ROTTEN GREEN TESTS

(FROM ICSE'19)

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WHAT IS A ROTTEN GREEN TEST?

ANATOMY OF A TEST

```
SetTest » testSetAdd

    | s |

    s := Set new.

    s add: 1.

    self assert: s size equals: 1.

    self assert: (s includes: 1)
```

```
class SetTest {
    method testSetAdd {

        def s = Set.new()

        s.add(1)

        self.assertEquals(s.size(),1)

        self.assert(s.includes(1))
    }
}
```

In Pharo
s add: 1. <=> s.add(1);

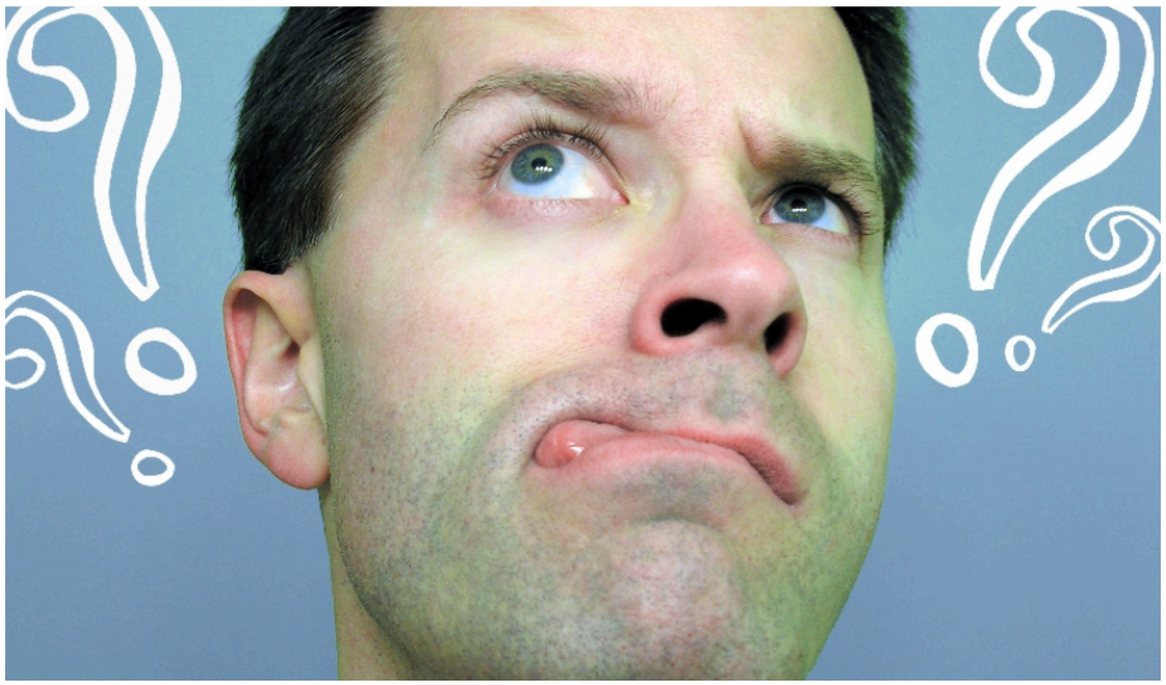
ANATOMY OF A SMOKE TEST

```
SetTest » testSetAddSmokeTest

    | s |

    s := Set new.

    s add: 1.

    s add: 1
```

- No assertion
- Not a rotten green test

A ROTTEN GREEN TEST IS

- A test *passing (green)*
- A test that contains at least one ***assertion***
- One or more assertions is ***not*** executed when test runs



A LITTLE SKETCH OF A ROTTEN GREEN TEST

```
class RottenTest {
    method testABC {
     if (false) then {self.assert(x)}
    }

}
```

A REAL ONE

```
TPrintOnSequencedTest » testPrintOnDelimiter

    | aStream result allElementsAsString |

    result := ''.

    aStream := ReadWriteStream on: result.

    self nonEmpty printOn: aStream delimiter: ', '.

    allElementsAsString := result findBetweenSubstrings: ', '.

    allElementsAsString withIndexDo: [:el :i |

        self assert: el equals: ((self nonEmpty at:i) asString) ]
```

