# cs304
# Software Engineering

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陈馨慧
Southern University of Science and Technology

Slides adapted from cs427 (UIUC) and cs304( SUSTech)

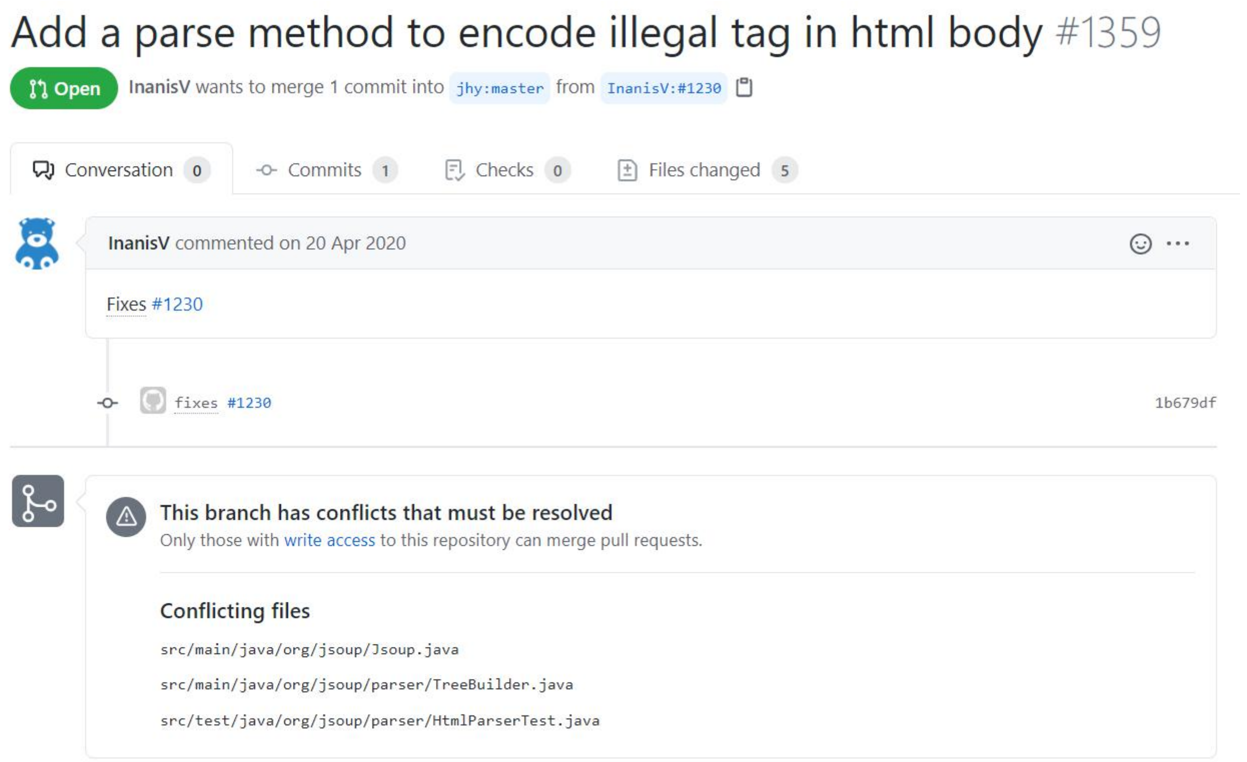
## Administrative Info

- **The deadline for MP0 and Project Proposal has passed**. Late submission get 0 score!
- **Progress Report has been posted due on** April 24
- **All assignments should be written in English**
  - One exception: The selected issues could be written by the developers in Chinese
- **All lab exercise should be submitted before next lab to avoid accumulating too much assignments**
- **Attend lab today for coverage lab!**

## Project

Rules for submitting pull requests

# Project Rules:
# What not to do when making pull request (PR)?



Add a parse method to encode illegal tag in html body #1359

Open InanisV wants to merge 1 commit into jhy:master from InanisV:#1230

InanisV commented on 20 Apr 2020

Fixes #1230

fixes #1230 1b679df

This branch has conflicts that must be resolved

Only those with write access to this repository can merge pull requests.

Conflicting files

```
src/main/java/org/jsoup/Jsoup.java
src/main/java/org/jsoup/parser/TreeBuilder.java
src/test/java/org/jsoup/parser/HtmlParserTest.java
```

- Need to change the code to resolve conflicts so that developers can merge cleanly

## Project Rules:
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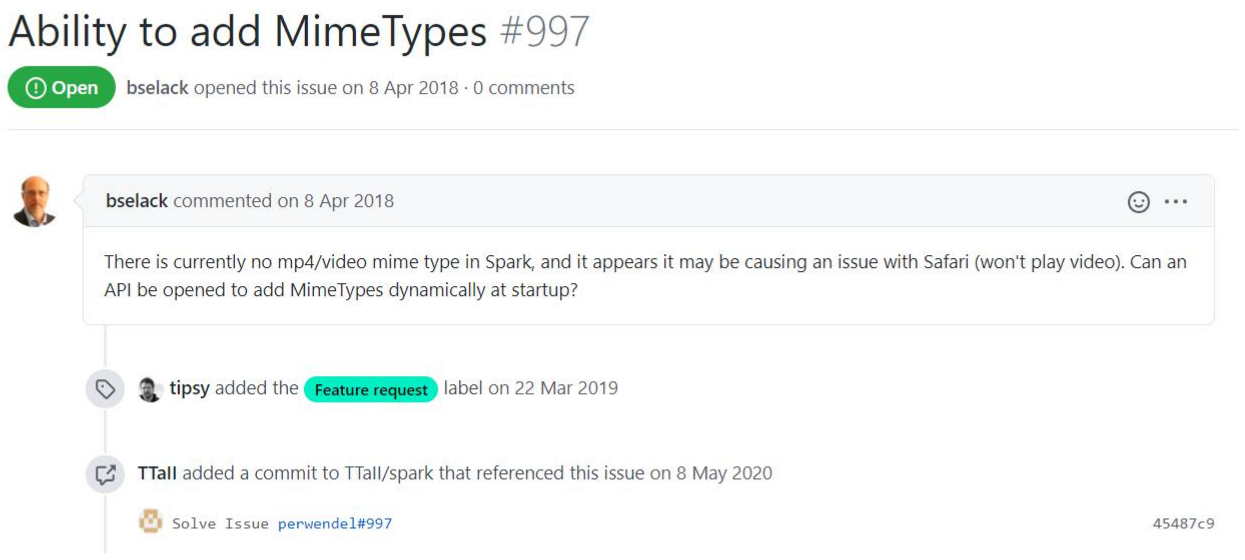

Ability to add MimeTypes #997

Open bselack opened this issue on 8 Apr 2018 · 0 comments

bselack commented on 8 Apr 2018

There is currently no mp4/video mime type in Spark, and it appears it may be causing an issue with Safari (won't play video). Can an API be opened to add MimeTypes dynamically at startup?

tipsy added the Feature request label on 22 Mar 2019

TTall added a commit to TTall/spark that referenced this issue on 8 May 2020

```
Solve Issue perwendel#997                                                    45487c9
```

- ➢No communication with the user and developer. Only fixing the way you like

## Project Rules:
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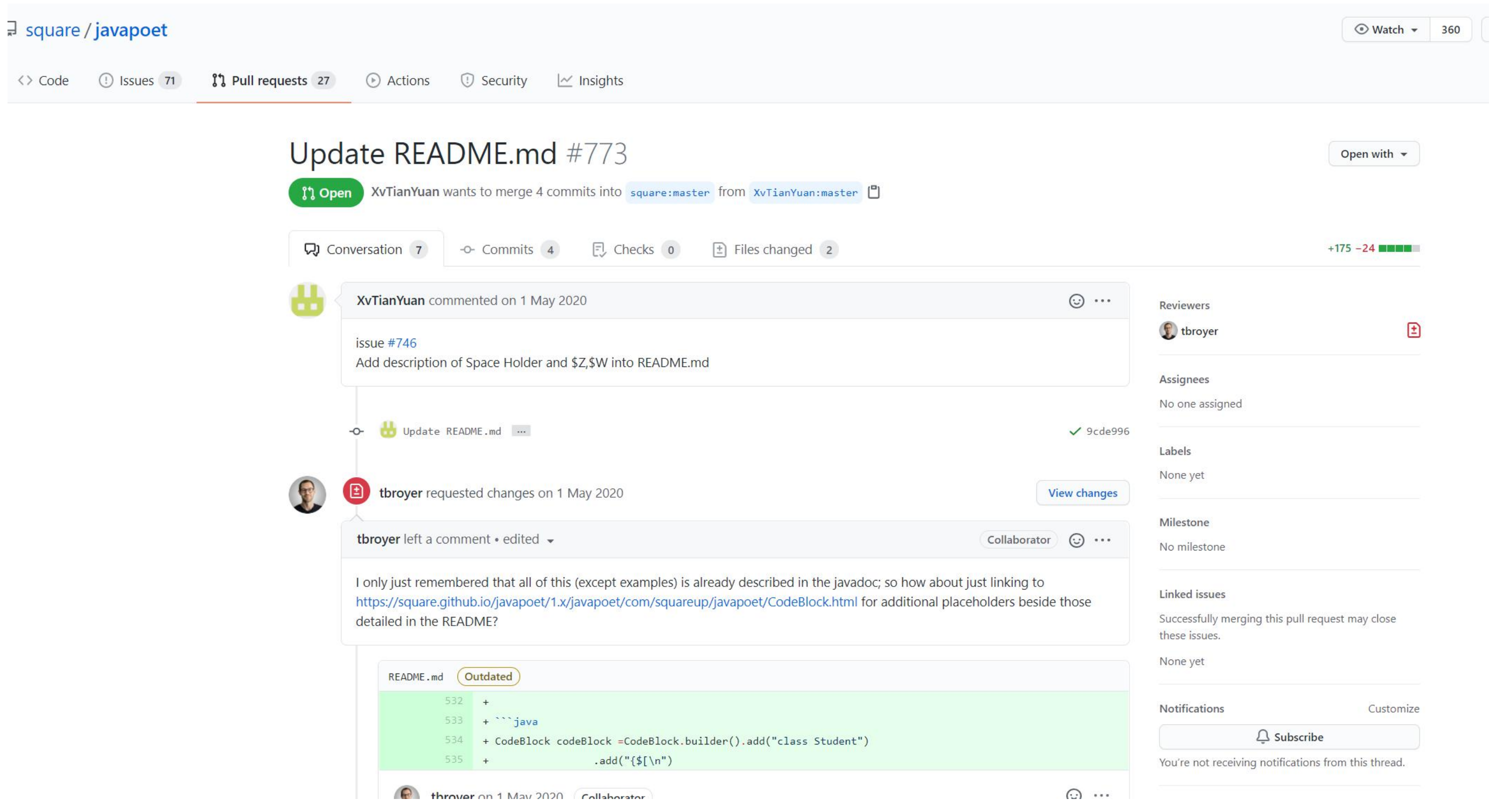


square / javapoet

Watch 360

Code | Issues 71 | Pull requests 27 | Actions | Security | Insights

Update README.md #773

Open with

Open — XvTianYuan wants to merge 4 commits into `square:master` from `XvTianYuan:master`

Conversation 7 | Commits 4 | Checks 0 | Files changed 2 — +175 −24

**XvTianYuan** commented on 1 May 2020

issue #746
Add description of Space Holder and $Z,$W into README.md

`Update README.md` … ✓ 9cde996

**tbroyer** requested changes on 1 May 2020 — View changes

**tbroyer** left a comment • edited — Collaborator

I only just remembered that all of this (except examples) is already described in the javadoc; so how about just linking to https://square.github.io/javapoet/1.x/javapoet/com/squareup/javapoet/CodeBlock.html for additional placeholders beside those detailed in the README?

README.md — Outdated

```
+
+ ```java
+ CodeBlock codeBlock =CodeBlock.builder().add("class Student")
+                 .add("{$[\n")
```

**Reviewers:** tbroyer

**Assignees:** No one assigned

**Labels:** None yet

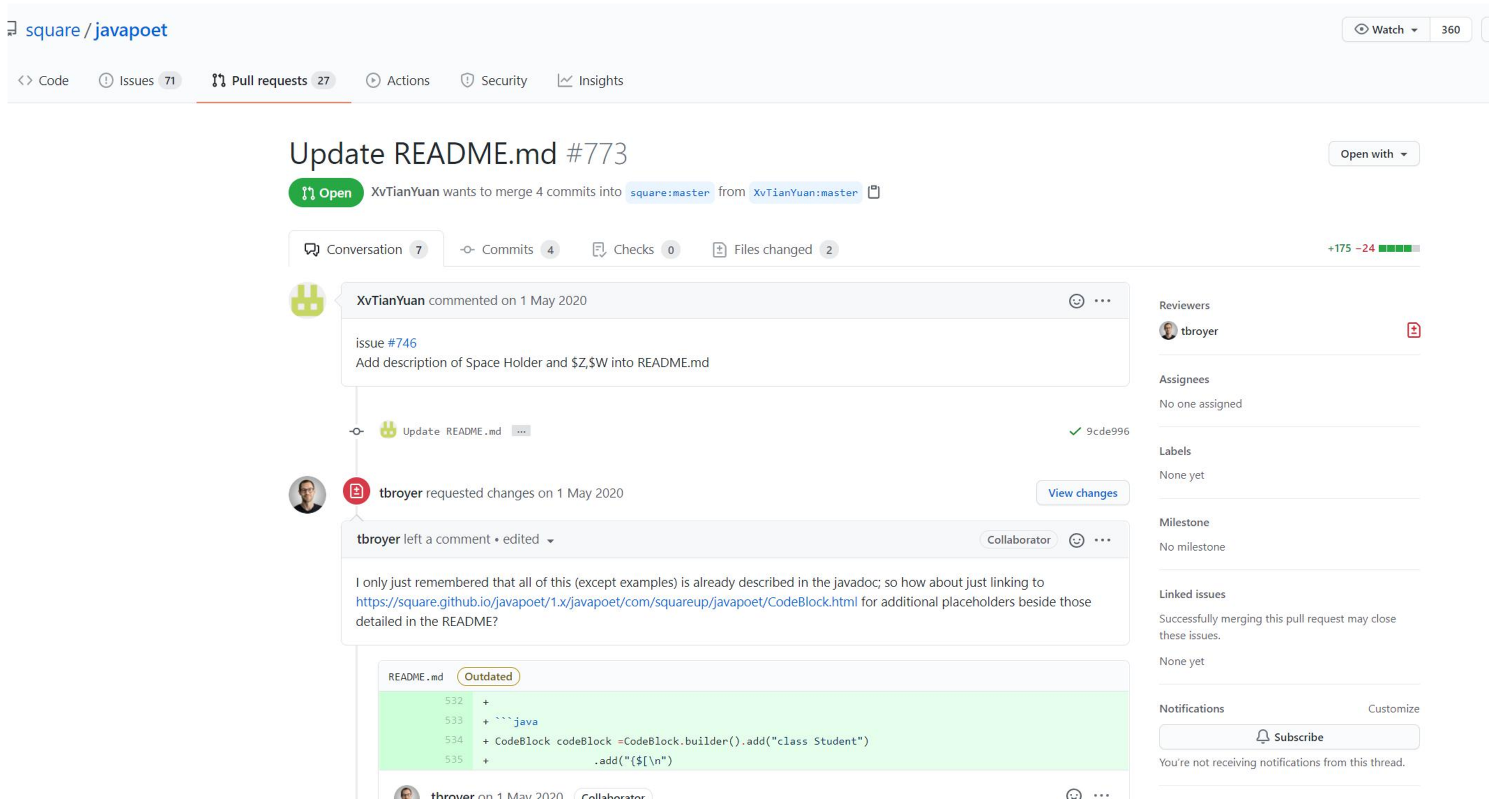
**Milestone:** No milestone

**Linked issues:** Successfully merging this pull request may close these issues. None yet

**Notifications** — Customize — Subscribe — You're not receiving notifications from this thread.

➢Do not choose documentation related issue.

## Project Rules:
## What not to do when making pull request (PR)?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README.md Outdated

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+ ```java
+ CodeBlock codeBlock =CodeBlock.builder().add("class Student")
+                 .add("{$[\n")
```

tbroyer on 1 May 2020 Collaborator

Reviewers: tbroyer

Assignees: No one assigned

Labels: None yet

Milestone: No milestone

Linked issues: Successfully merging this pull request may close these issues. None yet

Notifications: Customize · Subscribe · You're not receiving notifications from this thread.

