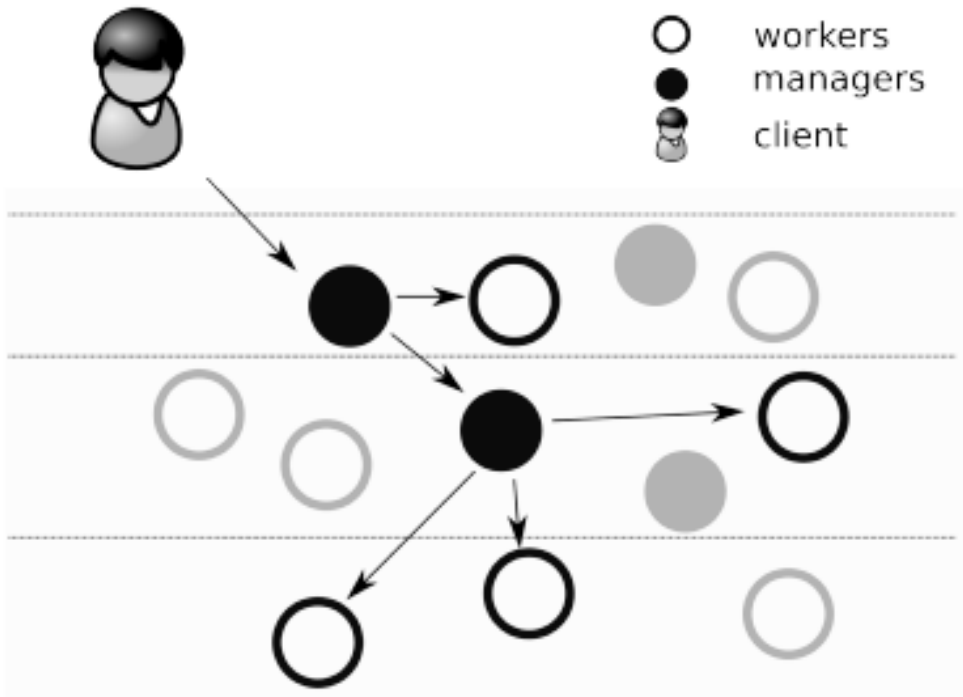
Testing, JUnit Extensions, TDD

PV260 Software Quality

March 30, 2016

Developers' Tests

- Unit tests
- Integration tests
- End-to-end tests



- Tomek Kaczanowski, *Practical Unit Testing with...*

Unit Tests

Unit test...

- focuses on single class
- makes sure that YOUR code works
- controls context
- knows nothing about the users of the tested system
- is unaware of layers, external systems and resources
- runs very quickly, is executed frequently

- Tomek Kaczanowski, *Practical Unit Testing with...*

Unit Tests

Unit test DOES NOT...

- talk to the database
- communicate across the network
- touch the file system
- misbehave when run in parallel with any other unit tests
- require special things done to your environment to run

- Michael Feathers, *A Set Of Unit Testing Rules*

Anatomy of a Unit Test

AAA

- Arrange
- Act
- Assert

BDD

- Given
- When
- Then

xUnit

- Setup
- Exercise
- Verify
- Teardown

`http://c2.com/cgi/wiki?ArrangeActAssert`
`http://martinfowler.com/bliki/GivenWhenThen.html`
`http://xunitpatterns.com/Four%20Phase%20Test.html`

JUnit extensions

- JUnit is an extremely powerful tool and virtually anything can be done using only the pure JUnit core functionality
- In some cases however we might benefit from using extensions of the basic functionality, syntactic sugar ...
- These allow us to work faster, reduce the boilerplate code which brings no value, and make the test suite easier to maintain
- For most common needs both third party libraries and native JUnit extensions (some only in experimental branch) exist

JUnit extensions

- Fluent API for assertions
  - Hamcrest `http://hamcrest.org/JavaHamcrest/`
  - AssertJ `http://joel-costigliola.github.io/assertj/`
- Parametrized /Data-Driven tests
  - JUnit Parametrized `http://junit.sourceforge.net/javadoc/org/junit/runners/Parameterized.html`
  - Zohhak runner `http://piotrturski.github.io/zohhak/`
  - JUnitParams `https://github.com/Pragmatists/JUnitParams`

JUnit extensions - cont

- Property testing using randomized input
  - JUnit Theories `http://junit.org/apidocs/org/junit/experimental/theories/Theories.html`
  - junit-quickcheck `https://github.com/pholser/junit-quickcheck`
- And many others
  - Unitils `http://www.unitils.org/summary.html`
  - catch-exception `https://github.com/Codearte/catch-exception`
  - tempus-fugit `http://tempusfugitlibrary.org/`

AssertJ

http://joel-costigliola.github.io/assertj/

- Rich DSL, specific for many types - Collections, Strings, numbers, Exceptions, Time ...
- Really helpful error messages
- Soft Assertions - show all errors, not just the first
- Extractors and Tuples
- Many extensions exist to test Database, Swing, Guava...

see homepage for extensive showcase of features

AssertJ

example: AssertJTest class

catch-exception

https://github.com/Codearte/catch-exception

- Catch and verify exceptions in a single line of code
- The test is more concise and easier to read.
- The test cannot be corrupted by a missing assertion.
- A single test can verify more than one thrown exception.
- The test can verify the properties of the thrown exception after the exception is caught.
- The test can specify by which method call the exception must be thrown.