A REAL ONE

```
TPrintOnSequencedTest » testPrintOnDelimiter

    | aStream result allElementsAsString |

    result := ''.

    aStream := ReadWriteStream on: result.

    self nonEmpty printOn: aStream delimiter: ', '.

    allElementsAsString := result findBetweenSubstrings: ', '.

    allElementsAsString withIndexDo: [:el :i |

        self assert: el equals: ((self nonEmpty at:i) asString) ]
```

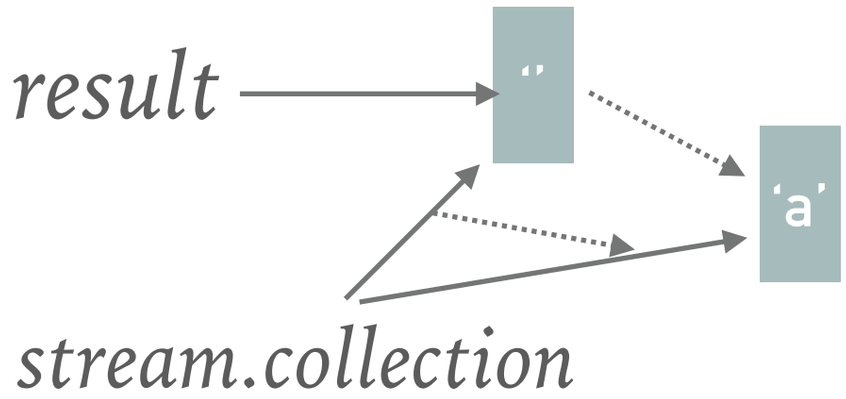
Not executed!

The programmer believed that the object on which the stream is working is “magically” mutated on stream growth

```
TPrintOnSequencedTest » testPrintOnDelimiter

    | aStream result allElementsAsString |

    result := ''.

    aStream := ReadWriteStream on: result.

    self nonEmpty printOn: aStream delimiter: ', '.

    allElementsAsString := result findBetweenSubstrings: ', '.

    allElementsAsString withIndexDo: [:el :i |

        self assert: el equals: ((self nonEmpty at:i) asString) ]
```

result stays empty

Iterator does not run



ROTTEN GREEN TEST WRITERS

- Rotten green tests are NOT intentional
- We say: this is ***not*** the programmer's fault
- Instead: it is the fault of testing tools that **do not report** them

WHY ARE ROTTEN GREEN TESTS BAD?

- Give a false sense of security
- Can easily pass unnoticed
- Not reported by testing frameworks prior to ***DrTest***

ROTTEN GREEN TEST IS...

- A test ***passing (green)***
- A test that contains at least one ***assertion***
- One or more assertions is ***not*** executed when test runs

MAINLY CAUSED BY

- Conditional code not executing a branch
- Iterating over an empty collection

ROTTEN GREEN TEST IS...

- A test ***passing (green)***
- A test that contains at least one ***assertion***
- One or more assertions is ***not*** executed when test runs

HOW TO IDENTIFY THEM?

HANDLING HELPERS

```
class RottenTest {
    method testABC {
        if (false) then {self.helper()}
    }

    method helper {
        self.secondHelper()
    }

    method secondHelper {
        self.assert(x)
    }
}
```

HANDLING HELPERS

```
class RottenTest {
    method testABC {
        if (false) then {self.helper()}
    }
    method helper {
        self.secondHelper()
    }
    method secondHelper {
        self.assert(x)
    }
}
```

Not executed!

Not executed!

ABOUT THE NEED FOR CALL SITE ANALYSIS

```
class RottenTest {
    method testDEF {
        self.badHelper()
        self.assert(true)
    }

    method badHelper {
        if (false) then {
            self.secondHelper()
        }
    }

    method secondHelper {
        self.assert(x)
    }
}
```

ABOUT THE NEED FOR CALL SITE ANALYSIS

```
class RottenTest {
    method testDEF {
        self.badHelper()
        self.assert(true)
    }

    method badHelper {
        if (false) then {
            self.secondHelper()
        }
    }

    method secondHelper {
        self.assert(x)
    }
}
```

Executed!

