 = **50 minutes**

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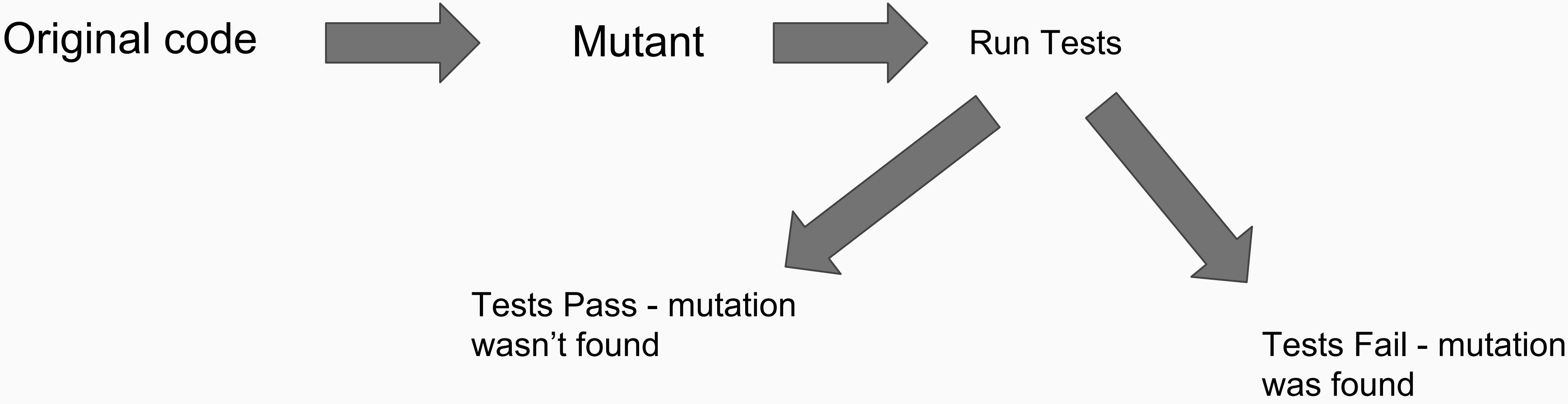
How It Works



Original code

Mutant

Run Tests

Tests Pass - mutation wasn’t found

Tests Fail - mutation was found

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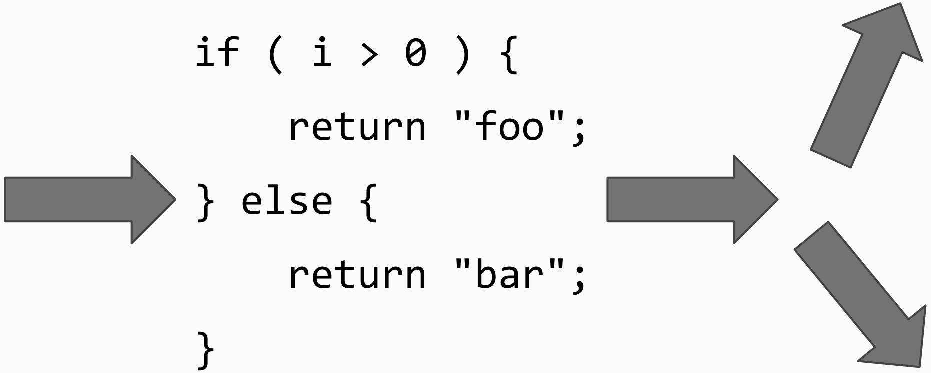
How It Works

Original code

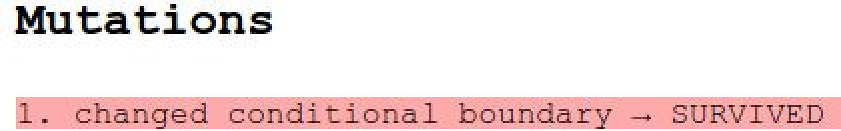
```
if ( i >= 0 ) {
    return "foo";
} else {
    return "bar";
}
```