- *Javadoc of CatchException class*

catch-exception

- Java 8 syntax (version 2.0.0)

```
MyObject myObject = new MyObject();
catchException(() -> myObject.doStuff(1));
Exception caught = caughtException();
assertThat(caught).is...
```

- pre-Java 8 syntax (version 1.4.4)

```
MyObject myObject = new MyObject();
catchException(myObject).doStuff(1);
Exception caught = caughtException();
assertThat(caught).is...
```

catch-exception

example: CatchExceptionTest class

Zohhak

https://code.google.com/p/zohhak/

Allows us to run one test on many sets of data, provided in annotation next to the testcase

```
@TestWith({
    "1,2,3",
    "-19,7,-12"
})
public void testAdd(int a, int b, int expected) {
    Calculator calc = new Calculator();
    int result = calc.add(a,b);
    assertEquals(expected, result);
}
```

Zohhak - Data

- The Strings inside the `@TestWith({...})` each represent one test input
- Inside each of these input Strings individual arguments for the test are separated by commas (',')
- Types of the arguments are infered from the parameters of the test method and the arguments are coerced to these types before being passed to the test
  - Coercion of basic primitive types comes out-of-th-box
  - Custom coercion for any type can be written

Zohhak - Coercions

For more complex types we have to teach zohhak how to convert from String (the String in data annotation) to our type

```
@Coercion
public Person toPerson(String input) {
    String[] split = input.split(";");
    Person person = new Person(split[0], split[1]);
    return person;
}
```

We can then use Person in our tests

```
@TestWith({
    "John;Doe",
    "Frank;Perceval"
})
public void testWithPerson(Person person){
```

Zohhak

example: Vector2DTest class

JUnitParams

https://github.com/Pragmatists/JUnitParams

- Same purpose as Zohhak
- + Can read data from file - CSV, Excel

example: CSVFileInputTest class

junit-quickcheck

http://pholser.github.io/junit-quickcheck/site/0.6/index.html

- We don't test concrete inputs but properties of code
- Input is generated randomly
- The test is a specification of what the code should do
- If error is found QuickCheck tries to 'Shrink' it to 'smallest' possible value which causes the same error
- Inspired by QuickCheck for Haskell `https://hackage.haskell.org/package/QuickCheck`

junit-quickcheck

```
@RunWith(JUnitQuickcheck.class)
public class SymmetricKeyCryptographyProperties {
    @Property
    public void decryptReversesEncrypt(
            byte[] plaintext, Key key){
        Crypto crypto = new Crypto(key);
        byte[] ciphertext = crypto.encrypt(plaintext);
        assertEquals(plaintext,
                     crypto.decrypt(ciphertext)));
    }
```

junit-quickcheck

Task 1

- Try to run QuickcheckTest, it should fail
- The test is correct, implementation is broken
- Find what is wrong with the current implementation
- Implement StringSplitter so that the test passes

junit-quickcheck

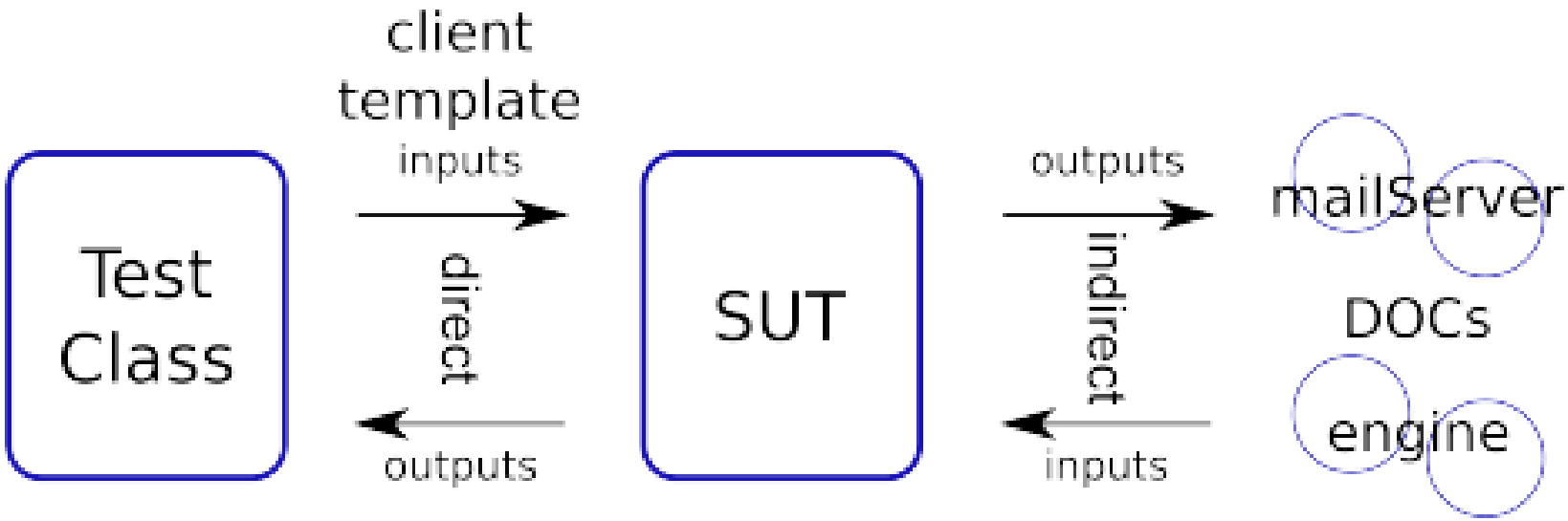
Task 2

- Come up with at least 3 properties of a sorting algorithm
- Work with the Sorter interface
- Write quickcheck test for each of these properties
- Implements the Sorter using algorithm of your choice