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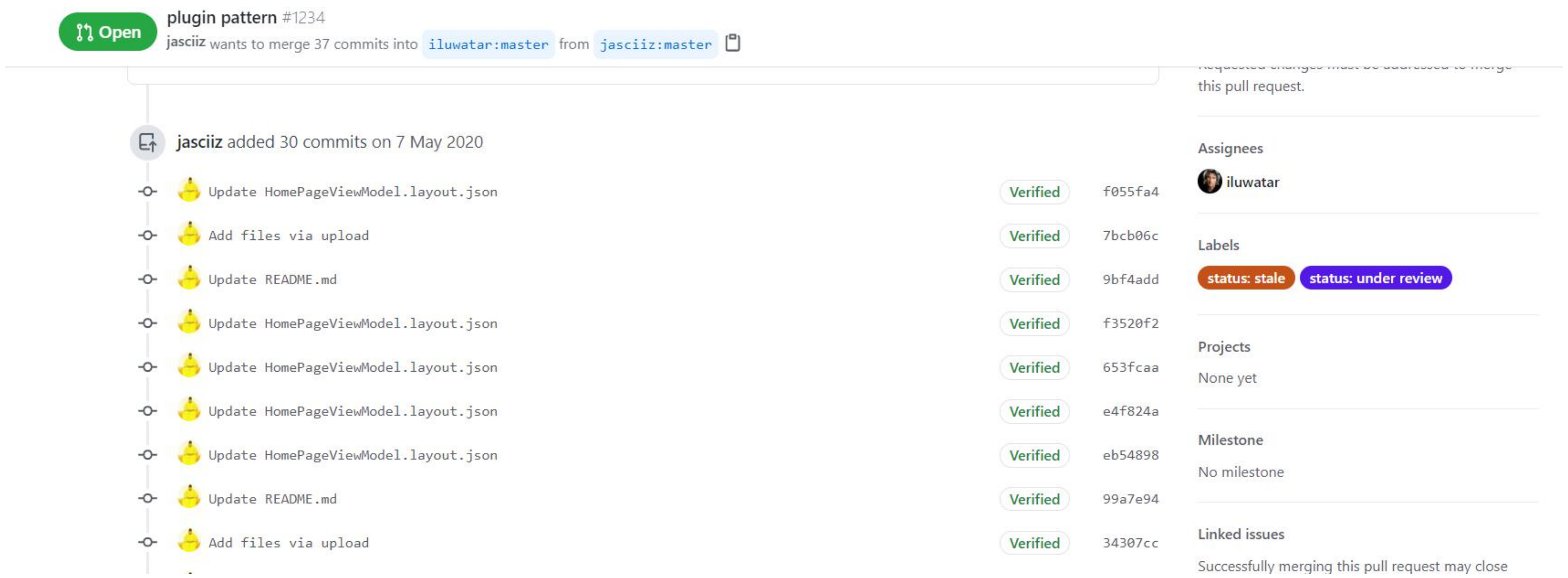


Open plugin pattern #1234
jasciiz wants to merge 37 commits into iluwatar:master from jasciiz:master

jasciiz added 30 commits on 7 May 2020

| | | |
|---|---|---|
| Update HomePageViewModel.layout.json | Verified | f055fa4 |
| Add files via upload | Verified | 7bcb06c |
| Update README.md | Verified | 9bf4add |
| Update HomePageViewModel.layout.json | Verified | f3520f2 |
| Update HomePageViewModel.layout.json | Verified | 653fcaa |
| Update HomePageViewModel.layout.json | Verified | e4f824a |
| Update HomePageViewModel.layout.json | Verified | eb54898 |
| Update README.md | Verified | 99a7e94 |
| Add files via upload | Verified | 34307cc |

this pull request.

Assignees
iluwatar

Labels
status: stale status: under review

Projects
None yet

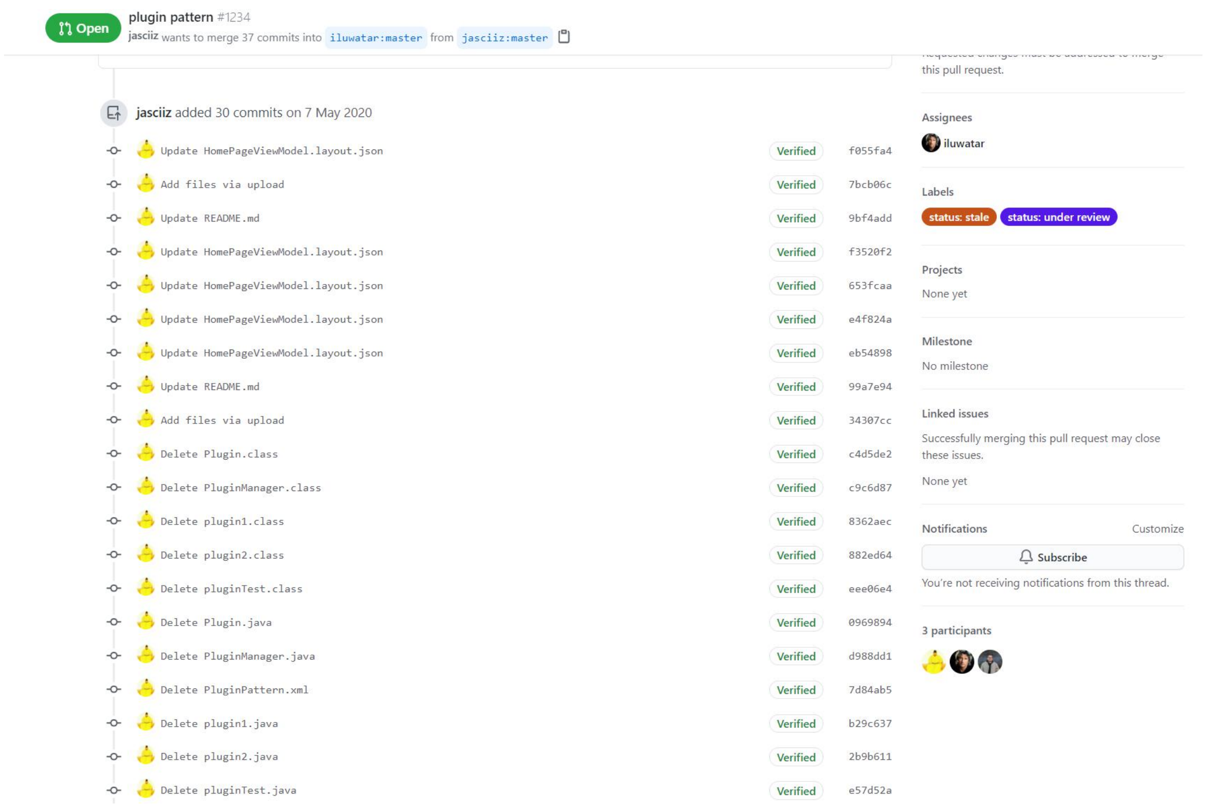
Milestone
No milestone

Linked issues
Successfully merging this pull request may close

- Do not adding too many commits to your PR. You PR should be short
- Make minimal changes to current code. A PR that change less lines will be more likely to be accepted!

Example from: https://github.com/iluwatar/java-design-patterns/pull/1234

## Project Rules:
## What not to do when making pull request (PR)?



Open **plugin pattern** #1234
jasciiz wants to merge 37 commits into `iluwatar:master` from `jasciiz:master`

**jasciiz** added 30 commits on 7 May 2020

| | | |
|---|---|---|
| Update HomePageViewModel.layout.json | Verified | f055fa4 |
| Add files via upload | Verified | 7bcb06c |
| Update README.md | Verified | 9bf4add |
| Update HomePageViewModel.layout.json | Verified | f3520f2 |
| Update HomePageViewModel.layout.json | Verified | 653fcaa |
| Update HomePageViewModel.layout.json | Verified | e4f824a |
| Update HomePageViewModel.layout.json | Verified | eb54898 |
| Update README.md | Verified | 99a7e94 |
| Add files via upload | Verified | 34307cc |
| Delete Plugin.class | Verified | c4d5de2 |
| Delete PluginManager.class | Verified | c9c6d87 |
| Delete plugin1.class | Verified | 8362aec |
| Delete plugin2.class | Verified | 882ed64 |
| Delete pluginTest.class | Verified | eee06e4 |
| Delete Plugin.java | Verified | 0969894 |
| Delete PluginManager.java | Verified | d988dd1 |
| Delete PluginPattern.xml | Verified | 7d84ab5 |
| Delete plugin1.java | Verified | b29c637 |
| Delete plugin2.java | Verified | 2b9b611 |
| Delete pluginTest.java | Verified | e57d52a |

Requested changes must be addressed to merge this pull request.

**Assignees**
iluwatar

**Labels**
status: stale · status: under review

**Projects**
None yet

**Milestone**
No milestone

**Linked issues**
Successfully merging this pull request may close these issues.
None yet

**Notifications** Customize
Subscribe
You're not receiving notifications from this thread.

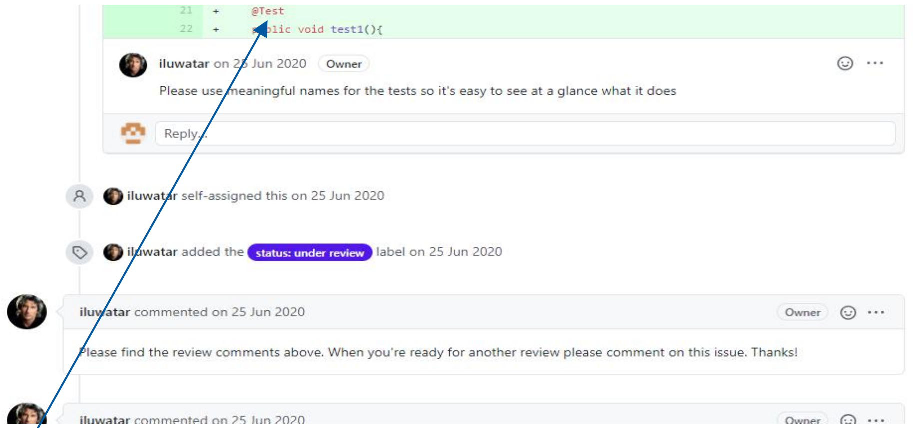
**3 participants**

- Do not adding too many commits to your PR. You PR should be short

From: https://github.com/iluwatar/java-design-patterns/pull/1234

# Project Rules: What not to do when making pull request (PR)?

- **Hit-and-run PR**: Commits and run away without responding. This is very bad practice because:
  - Waste time of developer in code review
  - Developers need to correct your mistake because you didn't even check if you are implementing the correct issue
  - Developer mention you several times but do not respond. Leave a bad reputation in GitHub



```
21  +      @Test
22  +      public void test1(){
```

iluwatar on 25 Jun 2020 Owner

Please use meaningful names for the tests so it's easy to see at a glance what it does

Reply...

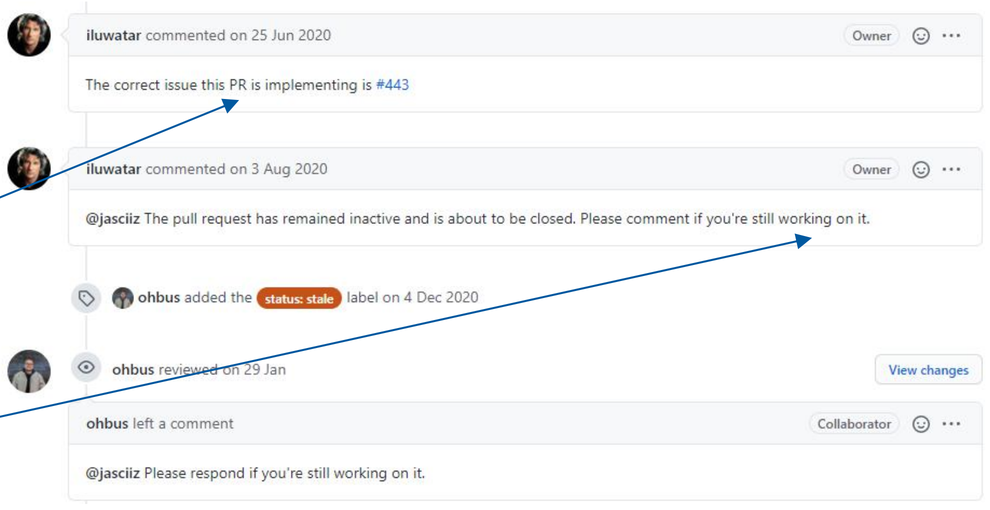
iluwatar self-assigned this on 25 Jun 2020

iluwatar added the status: under review label on 25 Jun 2020

iluwatar commented on 25 Jun 2020 Owner

Please find the review comments above. When you're ready for another review please comment on this issue. Thanks!

iluwatar commented on 25 Jun 2020 Owner



iluwatar commented on 25 Jun 2020 Owner

The correct issue this PR is implementing is #443

iluwatar commented on 3 Aug 2020 Owner

@jasciiz The pull request has remained inactive and is about to be closed. Please comment if you're still working on it.

ohbus added the status: stale label on 4 Dec 2020

ohbus reviewed on 29 Jan View changes

ohbus left a comment Collaborator

@jasciiz Please respond if you're still working on it.