Not executed!

Not executed!

IDENTIFYING ROTTEN GREEN TESTS

- We use both
  - *Static analysis,* to identify helpers and inherited methods
  - *Dynamic analysis,* to identify ***call*** sites that are not executed

IDENTIFYING ROTTEN GREEN TESTS

- **Static** Analysis
  - Identify “testing primitives” (assert:, deny:…)
  - Identify helper methods (abstract interpreter)
- **Dynamic** Analysis through instrumentation
  - Instrument the **call-sites** of the “test primitives”
- Run the test suite
  - Record green tests whose test primitives are not executed
- Generate Report

BEFORE TEST EXECUTION: FIRST IDENTIFYING THE HELPERS

```
class RottenTest {
    method testDEF {
        self.badHelper()
        self.assert(true)
    }

    method badHelper {
        if (false) then {
            self.secondHelper()
        }
    }

    method secondHelper {
        self.assert(x)
    }
}
```

BEFORE TEST EXECUTION: FIRST IDENTIFYING THE HELPERS

```
class RottenTest {
    method testDEF {
        self.badHelper()
        self.assert(true)
    }

    method badHelper {
        if (false) then {
            self.secondHelper()
        }
    }

    method secondHelper {
        self.assert(x)
    }
}
```

is an helper

is an helper

BEFORE TEST EXECUTION: INSTALLING CALL SITE SPIES

```
class RottenTest {
    method testDEF {
        self.badHelper()
        self.assert(true)
    }

    method badHelper {
        if (false) then {
            self.secondHelper()
        }
    }

    method secondHelper {
        self.assert(x)
    }
}
```

spy

spy

AT EXECUTION

```
class RottenTest {
    method testDEF {
        self.badHelper()
        self.assert(true)
    }

    method badHelper {
        if (false) then {
            self.secondHelper()
        }
    }

    method secondHelper {
        self.assert(x)
    }
}
```

spy

spy

CASE STUDIES (CHECK THE PAPER)

- 19,905 tests analysed on mature projects
- 294 rotten (25 fully rotten)

Project	Description	#pack.	#classes	#test	#tests classes	#helpers	found rotten tests: missed fail	missed skip	context dependent	fully rotten
Compiler	AST model and compiler of Pharo.	6	232	51	859	10	0	0	1	4
Aconcagua	Model representing measures.	2	84	27	661	2	0	0	0	0
Buoy	Various package extensions	12	51	19	185	0	0	0	0	0
Calypso	Pharo IDE.	58	705	157	2692	4	88	0	0	0
Collections	Pharo collection library.	16	222	59	5850	32	0	5	119	17
Fuel	Object serialization library.	6	131	30	518	4	0	0	5	0
Glamour	UI framework.	19	463	65	458	9	0	0	0	0
Moose	Software analysis platform.	66	491	120	1091	6	1	0	0	1
PetitParser2	Parser combinator framework.	14	319	78	1499	349	0	0	0	1
Pillar	Document processing platform.	32	354	127	3179	136	0	0	0	1
Polymath	Advanced maths library.	54	299	91	767	3	0	0	0	0
PostgreSQL	PostgreSQL Parser.	4	130	11	130	2	0	0	0	0
RenoirSt	DSL to generate CSS.	4	103	42	157	4	0	0	0	0
Seaside	Web application framework.	49	837	134	806	44	35	17	0	1
System	Low-level system packages	40	260	46	553	11	0	1	9	0
Telescope	Visualisation framework.	6	173	21	87	0	0	0	0	0
Zinc	HTTP library.	9	184	43	413	12	0	0	0	0

RESULTS

- **Missing fail:** test passes false to **assert:**, instead of using **fail**

- **Missed skip:** test contains guards to stop its execution early (under certain conditions), instead of using **skip**