Behavior Verification

State Verification

Behavior Verification



Mocking in Unit Testing

- Unit testing is simple for classes with no dependencies
- How do we test an object which depends on many other things (many of which might not even be implemented yet) ?
- We create stand-in objects which share interface with the required dependency
- Inside, instead of some complex behavior, these are hard-wired to work in the one particular test case
- We can create these substitutes either by hand or use a mocking framework

Mockito

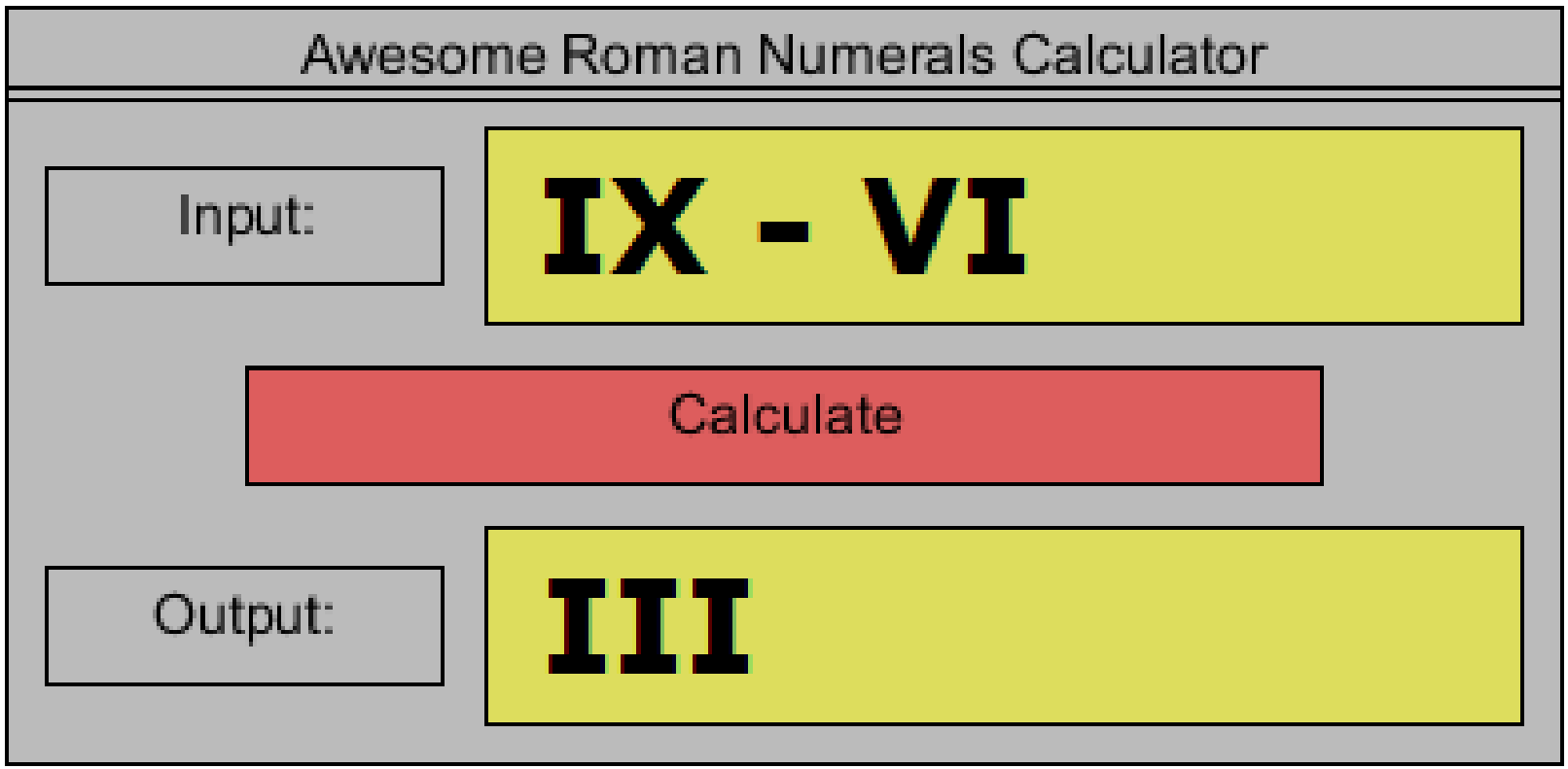
http://mockito.org/

> *We decided during the main conference that we should use JUnit 4 and Mockito because we think they are the future of TDD and mocking in Java.*
>
> *(Dan North - author of BDD)*

- Interaction verification
- Input stubbing (data, exceptions. . .)
- Test Spy wrappers
- Mock both classes and interfaces
- Lightweight API