Example from: https://github.com/iluwatar/java-design-patterns/pull/1234

## Recap: Failure and errors

- Q:Why is the difference between failure and errors?
- A:
  - Error：计算、观察或测量值或条件，与真实、规定或理论上正确的值或条件之间的差异（Discrepancy between a computed, observed or measured value or condition and the true, specified, or theoretically correct value or condition.），可译为“错误”。Error是能够导致系统出现Failure的系统内部状态。
  - Failure：当一个系统不能执行所要求的功能时，即为Failure，可译为“失效”。（Termination of the ability of an element or an item to perform a function as required.）

From: https://blog.csdn.net/yangxingpa/article/details/70754788

## Recap Example

**Fault: Should start searching at 0, not 1**

```
public static int numZero (int [ ] arr)
{  // Effects: If arr is null throw NullPo            ion
   // else return the number of occurrence            rr
   int count = 0;
   for (int i = 1; i < arr.length; i++)
   {
      if (arr [ i ] ==
      {
         count++;
      }
   }
   return count;
}
```

**Test 1**
**[ 2, 7, 0 ]**
**Expected: 1**
**Actual: 1**

**Error exists but no failure**
**Because expected=actual**

**Test 2**
**[ 0, 2, 7 ]**
**Expected: 1**
**Actual: 0**

**Error causes failure**
**Because error propagates to the output**

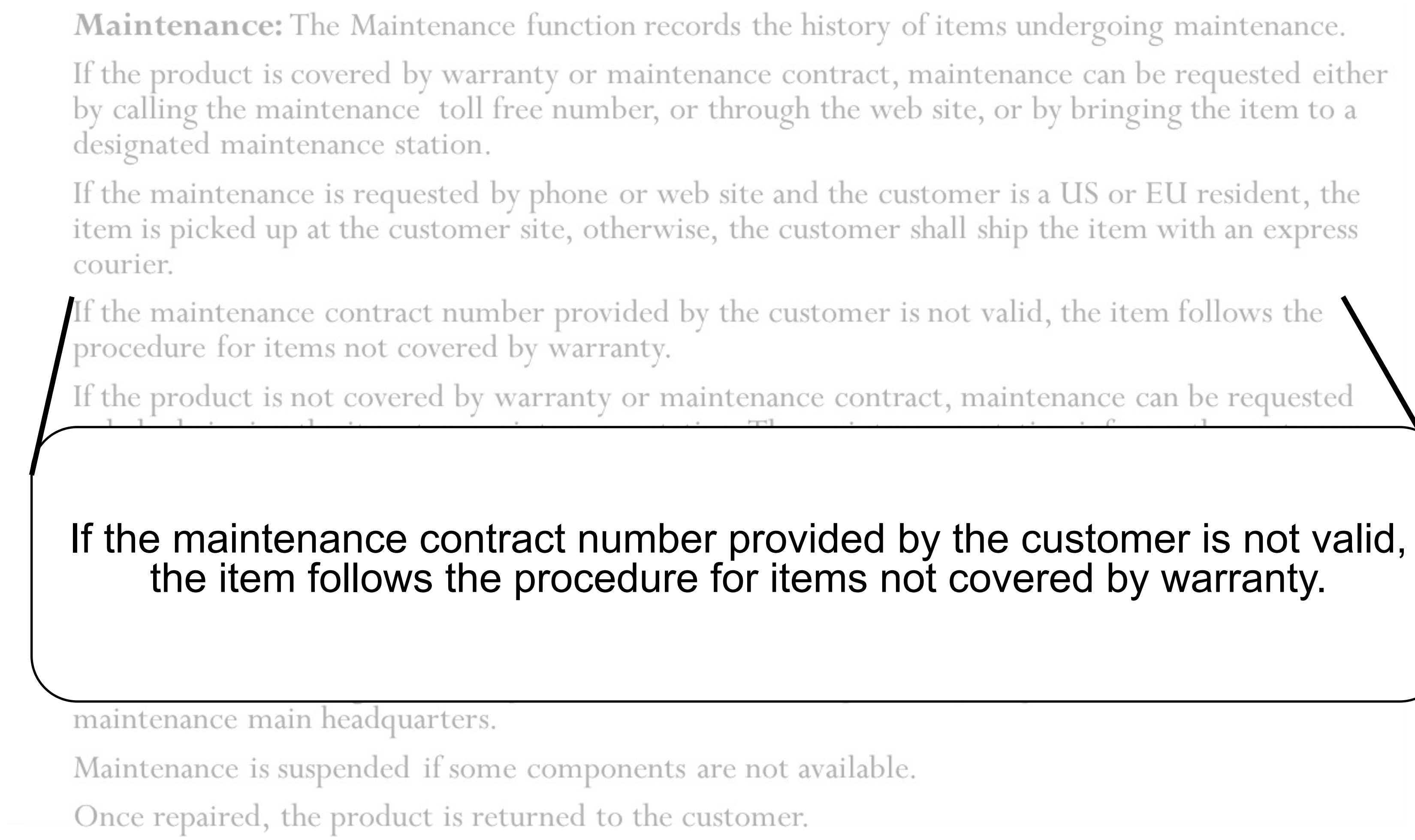
## Test Driven Development (TDD)

**One of the core practices in XP**

## Kent Beck's rules

- Beck's concept of test-driven development centers on two basic rules:
  - Never write a single line of code unless you have a failing automated test.
  - Eliminate duplication.

## Informal Requirements



**Maintenance:** The Maintenance function records the history of items undergoing maintenance.

If the product is covered by warranty or maintenance contract, maintenance can be requested either by calling the maintenance toll free number, or through the web site, or by bringing the item to a designated maintenance station.

If the maintenance is requested by phone or web site and the customer is a US or EU resident, the item is picked up at the customer site, otherwise, the customer shall ship the item with an express courier.

If the maintenance contract number provided by the customer is not valid, the item follows the procedure for items not covered by warranty.

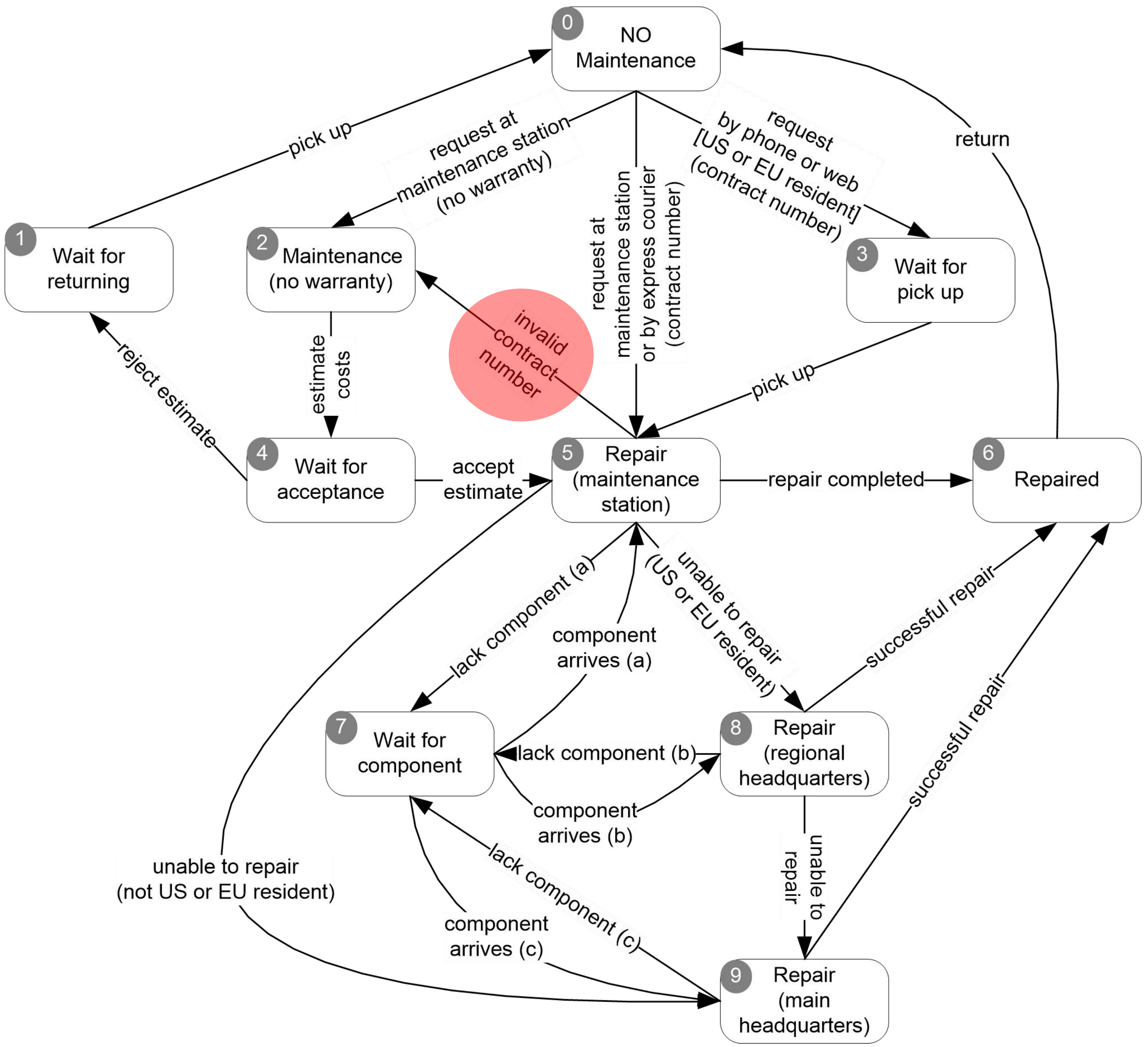
If the product is not covered by warranty or maintenance contract, maintenance can be requested

maintenance main headquarters.

Maintenance is suspended if some components are not available.

Once repaired, the product is returned to the customer.

If the maintenance contract number provided by the customer is not valid, the item follows the procedure for items not covered by warranty.



0 NO Maintenance
1 Wait for returning
2 Maintenance (no warranty)
3 Wait for pick up
4 Wait for acceptance
5 Repair (maintenance station)
6 Repaired
7 Wait for component
8 Repair (regional headquarters)
9 Repair (main headquarters)
pick up
request at maintenance station (no warranty)
request at maintenance station or by express courier (contract number)
request by phone or web [US or EU resident] (contract number)
return
invalid contract number
estimate costs
reject estimate
pick up
accept estimate
repair completed
lack component (a)
component arrives (a)
unable to repair (US or EU resident)
successful repair
lack component (b)
component arrives (b)
unable to repair
successful repair
unable to repair (not US or EU resident)
component arrives (c)
lack component (c)

## Ambiguity in Informal Requirements

If the maintenance contract number provided by the customer is not valid

- Contract number cannot contain alphabets or special characters?
- Contract number must be 5 digits?
- Contract number cannot start with 0?

## Requirements based on Test Cases

```
@Test
public void testContractNumberCorrectLength() {
	assertTrue(contract.isValidContractNumber(“12345”));
}
```

```
@Test
public void testContractNumberTooLong() {
	assertFalse(contract.isValidContractNumber(“53434434343”));
}
```

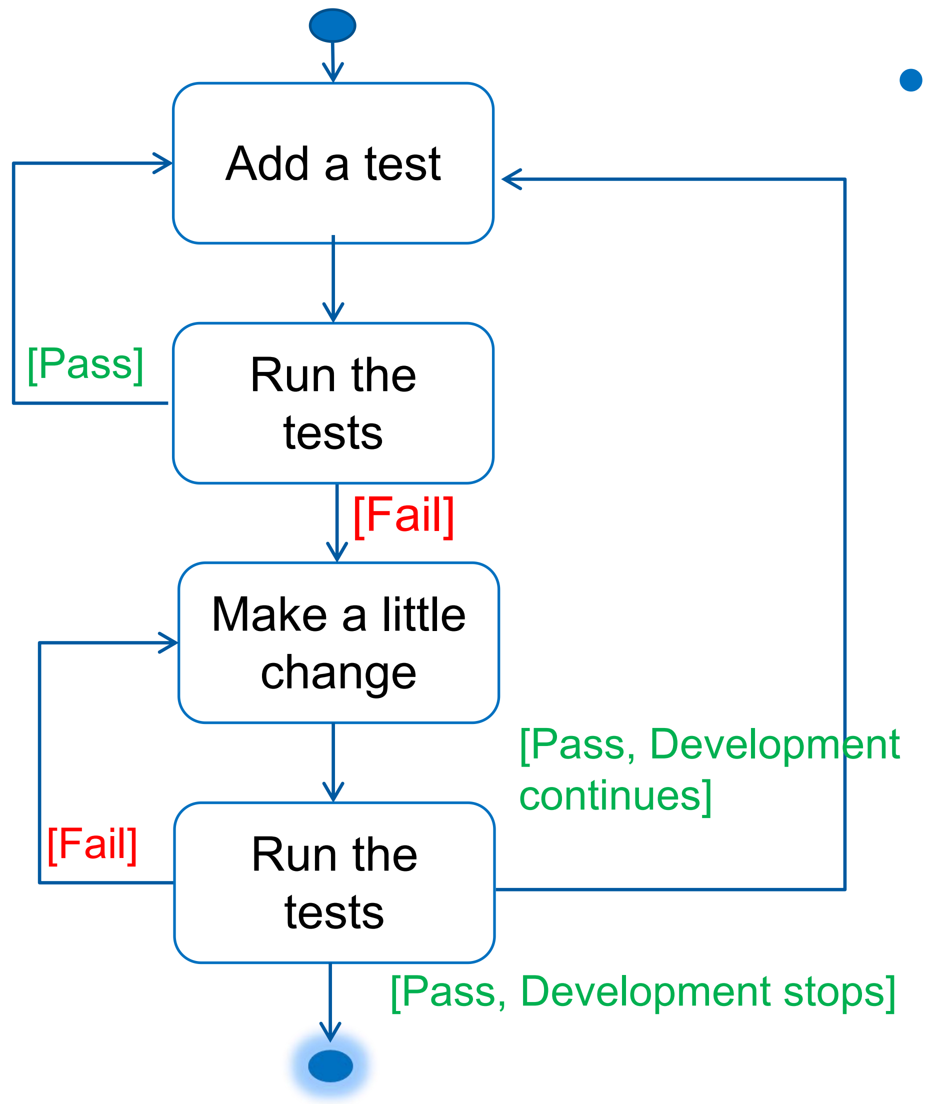
```
@Test
public void testContractNumberNoSpecialCharacter() {
	assertTrue(contract.isValidContractNumber(“08067”));
}
```

```
@Test
public void testContractNumberWithSpecialCharacter() {
	assertFalse(contract.isValidContractNumber(“98&67”));
}
```

## Informal Requirements versus Test cases

- Test cases are more specific than requirements.
- But: How to develop code based on test cases?
  - Follow the steps in Test Driven Development(TDD)

## Steps in Test Driven Development (TDD)



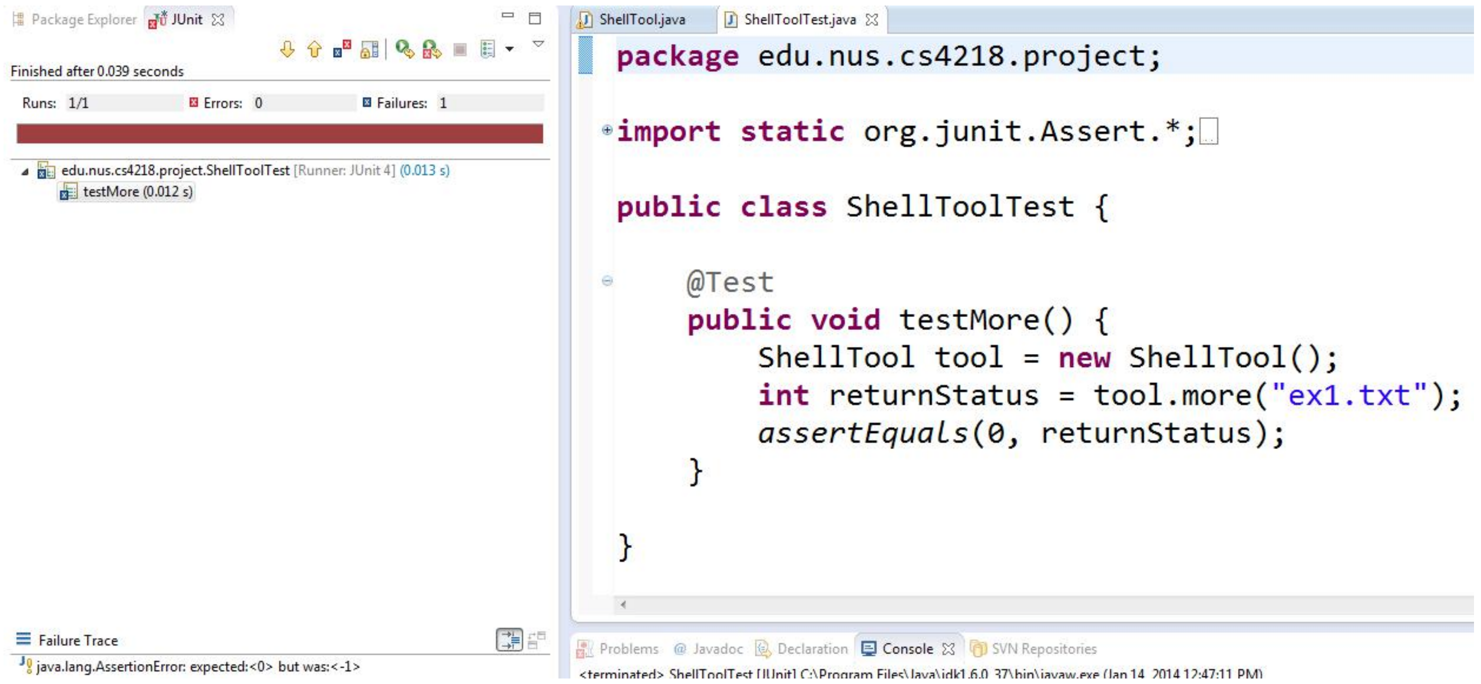
- The iterative process
  - Quickly add a test.
  - Run all tests and see the new one fail.
  - Make a little change to code.
  - Run all tests and see them all succeed.
  - Refactor to remove duplication.