Mutant

```
if ( i > 0 ) {
    return "foo";
} else {
    return "bar";
}
```



Run Tests

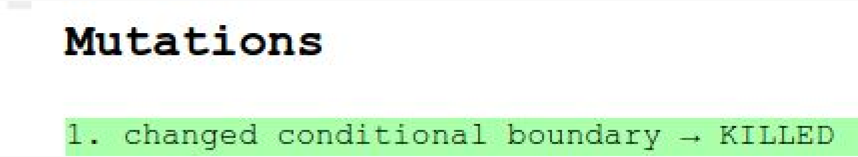


Mutations

1. changed conditional boundary → SURVIVED

Tests Pass - mutation wasn’t found

Tests Fail - mutation was found



Mutations

1. changed conditional boundary → KILLED

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Mutation Operators (Mutators)

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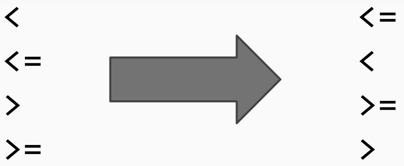
Mutator: Conditionals Boundary Mutator



<	<=
<=	<
>	>=
>=	>

```
if (a < b) {
  // do something
}
```

```
if (a <= b) {
  // do something
}
```

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Mutator: Negate Conditionals Mutator

`==`	`!=`
`!=`	`++`
`<=`	`>`
`>=`	`<`
`<`	`>=`
`>`	`<=`

```
if (a == b) {
  // do something
}
```

```
if (a != b) {
  // do something
}
```

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Mutator: Void Method Call

```
public void someVoidMethod(int i) {
  // does something
}

public int foo() {
  int i = 5;
  doSomething(i);
  return i;
}
```

```
public void someVoidMethod(int i) {
  // does something
}

public int foo() {
  int i = 5;
  // don’t do anything
  return i;
}
```

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Mutator: Constructor Call

```
public Object foo() {
  Object o = new Object();
  return o;
}
```

```
public Object foo() {
  Object o = null;
  return o;
}
```

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Mutators: Many More

- Replace constants
- Replace return values to defaults
- And many others

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Tooling

- PIT - http://pitest.org/
- Ruby: Mutant: https://github.com/mbj/mutant
- Popular in communities where testing (TDD) is already popular

PIT

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PIT Features

- Bytecode modifications (to avoid recompilation)
- Integrates easily with:
  - Java 6, 7, 8
  - JUnit, TestNG
  - Eclipse, Intellij
  - Gradle, Maven, Ant
  - Sonar, Jenkins
  - Mocking frameworks
- For each mutation, it tries to minimize number of tests to run
- Allows to choose which mutators we want to use
- Doesn’t work with Scala
- Doesn’t store mutated code
- Generates simple HTML report, or XML report for other tools

Performance Nowadays:

- Not really a problem on CI server when using modern tools (PIT)
- PIT can analyze only changed code (looking at your SCM)
- Practical tests:
  - Apache `commons-math`:
  - 177k lines of code
  - 109k lines of tests
  - 8 minutes to test
  - PIT takes 1:15h with 4 threads

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Demo

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Problems With Mutation Testing

Mutants can be dangerous:

```
if(false){
  Runtime.getRuntime().exec("rm -rf /");
}
```

Defensive programming:

```
if(i > 0){
  throw new IllegalArgumentException(
    “argument i must be positive”
 );
}
return Math.sqrt(i);
```

Equivalent Mutants:

```
int i = 2;
if ( i >= 1 ) {
    return "foo";
}
// is equivalent to
int i = 2;
if ( i > 1 ) {
    return "foo";
}
```

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Summary

- Mutation testing tests your tests
- Code coverage gives you false sense of security
- PIT is extremely easy to introduce into Java project

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Time for questions

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Thank You!

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