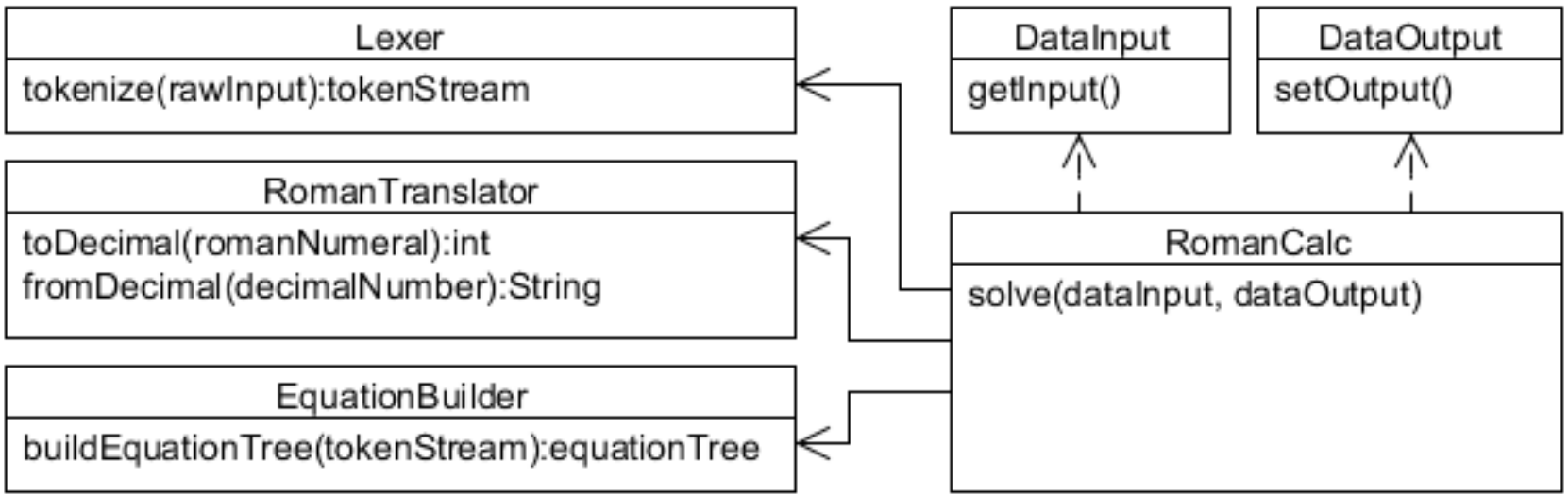
Working Example

- Model for an app doing basic math on Roman numerals
- We only care about the inner logic, the UI doesn't concern us



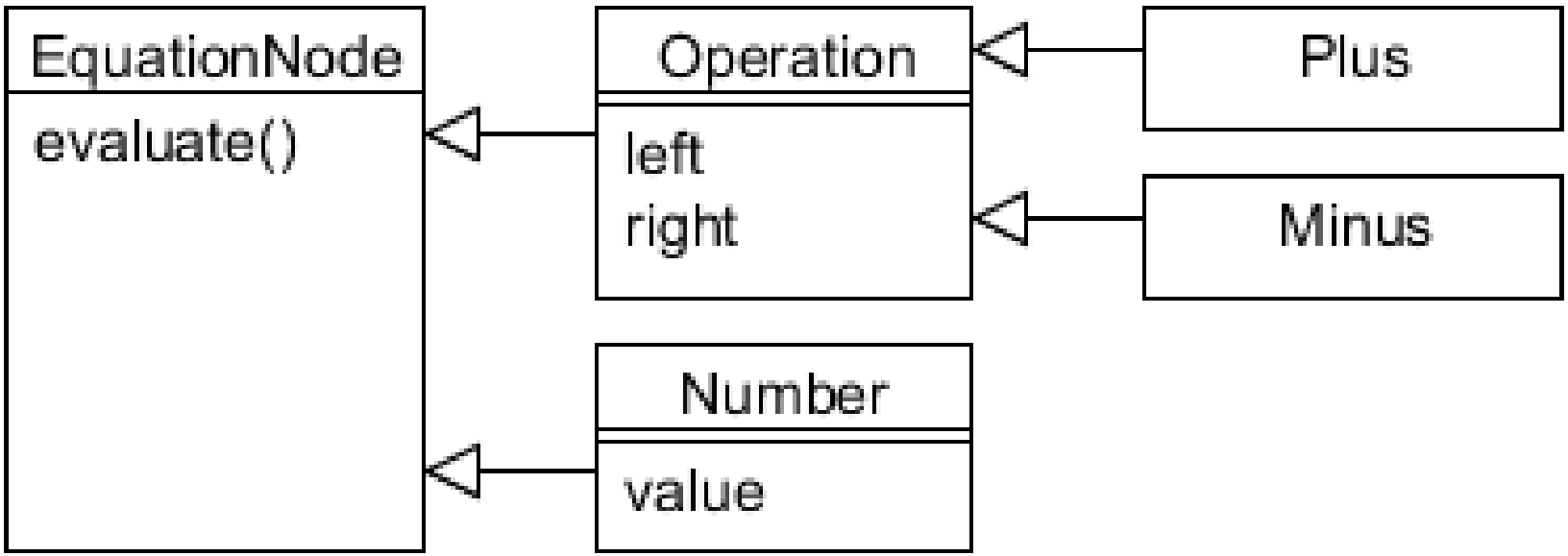
Working Example - Structure

- We already have the design done, all interfaces are prepared
- DataInput and DataOutput represent the textboxes
- Clicking the Calculate button calls the solve method