## Test First Scenario

- Write test for the newly added functionality
  - These test cases will serve as a specification for your implementation
  - These test cases should fail now because the corresponding methods are not implemented
  - Write minimal code to make the test pass
  - Add more tests

# Run the tests

- Run the tests that your team gets to see the failing ones
  - Failing test cases indicates missing functionality



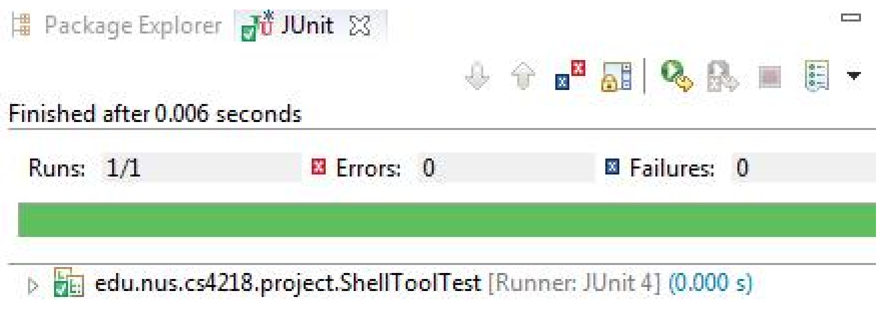
```
Finished after 0.039 seconds
Runs: 1/1    Errors: 0    Failures: 1
edu.nus.cs4218.project.ShellToolTest [Runner: JUnit 4] (0.013 s)
    testMore (0.012 s)
java.lang.AssertionError: expected:<0> but was:<-1>
```

```java
package edu.nus.cs4218.project;

import static org.junit.Assert.*;

public class ShellToolTest {

    @Test
    public void testMore() {
        ShellTool tool = new ShellTool();
        int returnStatus = tool.more("ex1.txt");
        assertEquals(0, returnStatus);
    }

}
```

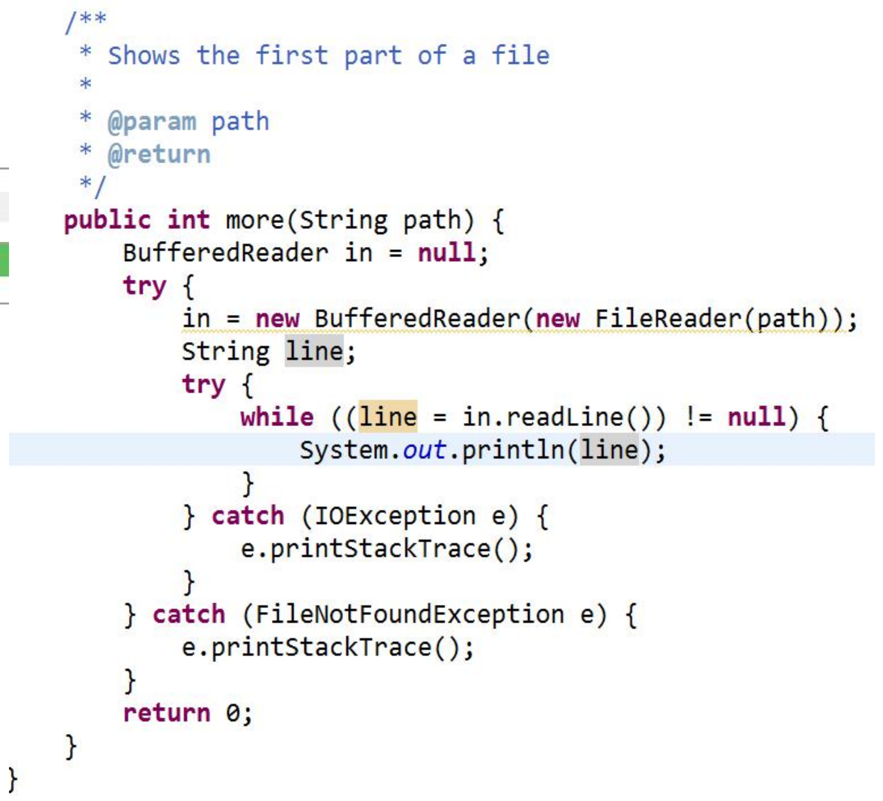
```
<terminated> ShellToolTest [JUnit] C:\Program Files\Java\jdk1.6.0_37\bin\javaw.exe (Jan 14, 2014 12:47:11 PM)
```

# Make them Pass

- Add code to make the failing tests pass
  - After implementing all the missing functionalities, all failing test cases should now pass



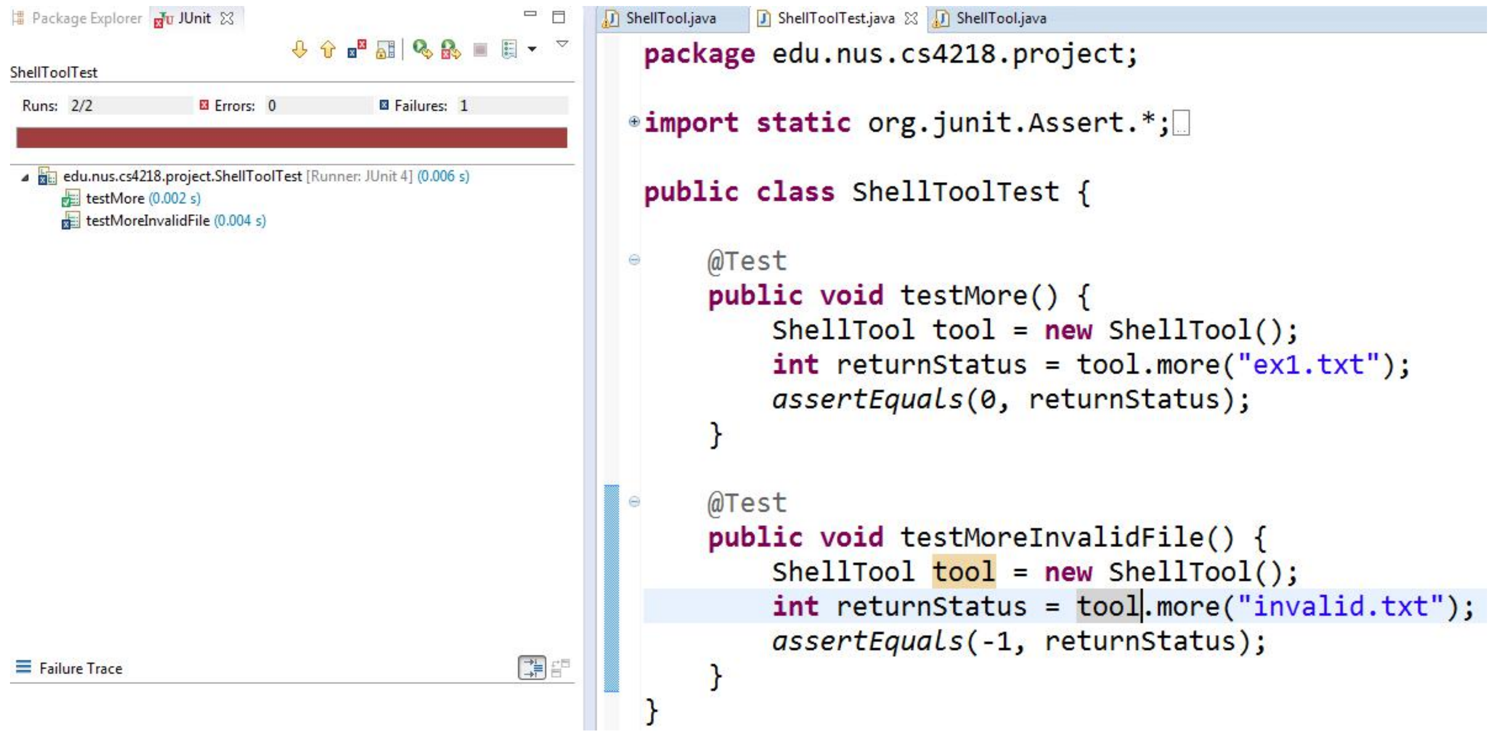
```
Package Explorer   JUnit

Finished after 0.006 seconds

Runs: 1/1      Errors: 0      Failures: 0

edu.nus.cs4218.project.ShellToolTest [Runner: JUnit 4] (0.000 s)
```



```
    /**
     * Shows the first part of a file
     *
     * @param path
     * @return
     */
    public int more(String path) {
        BufferedReader in = null;
        try {
            in = new BufferedReader(new FileReader(path));
            String line;
            try {
                while ((line = in.readLine()) != null) {
                    System.out.println(line);
                }
            } catch (IOException e) {
                e.printStackTrace();
            }
        } catch (FileNotFoundException e) {
            e.printStackTrace();
        }
        return 0;
    }
}
```

# Add more tests

- Add more tests for
  - Newly added components or helper methods
  - Checking for corner cases
- Run the new set of tests to see the failing ones

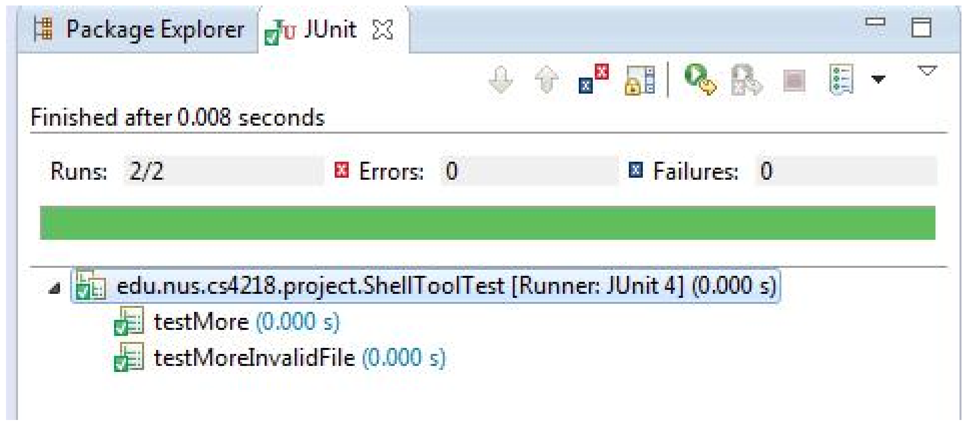


```
ShellToolTest
Runs:  2/2      Errors:  0      Failures:  1

edu.nus.cs4218.project.ShellToolTest [Runner: JUnit 4] (0.006 s)
    testMore (0.002 s)
    testMoreInvalidFile (0.004 s)
```

```java
package edu.nus.cs4218.project;

import static org.junit.Assert.*;

public class ShellToolTest {

    @Test
    public void testMore() {
        ShellTool tool = new ShellTool();
        int returnStatus = tool.more("ex1.txt");
        assertEquals(0, returnStatus);
    }

    @Test
    public void testMoreInvalidFile() {
        ShellTool tool = new ShellTool();
        int returnStatus = tool.more("invalid.txt");
        assertEquals(-1, returnStatus);
    }
}
```

## Make them Pass

- Add more code to make the added tests pass
  - After implementing all the helper methods and checking for corner cases, all new failing test cases should now pass



```
Finished after 0.008 seconds

Runs: 2/2    Errors: 0    Failures: 0

edu.nus.cs4218.project.ShellToolTest [Runner: JUnit 4] (0.000 s)
    testMore (0.000 s)
    testMoreInvalidFile (0.000 s)
```

Lesson Learned from Pair Testing

## How to write good test?
## How to create a good test suite?

# Which example has better tests?

**Example 1 is better!**

- **Each test should be independent of each other**

## Example 1

```
@Test
public void popTest() {
 MyStack s = new MyStack ();
  s.push (314);
  assertEquals (314, s.pop ());
}
@Test
public void sizeTest() {
 MyStack s = new MyStack ();
 s.push (2);
 assertEquals (1, s.size ());
}
```

## Example 2

```
MyStack s = new MyStack ();
@Test
public void popTest() {
 s.push (314);
 assertEquals (314, s.pop ());
}

@Test
public void sizeTest() {
 s.push (2);
 assertEquals (1, s.size ());
}
```

## Which example has better tests?

**Example 2 is better!**

- **Any given behaviour should be specified in one and only one test.**

### Example 1

```
@Test
public void sizeTest() {
  MyStack s = new MyStack ();
  assertEquals (0, s.size ());
  s.push (2);
  assertEquals (1, s.size ());
}
```

Multiple assertions are bad because after one assertion fail, execution stops

### Example 2

```
@Test
public void emptyTest() {
  MyStack s = new MyStack ();
  assertEquals (0, s.size ());
}

@Test
public void sizeTest() {
  MyStack s = new MyStack ();
  s.push (2);
  assertEquals (1, s.size ());
}
```

# Which tests is correct?

**Example 2 is correct!**

➢ Correct method signature should be assertEquals(expected,actual)

## Example 1

```
@Test
public void sizeTest() {
 MyStack s = new MyStack ();
 assertEquals (s.size (),0);
}
```

## Example 2

```
@Test
public void emptyTest() {
  MyStack s = new MyStack ();
  assertEquals (0, s.size ());
}
```

# Which tests is correct?

**Example 1 is correct!**

- ➢ Use .equals() to compare strings

## Example 1

```
@Test
public void sizeTest() {
 MyStack s = new MyStack ();
 s.push("Hello");
 assertEquals ("Hello", s.pop());
}
```

## Example 2

```
@Test
public void emptyTest() {
 MyStack s = new MyStack ();
 s.push("Hello");
 assertTrue (s.pop()=="Hello");
}
```

## Is there a standard measurement for test quality?

Yes, code coverage!