- **Context-dependent logic:** complex logic with different assertions in different branches — some may be rotten too

- **Fully rotten:** other tests that do not execute one or more assertions

MISSED FAIL

➤ Test passes false to **assert:**, instead of using **fail**

```
TSequencedElementAccessTest » test0FixtureSequencedElementAccessTest
    self moreThan4Elements.
    self assert: self moreThan4Elements size >= 4.
    self subCollectionNotIn
        detect: [:each | (self moreThan4Elements includes: each) not]
        ifNone: [ self fail ].
self elementNotInForElementAccessing.
self deny: (self moreThan4Elements includes: self
elementNotInForElementAccessing).
self elementInForElementAccessing.
self assert: (self moreThan4Elements includes: self
elementInForElementAccessing)
```

SOLVING MISSING FAIL

- Test passes false to **assert:**
- Check on a case by case basis
- Use **fail** to really indicate that the assertion should not be executed

MISSED SKIP

- Test contains guards to stop its execution early (under certain conditions), instead of using **skip**

```
OCContextTempMappingTest »
testAccessingArgOfOuterBlockFromAnotherDeepBlock
    | actual |
    "Check source code availability; do not fail on images without sources"
    thisContext method hasSourceCode
        ifTrue: [self skip]
    actual := [:outerArg | outerArg asString.
                    [ :innerArg | innerArg asString.
                    thisContext tempNamed: #outerArg ] value: #innerValue.
                ] value: #outerValue.
    self assert: actual equals: #outerValue
```

SOLVING MISSED SKIP

- Test contains guards to stop its execution early (under certain conditions), instead of using **skip**
- Easy to fix: use **self skip**
- Runner can then report correctly

CONTEXT DEPENDENT LOGIC

- Complex logic with different assertions in different branches — some may be rotten too

```
FLBasicSerializationTest » testCharacter
    "Test character serialization. If the code is less than 255 the
same instance is used. But if it is bigger, new ones are
created."
self assertSerializationIdentityOf: $a.
FLPlatform current isSpur
    ifTrue: [ self assertSerializationIdentityOf: (Character value: 12345).
    "Japanese Hiragana 'A' " ]
    ifFalse: [ self assertSerializationEqualityOf: (Character value: 12345).
    "Japanese Hiragana 'A' " ].
self assertSerializationEqualityOf: Character allCharacters.
self assertSerializationEqualityOf: (Array with: $a with: (Character value:
12345)).
```

SOLVING CONTEXT DEPENDENT LOGIC

- Complex logic with different assertions in different branches — some may be rotten too
- How to fix:
  - create a separate test for each branch
  - use **self skip** to execute the test only when it applies

FULLY ROTTEN TESTS

- Other tests that do not execute one or more assertions

```
testFamixPackageNamespace
    self
        should: [ self assert: self packReferee ]
        raise: Error
```

```
testFamixPackageNamespace {
    try{
        self.assert(self.packReferee())
        self.fail()
    } catch(Error e){  }
}
```

- packageP5FullReferee ***did*** raise Error, so assert: is never invoked!

FULLY ROTTEN

- Other tests that do not execute one or more assertions

```
MustBeBooleanTests » testAnd (original)
    | myBooleanObject |
    myBooleanObject := MyBooleanObject new.
    self deny: (myBooleanObject and: [true])
```

- Compiled method bytecode was dynamically rewritten by the compiler as:

```
MustBeBooleanTests » testAnd (rewritten)
    | myBooleanObject |
    myBooleanObject := MyBooleanObject new.
    ^ (myBooleanObject) and: [ true ]
```

*Oops the **deny**: disappeared!*

SOLVING FULLY ROTTEN

- Case-by-case analysis and repair

CONCLUSION

- Rotten Green Tests exist. Yes M'dam
- Every Unit-testing framework should report them
- ***DrTests*** the new Pharo Unit framework reports them

- Working on Java and Python replication
  - Found many of them in great Java frameworks :)
  - Looking for extra case studies