Working Example - Structure

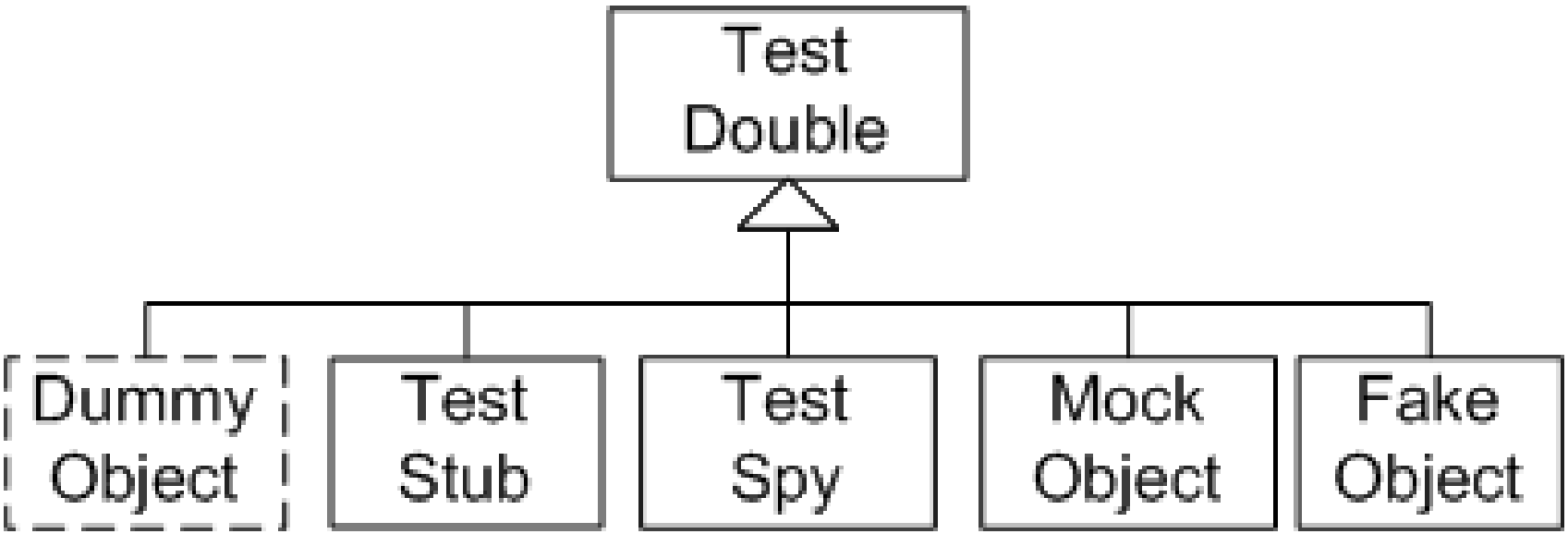
- Lexer tokenizes the raw input
- Number tokens are translated by the RomanTranslator and sent to EquationBuilder
- Tree representation of the equation is assembled
- The decimal result is translated to Roman numerals
- Formated result is sent back to output



Test Doubles Hierarchy

http://xunitpatterns.com/Test%20Double.html

- There are many types of stand-in objects used in testing
- Each plays a different role, the simplest type possible should be used (That is dont use a Mock if all you need is a Dummy)