## What is Code Coverage?

- Code coverage is a measure used to describe the degree to which the source code of a program is executed when a particular **test suite runs**

A form of dynamic analysis:动态分析

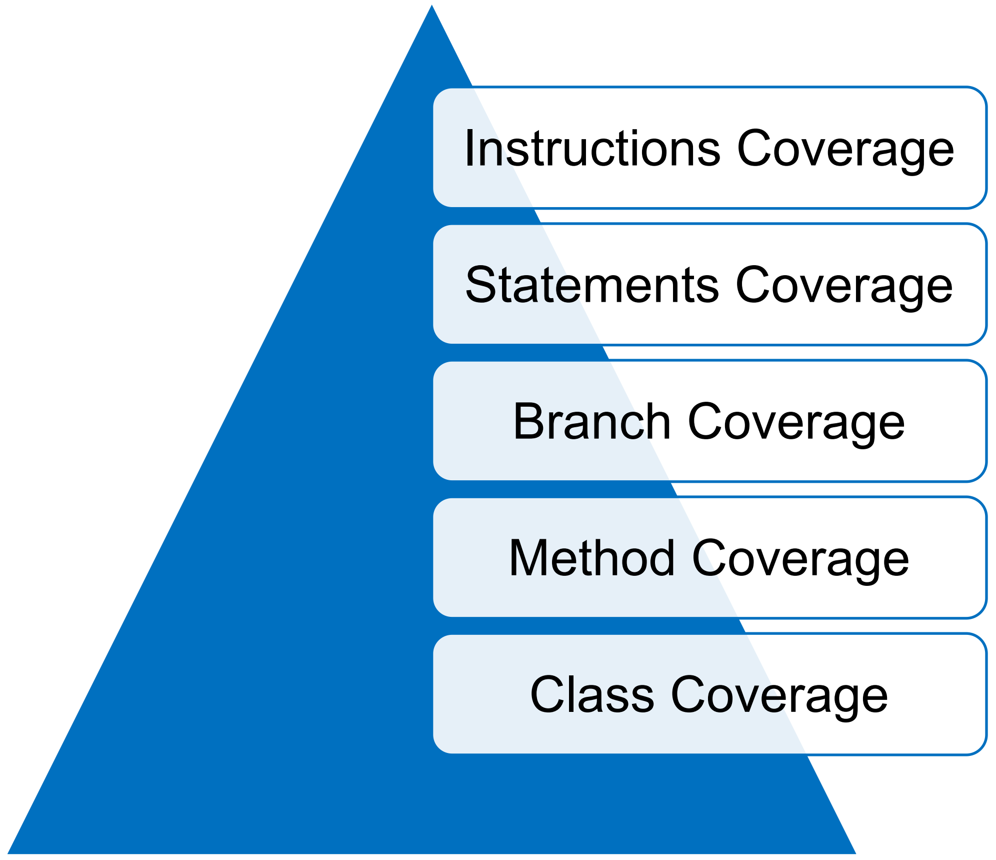
- Code Coverage is classified as a White box testing
  - White Box testing: Testing where internal structure/ design/ implementation of the item being tested is known

# Benefits of Code Coverage

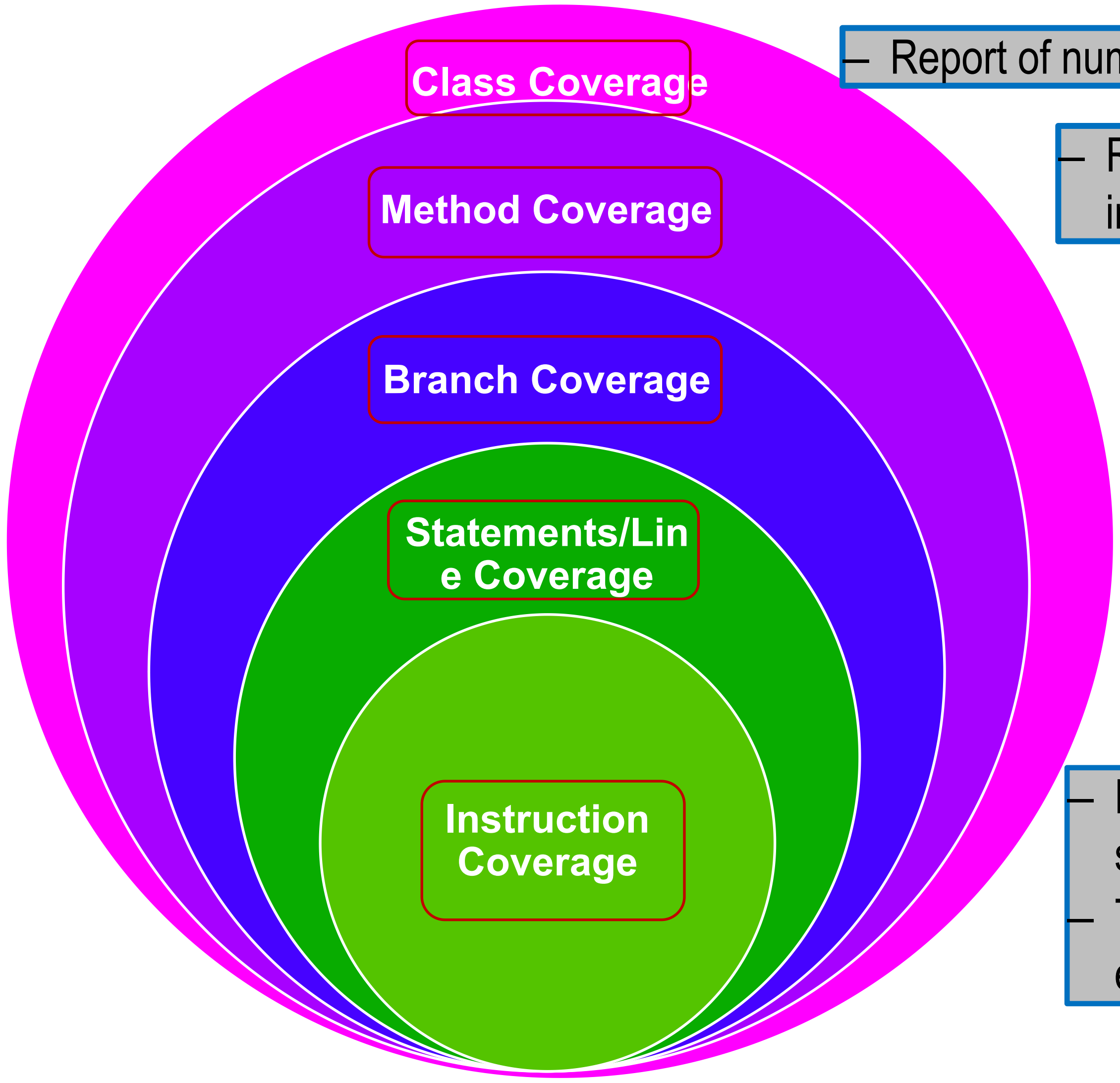
- Identify untested part of codebase
- Improve the Quality by improved test coverage
- Identify testing gaps or missing tests
- Identify the redundant/dead Code

## Coverage Criteria

- To measure what percentage of code has been exercised by a test suite, one or more coverage criteria are used



# Basic Coverage Criteria



- Report of number of classes from the code base covered

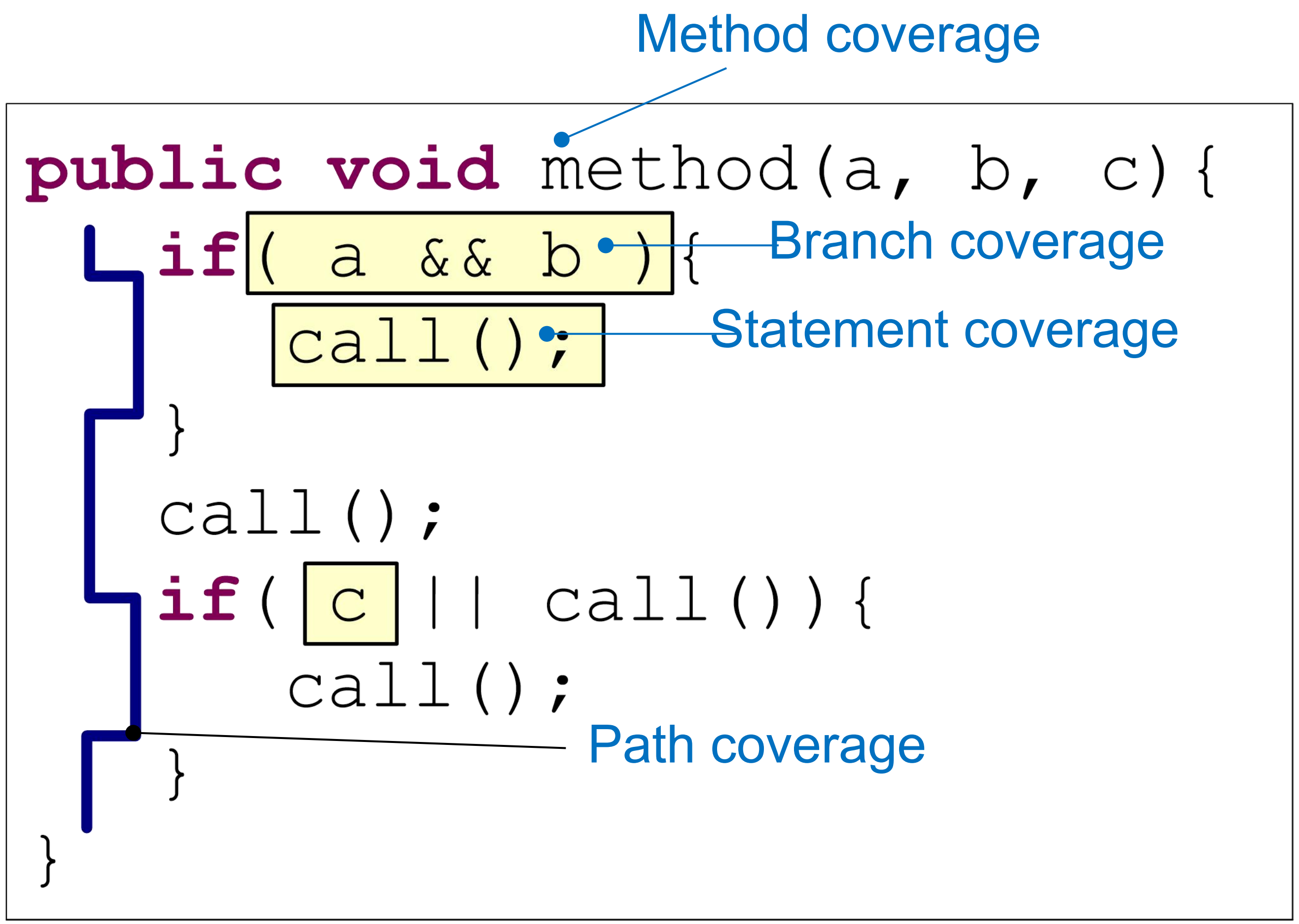
- Reports whether a method (function) was invoked while testing the application

- Reports whether Boolean expressions evaluate to true AND false

- Reports whether each executable statement was executed

- Method’s bytecode stream is a sequence of instructions for JVM
- The Bytecode for a method are executed when that method is invoked

# Code Coverage



```
public void method(a, b, c){
    if( a && b ){
        call();
    }
    call();
    if( c || call()){
        call();
    }
}
```

## Equation for Computing Coverage

$$\text{Statement Coverage} = \frac{\text{Number of executed statements}}{\text{Total number of statements}} \times 100$$

$$\text{Branch Coverage} = \frac{\text{Number of Executed Branches}}{\text{Total Number of Branches}}$$

## Code Coverage Analysis Process

Writing test cases and execute them

Finding areas of code not covered using Code Coverage Tool

Creating additional tests for identified gaps to increase test coverage

Determining a quantitative measure of code coverage

# Code Coverage using JaCoCo

*JaCoCo is an open source code coverage Tool for Java, which has been created by the EclEmma team*

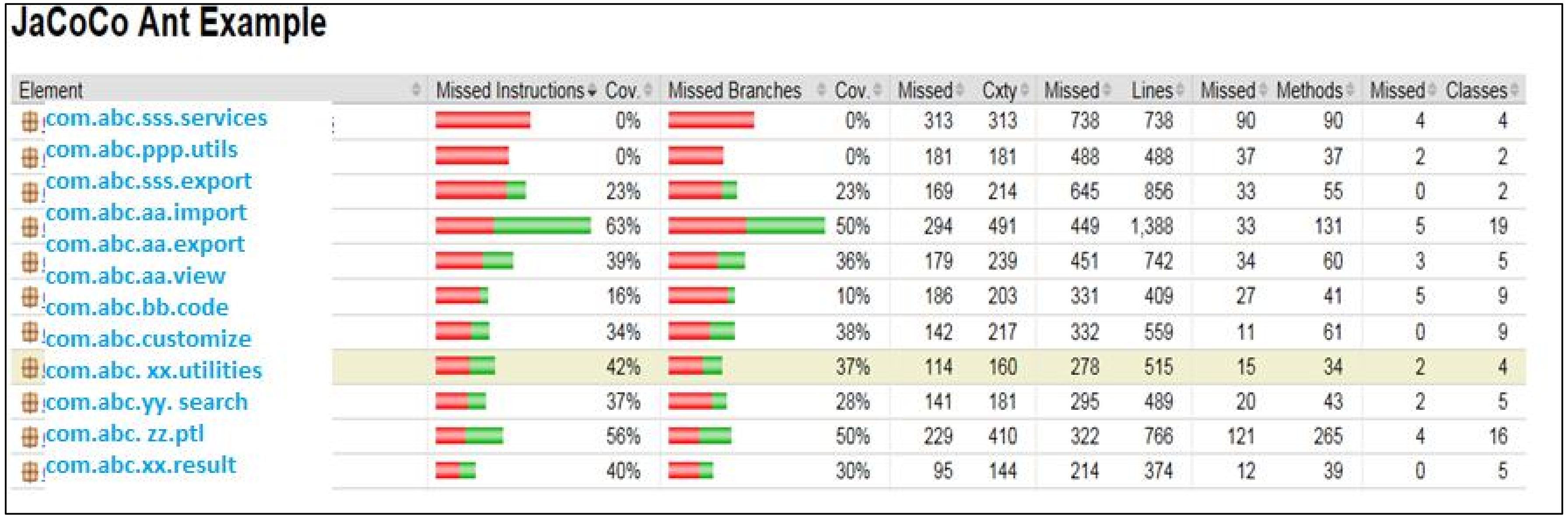
- Configure JaCoCo agent with JVM of your system to instrument java classes
- .EXEC file gets generated while the test cases are executed on the system
- Generate Code Coverage report using ant (in different formats)

The agent jacocoagent.jar is part of the JaCoCo distribution and includes all required dependencies. A Java agent can be activated with the following JVM option: -javaagent:*[yourpath/]*jacocoagent.jar=*[option1]*=*[value1]*,*[option2]*=*[value2]*

Example-
java -jar-<Jar> -javaagent:<Jacoco location path>/jacocoagent.jar=destfile=<Jacoco location>/jacoco.exec