Dummy Object

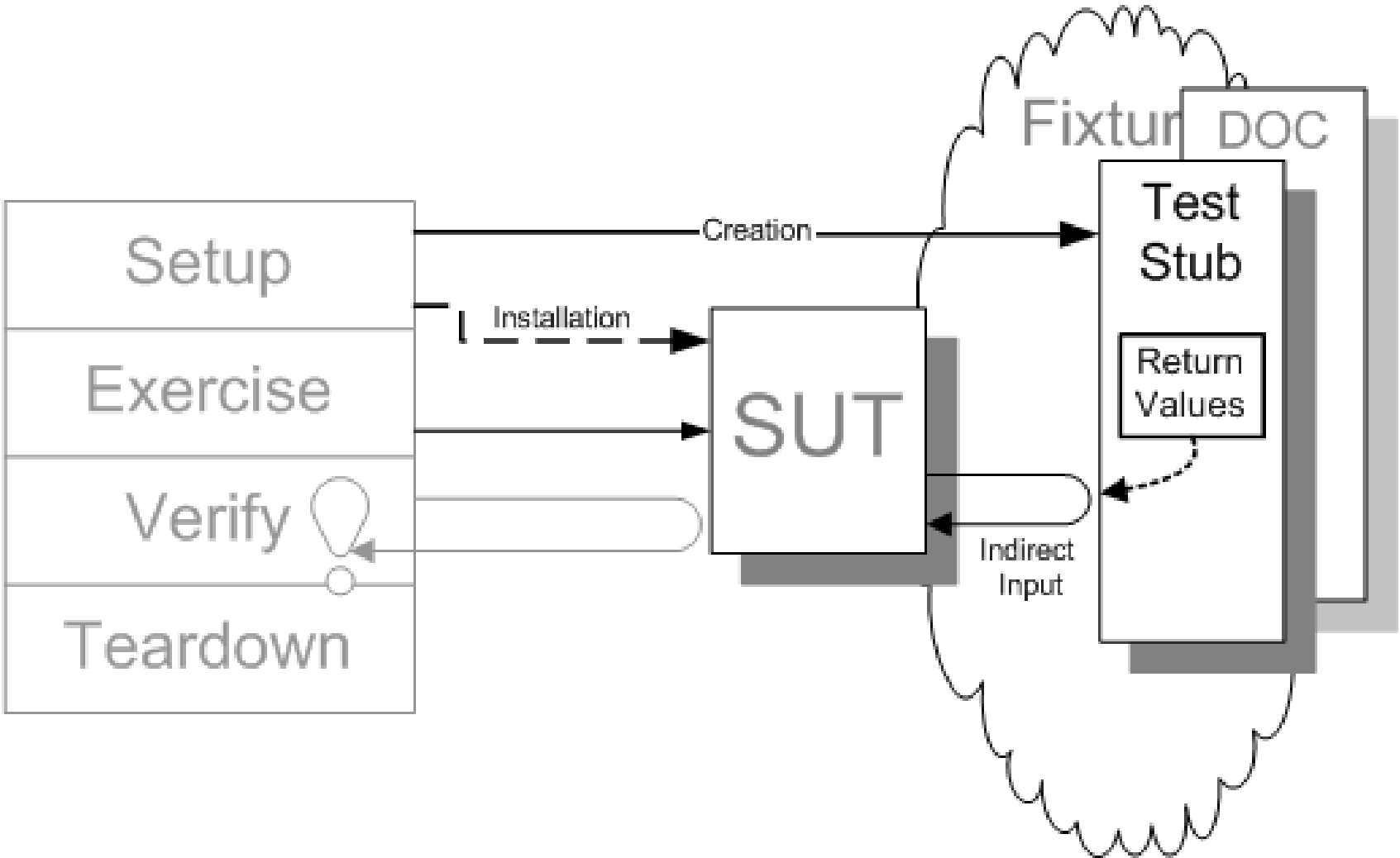
RomanCalculatorTest#testExceptionFromInput

- We need to provide real object (that is not *null*), but at the same time we know it will never be used during the test
- Even better, we pass *null* to the test which helps readability as we are clearly signalling that the value is not used
- This is of course not possible with null-checks in constructors, so we have to use dummies instead.
- To Assert or Not To Assert
  `http://misko.hevery.com/page/5/`

Test Stub

RomanTranslatingTokenStream#testConvertsToDecimalTokens

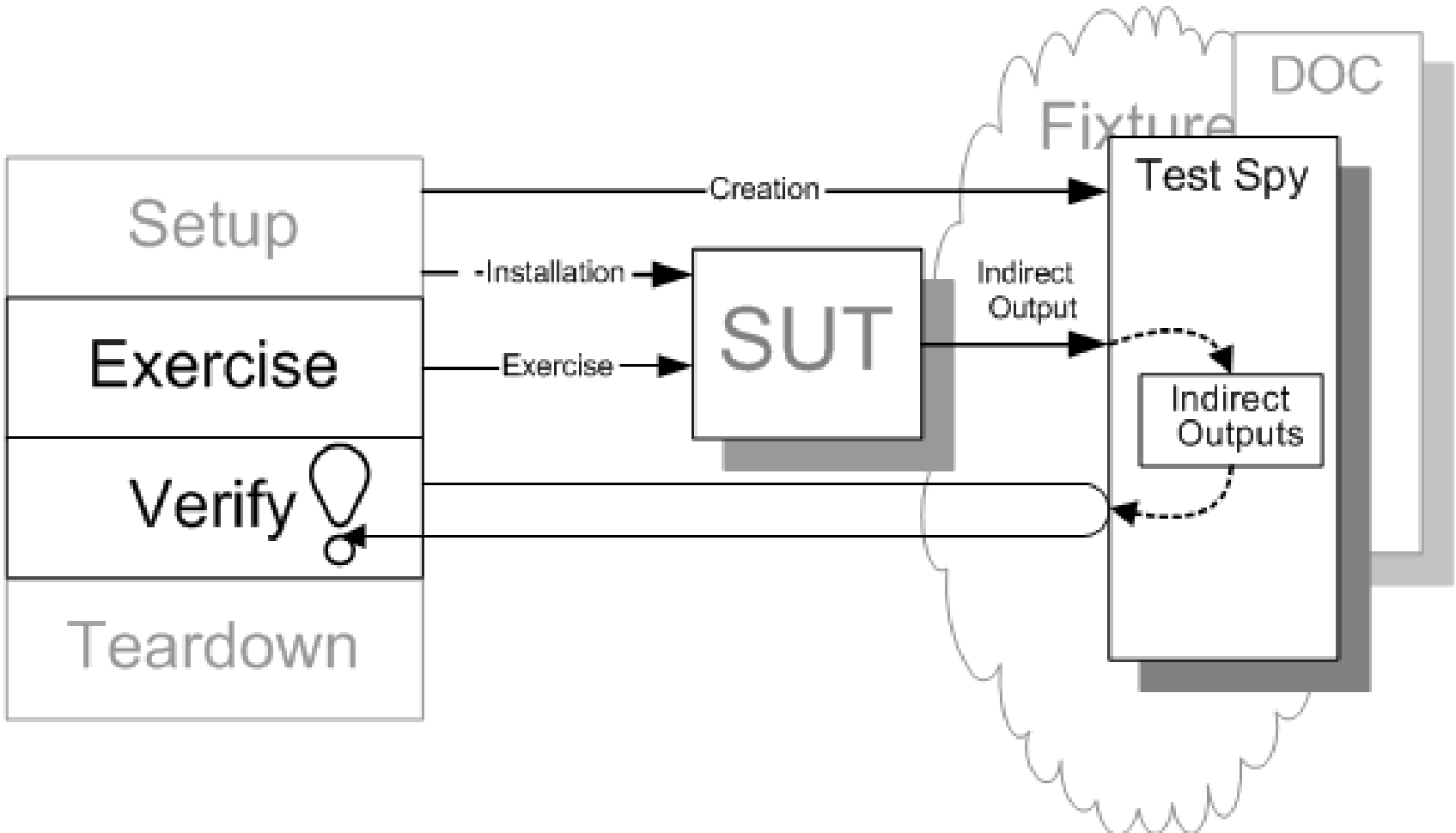
- We want one of SUT's dependencies to provide specific input to the SUT when queried



Test Spy

RomanTranslatingTokenStream#testRecognizesRomanNumeral

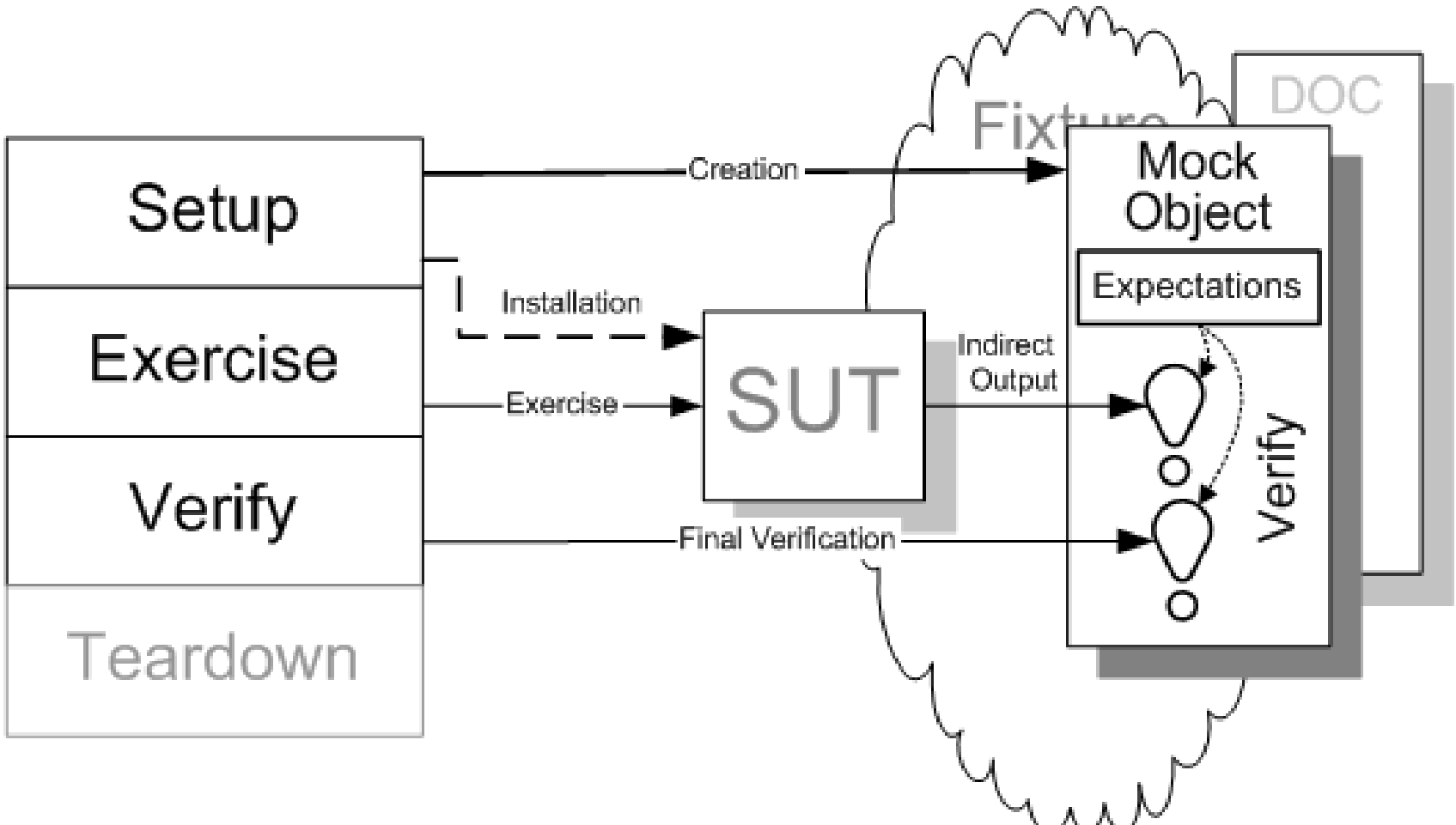
- We want to know SUT's interacts with one of its dependencies
- The spy only records the interaction, it is checked manually