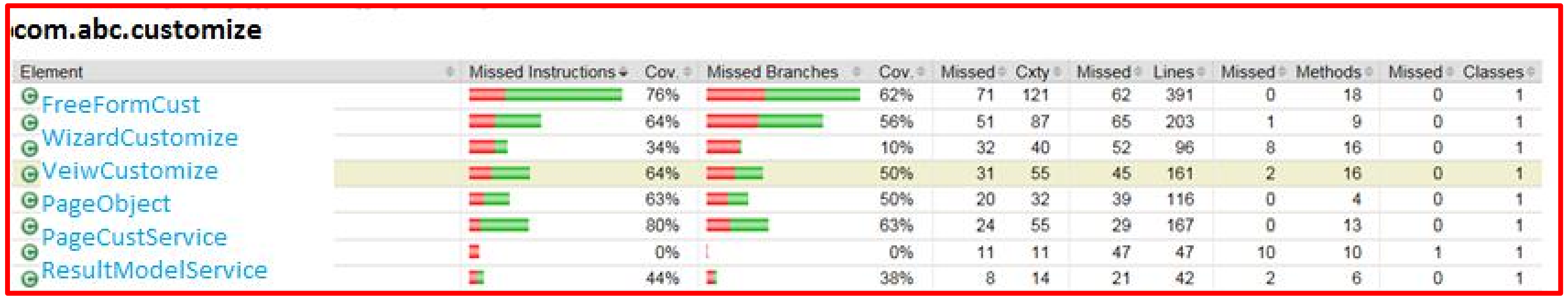
# Code Coverage using JaCoCo

- JaCoCo offers instructions, line, branch, class and package coverage



**JaCoCo Ant Example**

| Element | Missed Instructions | Cov. | Missed Branches | Cov. | Missed | Cxty | Missed | Lines | Missed | Methods | Missed | Classes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| com.abc.sss.services | | 0% | | 0% | 313 | 313 | 738 | 738 | 90 | 90 | 4 | 4 |
| com.abc.ppp.utils | | 0% | | 0% | 181 | 181 | 488 | 488 | 37 | 37 | 2 | 2 |
| com.abc.sss.export | | 23% | | 23% | 169 | 214 | 645 | 856 | 33 | 55 | 0 | 2 |
| com.abc.aa.import | | 63% | | 50% | 294 | 491 | 449 | 1,388 | 33 | 131 | 5 | 19 |
| com.abc.aa.export | | 39% | | 36% | 179 | 239 | 451 | 742 | 34 | 60 | 3 | 5 |
| com.abc.aa.view | | 16% | | 10% | 186 | 203 | 331 | 409 | 27 | 41 | 5 | 9 |
| com.abc.bb.code | | 34% | | 38% | 142 | 217 | 332 | 559 | 11 | 61 | 0 | 9 |
| com.abc.customize | | 42% | | 37% | 114 | 160 | 278 | 515 | 15 | 34 | 2 | 4 |
| com.abc. xx.utilities | | 37% | | 28% | 141 | 181 | 295 | 489 | 20 | 43 | 2 | 5 |
| com.abc.yy. search | | 56% | | 50% | 229 | 410 | 322 | 766 | 121 | 265 | 4 | 16 |
| com.abc. zz.ptl | | 40% | | 30% | 95 | 144 | 214 | 374 | 12 | 39 | 0 | 5 |
| com.abc.xx.result | | | | | | | | | | | | |



**com.abc.customize**

| Element | Missed Instructions | Cov. | Missed Branches | Cov. | Missed | Cxty | Missed | Lines | Missed | Methods | Missed | Classes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FreeFormCust | | 76% | | 62% | 71 | 121 | 62 | 391 | 0 | 18 | 0 | 1 |
| WizardCustomize | | 64% | | 56% | 51 | 87 | 65 | 203 | 1 | 9 | 0 | 1 |
| | | 34% | | 10% | 32 | 40 | 52 | 96 | 8 | 16 | 0 | 1 |
| VeiwCustomize | | 64% | | 50% | 31 | 55 | 45 | 161 | 2 | 16 | 0 | 1 |
| PageObject | | 63% | | 50% | 20 | 32 | 39 | 116 | 0 | 4 | 0 | 1 |
| PageCustService | | 80% | | 63% | 24 | 55 | 29 | 167 | 0 | 13 | 0 | 1 |
| | | 0% | | 0% | 11 | 11 | 47 | 47 | 10 | 10 | 1 | 1 |
| ResultModelService | | 44% | | 38% | 8 | 14 | 21 | 42 | 2 | 6 | 0 | 1 |

## Other tools for code coverage

- Cobertura
- Atlassian Clover
- DevPartner
- JTest
- Bullseye for C++
- Sonar
- Kalistick

## Other references

- https://en.wikipedia.org/wiki/Code_coverage
- https://en.wikipedia.org/wiki/White-box_testing
- http://www.eclemma.org/jacoco/
- http://www.jacoco.org/jacoco/trunk/doc/
- https://www.atlassian.com/software/clover

*Learn about how to use JaCoCo in the lab today!

## Is Code Coverage a good measurement?

# Achieving code coverage

```
@Test
public void add_should_add() {
            new Math().add(1, 1);
}
```

But, where is the assert?

As long as the Code Coverage is OK...

# Code coverage as a measure of test quality

**Any metric can be gamed! Code coverage is a metric…**

**⇒ Code coverage can be gamed**

**On purpose Or by accident**

## Code coverage as a measure of test quality

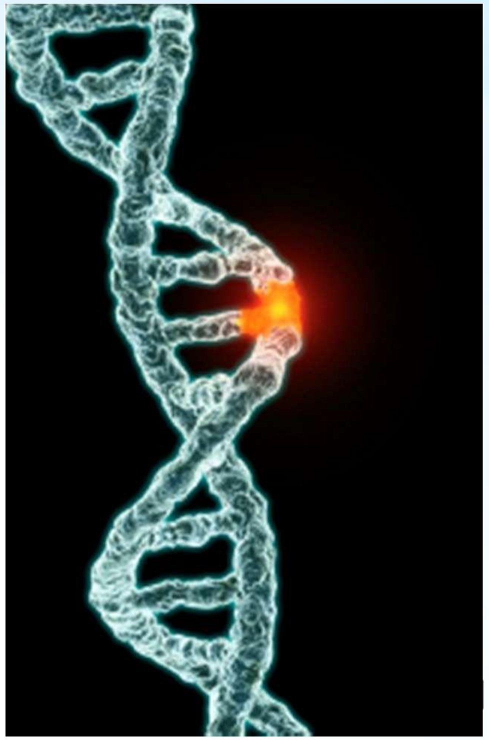
Code Coverage lulls you into a false sense of security (虛假的安全感)…

# The problem still remains

Code coverage cannot ensure test  quality

- Is there another way?

**Mutation Testing** to the rescue!



# What is Mutation ?

**General View**

We are performing mutation analysis whenever we

- use well defined rules
- defined on syntactic descriptions
- to make systematic changes
- to the syntax or to objects developed from the syntax

**mutation operators**

**grammars**

**Applied universally or according to empirically verified distributions**

**grammar**

**ground strings**

**(tests or programs)**

# Why Mutation?

```
public int m1(int i1, int i2) {
    return i1 + i2;
    }
```

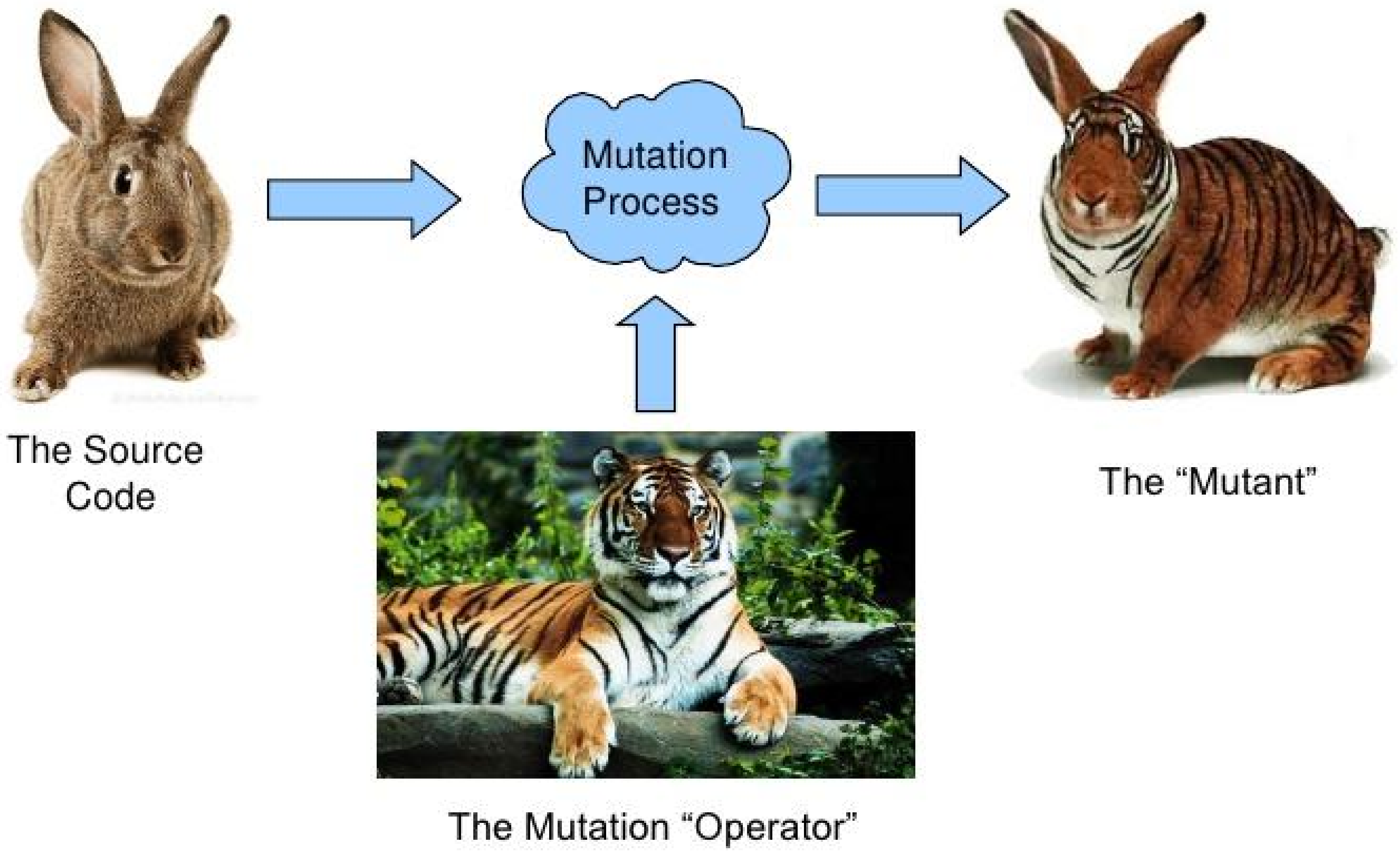
```
public int m1(int i1, int i2) {
    return i1 - i2;
    }
```

- What is the changes?
- Which is the correct program?
  - m1(1,0) Output: 1
  - m1(1,2)  Output: 3

## Why Mutation?

- Mutant processes are created to try to mimic typical syntactic errors made by programmers
- Many differing mutants are run against the specified tests to assess the quality of the tests
- The tests are attributed a score between 0 and 1, as to whether they can distinguish between the original and the mutants

## How does it work?
## 1st Step: Create the Mutant



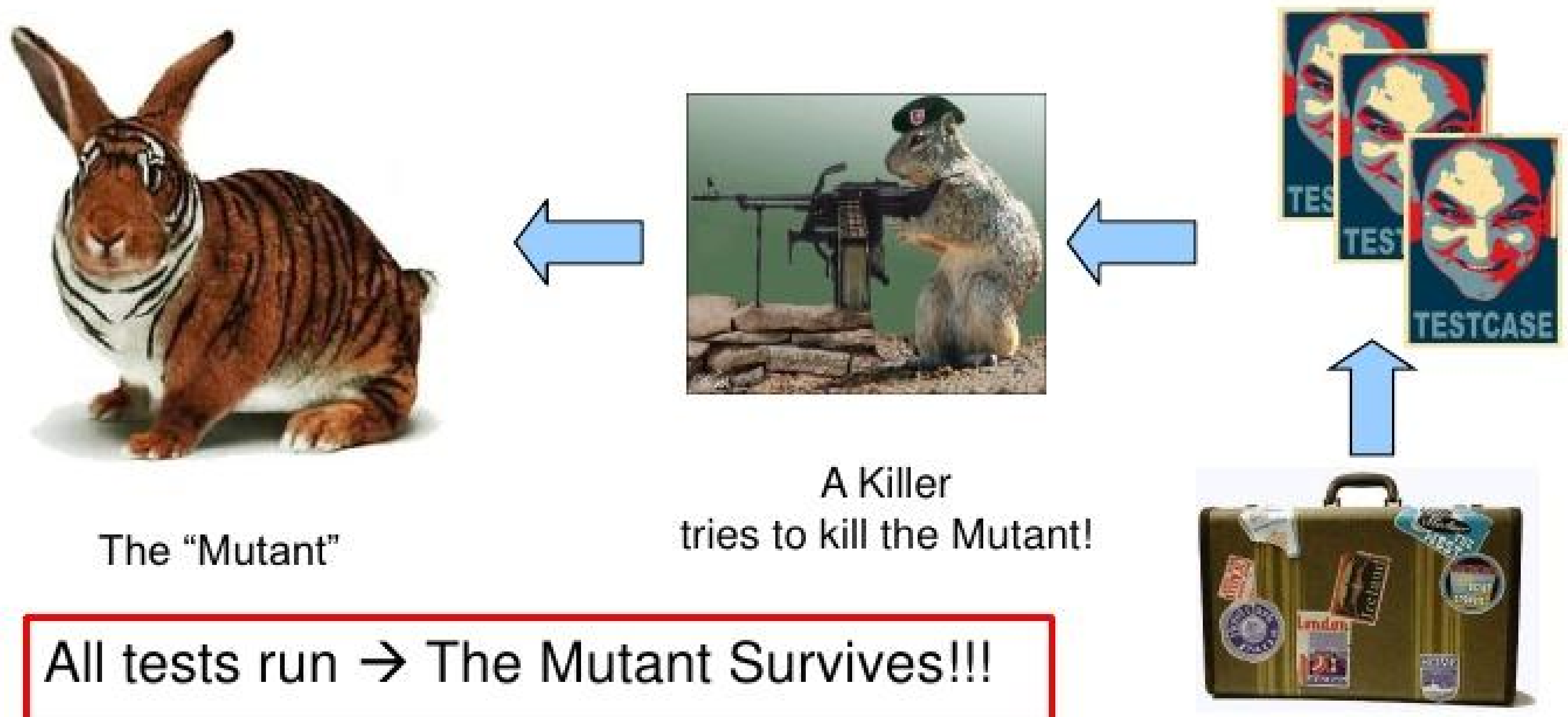
## Examples

```
DebitCard>>= anotherDebitCard
   ^(type = anotherDebitCard type)
    and: [ number = anotherDebitCard number ]
```

Operator: Change #and: by #or:

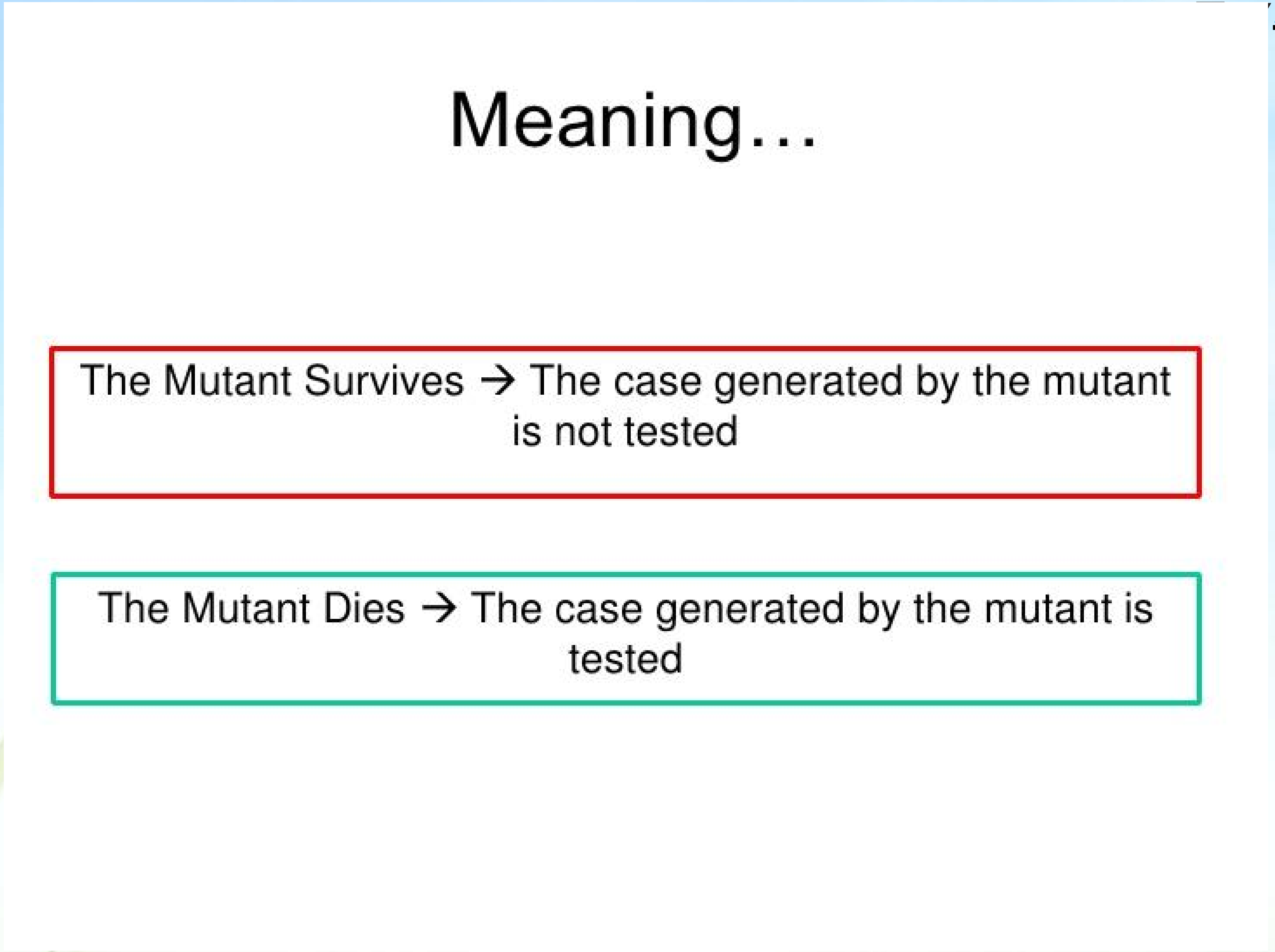
```
CreditCard>>= anotherDebitCard
   ^(type = anotherDebitCard type)
     or: [ number = anotherDebitCard number ]
```

## How does it work?
## 2nd Step: Try to Kill the Mutant



All tests run → The Mutant Survives!!!

A test fails or errors → The Mutant Dies



## Meaning…

The Mutant Survives → The case generated by the mutant is not tested

The Mutant Dies → The case generated by the mutant is tested

EVOSUITE

# Example: Killing mutants

```
@Test
public void add_should_add() {
    new Math().add(1, 1);
    Assert.assertEquals(sum, 2);

}
```

Execute Test ✔

Mutant Killed

# Mutation Testing in Java

PIT is a tool for Mutation testing

Available as

- Command-line tool
  Ant target
- Maven plugin

pitest.org

## Mutators

Mutators are patterns applied to  source code
to produce mutations

# PIT mutators sample

| Name | Example source | Result |
|---|---|---|
| Conditionals Boundary | > | >= |
| Negate Conditionals | == | != |
| Remove Conditionals | foo == bar | true |
| Math | + | - |
| Increments | foo++ | foo-- |
| Invert Negatives | -foo | foo |
| Inline Constant | static final FOO= 42 | static final FOO = 43 |
| Return Values | return true | return false |
| Void Method Call | System.out.println("foo") | |
| Non Void Method Call | long t = System.currentTimeMillis() | long t = 0 |
| Constructor Call | Date d = new Date(d); | Date d = null; |

## Example of Important mutators

Conditionals Boundary

- Probably a potential serious bug smell

```
if (foo > bar)
```

## Is there any tool that helps you increase coverage fast by generating JUnit tests automatically?

- Yes, there are several popular open-source test generations
  - Randoop
  - Evosuite

From:http://www.evosuite.org/evosuite-tutorials/

## History

ICST 2010
Third International Conference on
Software Testing, Verification and Validation
Paris, France
April 6-9, 2010
ICST

**April 9, 2010**

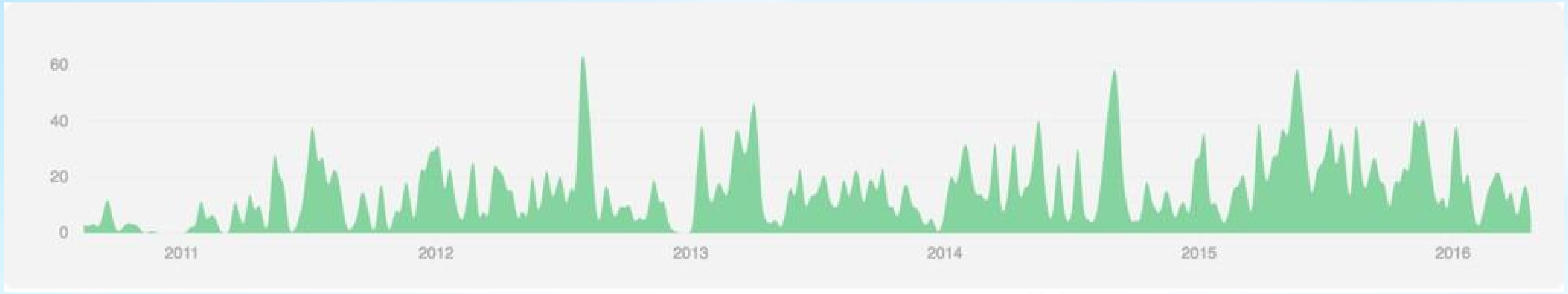
**"Evolutionary Generation of Whole Test Suites"**

**11th International Conference on Software Quality (QSIC 2011)**

**Who is he?**

- **Andrea Arcuri**
- **Prof. Xin Yao's previous students**

# Stats of the Evosuite projects on GitHub

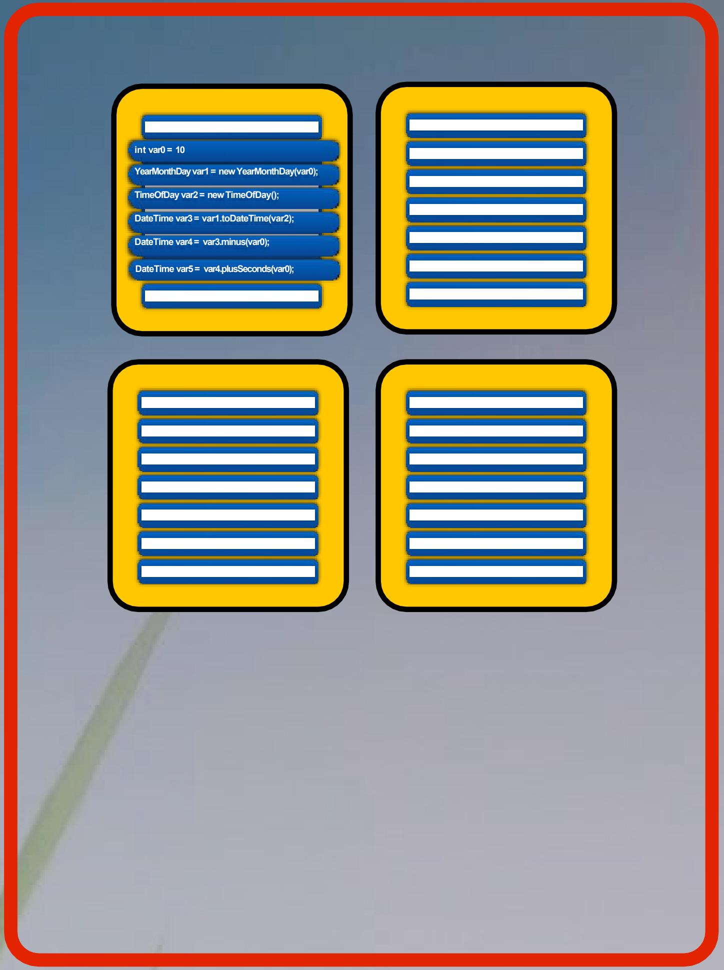


- 6,865 commits
- 229,889 LOC
- 2,420 tests

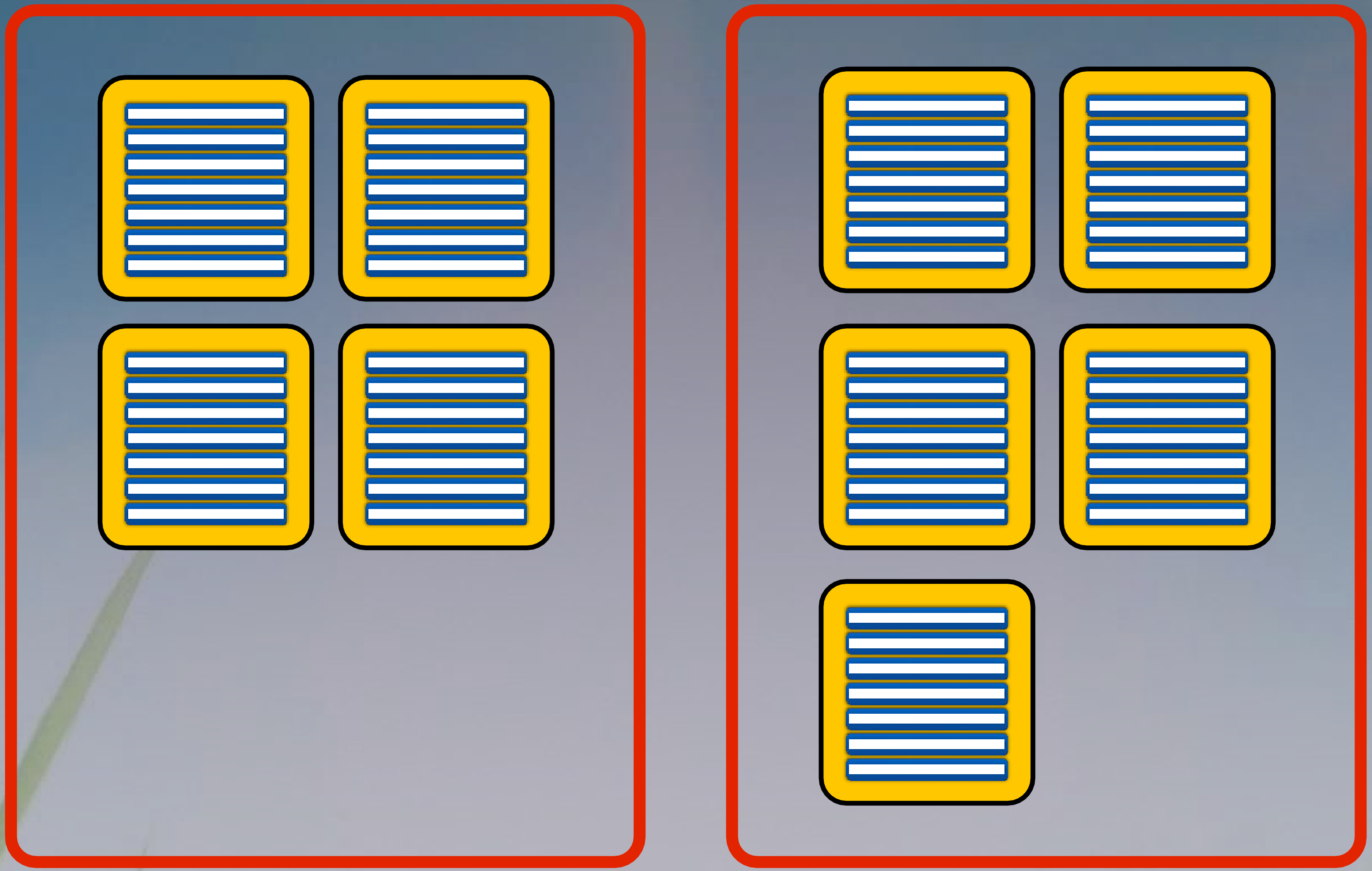
## How does it works?

EvoSuite uses evolutionary algorithm to generate and optimize whole test suites towards satisfying a coverage criterion.

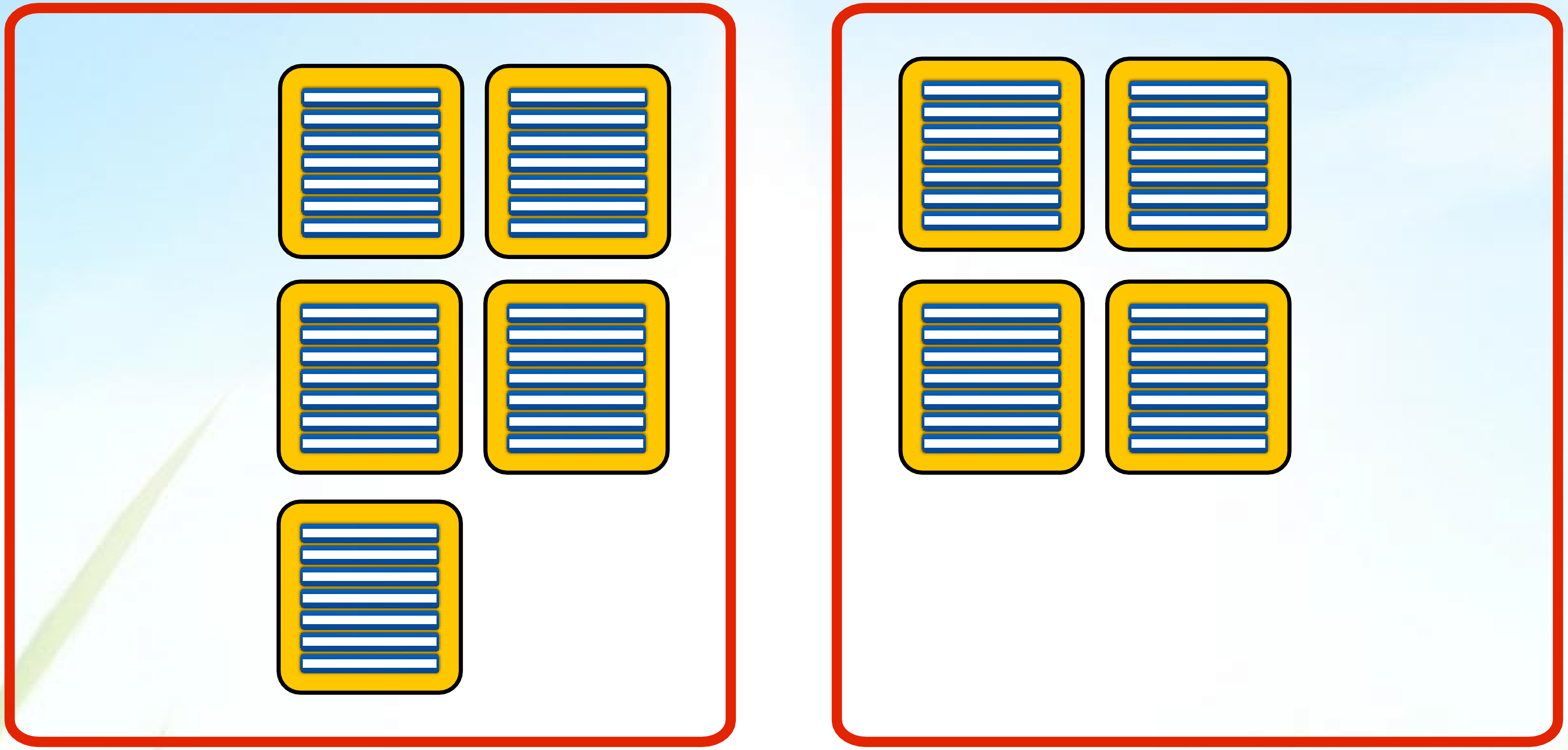
```
@Test

public void test()
{
    int var0 = 10
    YearMonthDay var1 = new
    YearMonthDay(var0);  TimeOfDay var2 =
    new TimeOfDay();  DateTime var3 =
    var1.toDateTime(var2);  DateTime var4 =
    var3.minus(var0);
}
```



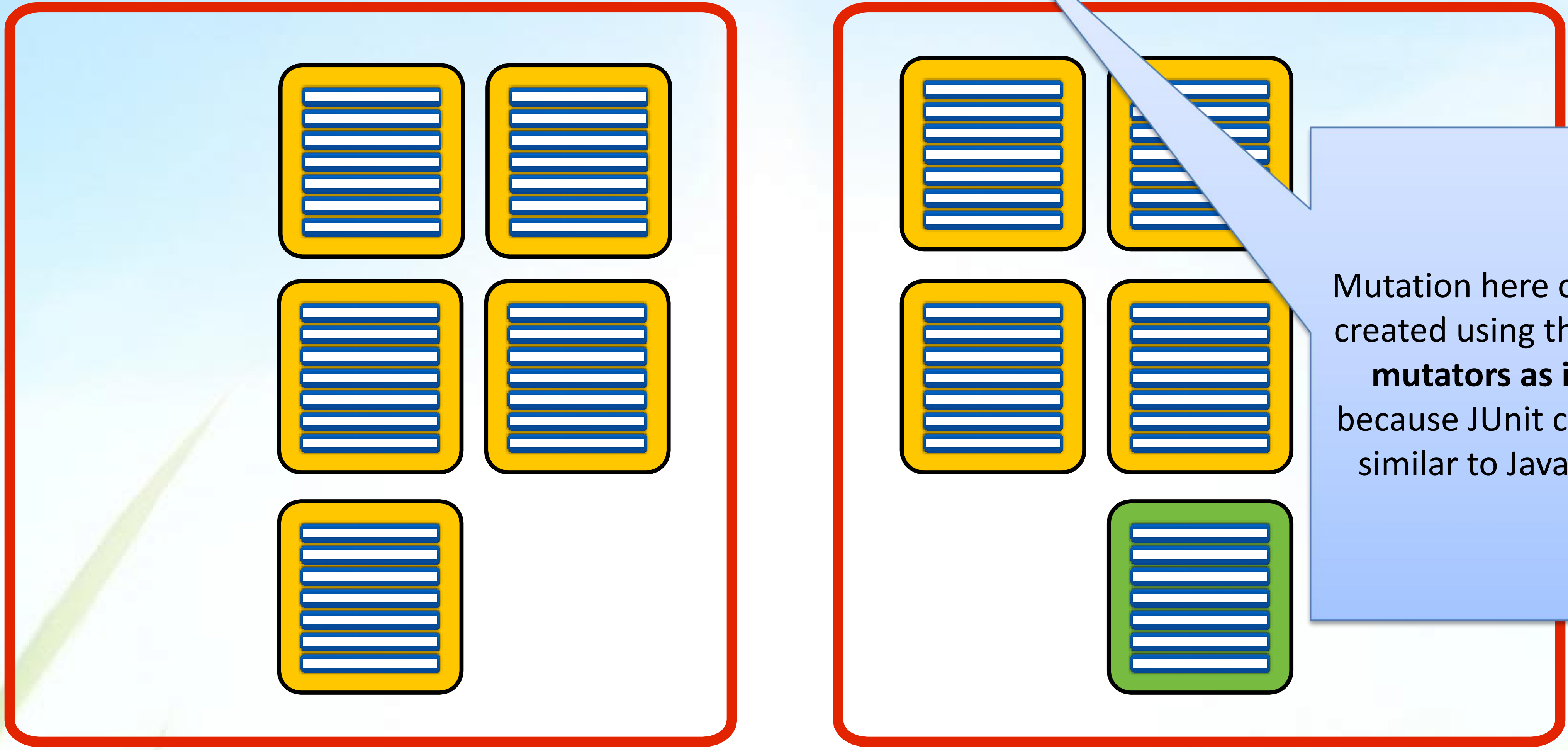
```
int var0 = 10
YearMonthDay var1 = new YearMonthDay(var0);
TimeOfDay var2 = new TimeOfDay();
DateTime var3 = var1.toDateTime(var2);
DateTime var4 = var3.minus(var0);
DateTime var5 = var4.plusSeconds(var0);
```



# Crossover

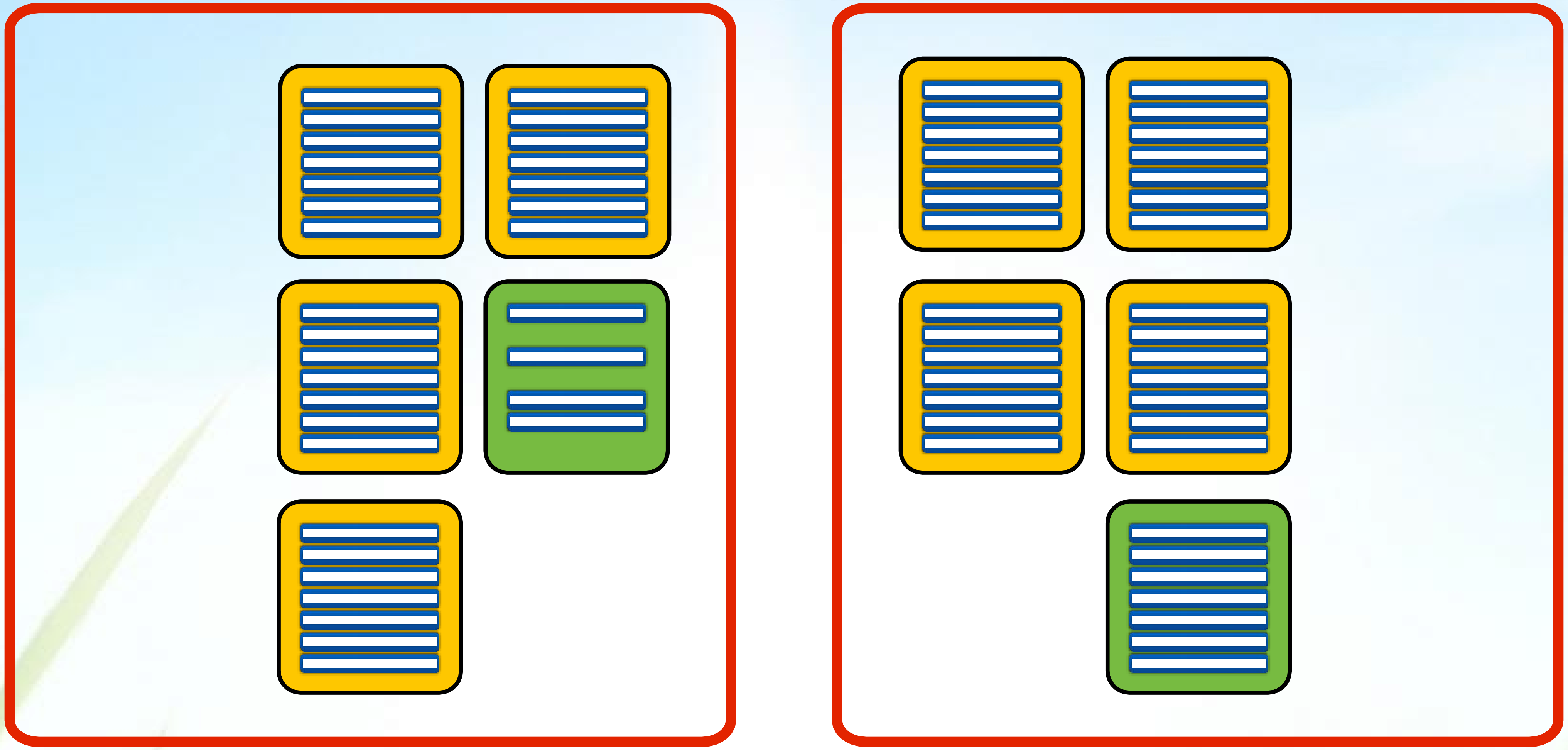


# Mutation

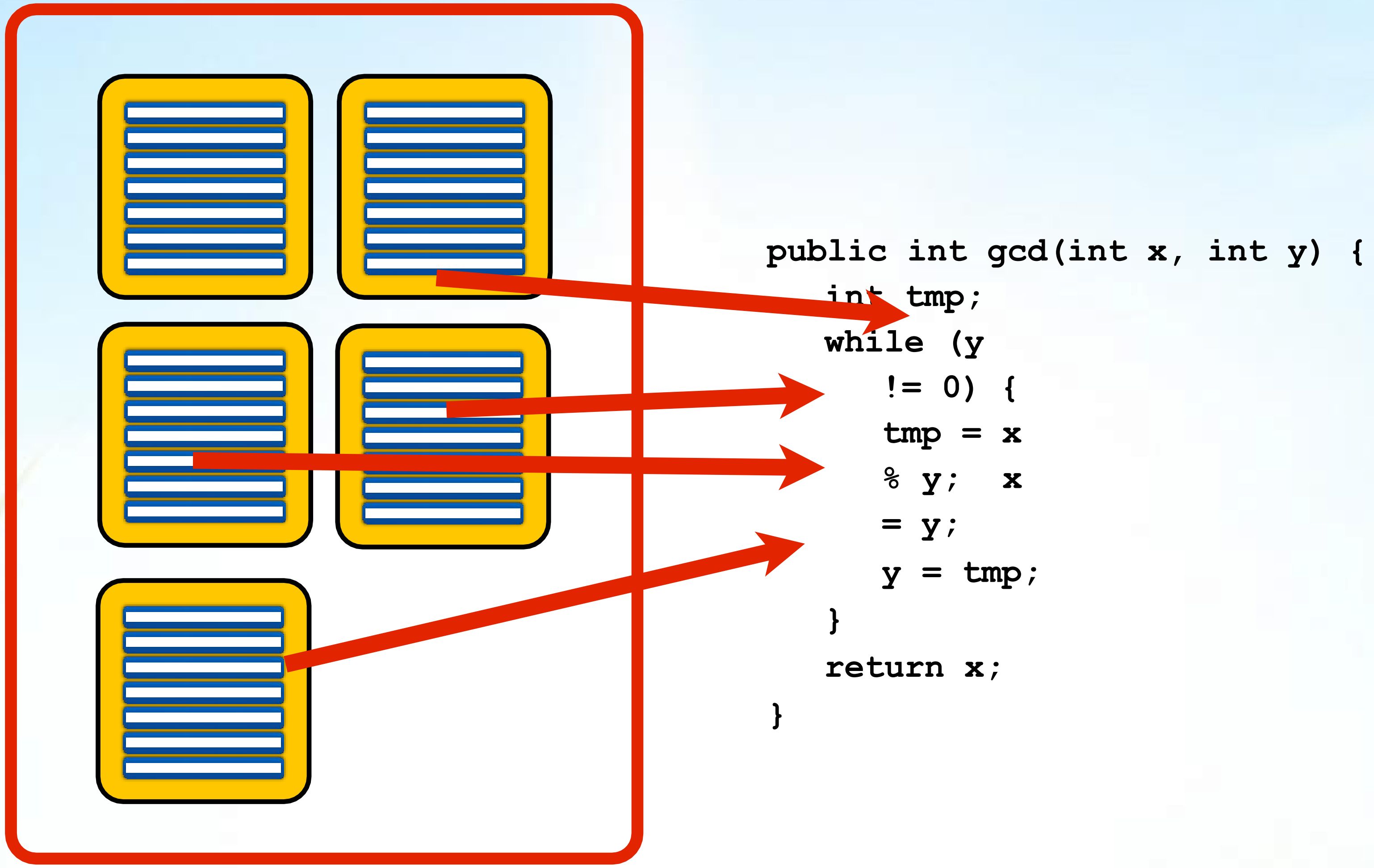


Mutation here could be created using the **same mutators as in PIT** because JUnit code are similar to Java code.

# Mutation



# Fitness



```
public int gcd(int x, int y) {
    int tmp;
    while (y
        != 0) {
        tmp = x
        % y;   x
        = y;
        y = tmp;
    }
    return x;
}
```

# Getting EvoSuite

`http://www.evosuite.org/downloads`

- **Jar release - for command line usage**
- **Maven plugin**
- **IntelliJ plugin**
- **Eclipse plugin**
- **Jenkins plugin**

**You will be using Evosuite during the lab this week**

# When to use and not to use Evosuite?

- **Should I use EvoSuite…**
- **…to test my own Javacode?**
- **Yes,  of course**

EVOSUITE

## When to use and not to use Evosuite?

- Should I use EvoSuite…
- …to implement my ideas on unit test generation?
- Yes, of course

## When to use and not to use Evosuite?

- **Should I use EvoSuite…**
- **…to study developer behaviour?**
- **Yes,  of course**

# When to use and not to use Evosuite?

- **Should I use EvoSuite…**
- **…to generate unit tests for my experiment on X?**
- **Yes, of course**

## When to use and not to use Evosuite?

- **Should I use EvoSuite…**
- **…to build a unit test generator for a different language ?**
- **Evosuite is 90% JVM Handling code**
- **Would need to reimplement representation, search operators, fitness functions, test execution, …**

## When to use and not to use Evosuite?

- **Should I use EvoSuite…**
- **…to create an Android testing tool?**
- **Android uses Java Dalvik bytecode**
- **Can also compile to Java bytecode**
- **How to handle Android dependencies?**

EVOSUITE

## When to use and not to use Evosuite?

- Should I use EvoSuite…
- …to create aGUI testing tool?
- If you want to test Java/Swing applications …
- But whole test suite optimisation many not be the right choice

EVOSUITE

# Research they are working on...

- Increasing coverage…
- Readability optimisation
- Better environment handling
- Mocking and private reflection
- Finding out how developers benefit most from using test generation
- User studies, replications

# Method Names

```
@Test(timeout = 4000)
public void test3() throws Throwable
                                   {
     StringExample stringExample0 = new
     StringExample();  boolean boolean0 =
     stringExample0.foo("");  assertFalse(boolean0);
}
```

```
@Test(timeout = 4000)
public void testFooReturningFalse() throws Throwable  {
     StringExample stringExample0 = new
     StringExample();  boolean boolean0 =
     stringExample0.foo("");  assertFalse(boolean0);
}
```

# Variable Names

```
@Test(timeout = 4000)
public void testFooReturningFalse()throws Throwable

      {  StringExample stringExample0 = new
      StringExample();  boolean boolean0 =
      stringExample0.foo("");  assertFalse(boolean0);
}
```

```
@Test(timeout = 4000)
public void testFooReturningFalse()throws Throwable

      {  StringExample invokesFoo = new StringExample();
      boolean resultFromFoo = invokesFoo.foo("");
      assertFalse(resultFromFoo);
}
```

# Online Tutorials

- Using EvoSuite on the command line:
  http://www.evosuite.org/documentation/tutorial-part-1/
- Using EvoSuite with Maven:
  http://www.evosuite.org/documentation/tutorial-part-2/
- Running experiments with EvoSuite:
  http://www.evosuite.org/documentation/tutorial-part-3/
- Extending EvoSuite:
  http://www.evosuite.org/documentation/tutorial-part-4/