Mock Object

RomanTranslatingTokenStream#testCorrectInputSingleOperator

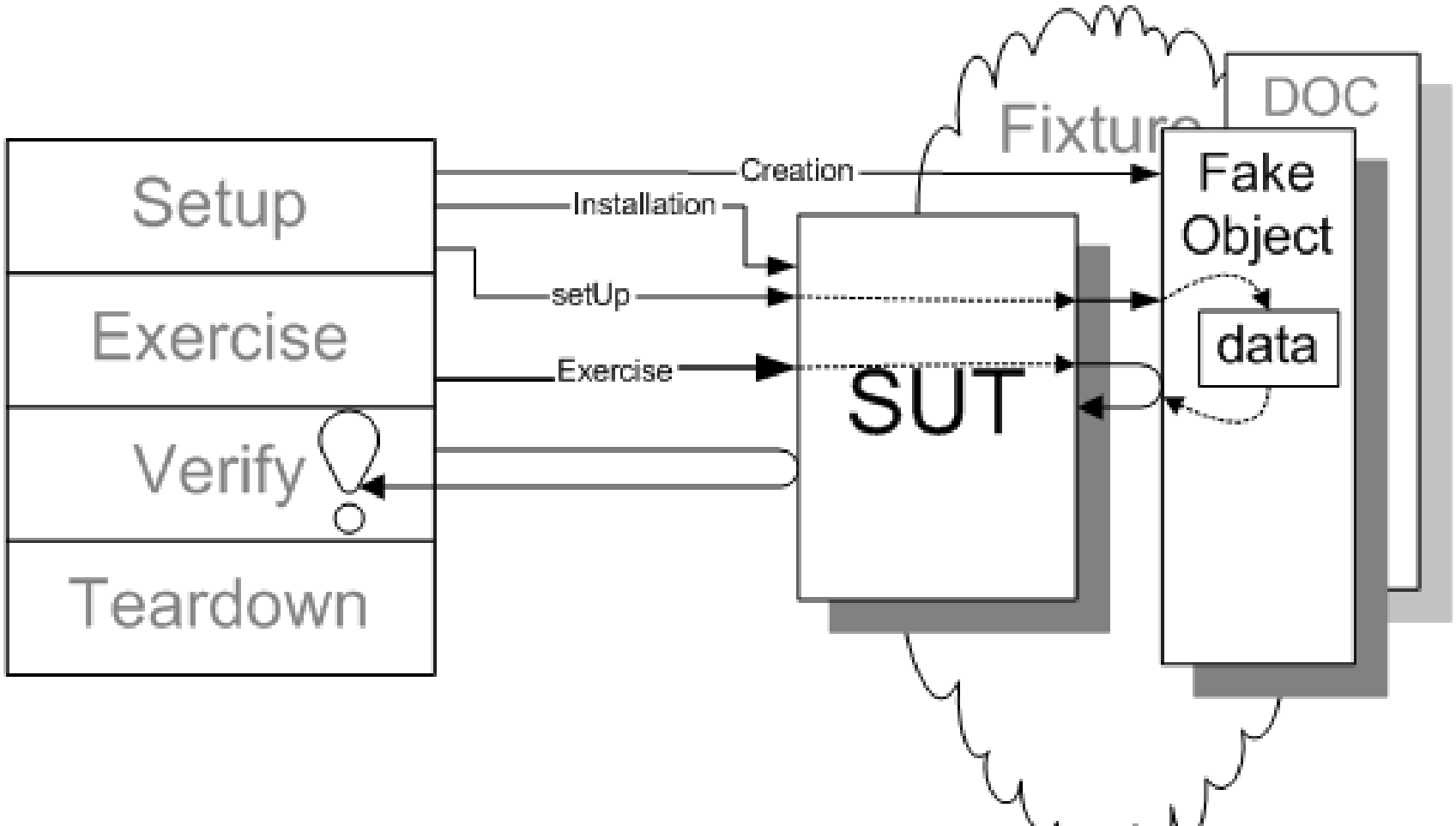
- Similar task as Test Spy, but checks the validity of SUT's interaction with the mock on the fly



Fake Object

No Example

- Has the same functionality as its real counterpart, but implements it in a more test friendly way
- e.g. an in-memory database instead of disk-based one



Test Spy vs. Mock

Test Spy

Mockito

- Arrange → Act → Assert
- Whole test runs
- Nice
- Verification always in caller

Mock

EasyMock

- Record → Exercise → Verify
- Stop on first error
- Strict
- Might be suppressed by environment

Test Doubles Exercise

Task 1

- implement all tests in CustomerAnalysisTest
- try to use Mockito in some cases and manual Test Doubles in others

Test Coverage

In computer science, test coverage is a measure used to describe the degree to which the source code of a program is tested by a particular test suite.

- High coverage does not necasarilly mean that your project has quality tests (there could be tests with no assertions, hardly maintainable tests . . .)
- However, low coverage can point to parts of insufficiently tested code which has a high chance of containing all kinds of bugs and other problems

Types of Coverage

Consider this code:

```
public int doIt(boolean c1, boolean c2, boolean c3) {
    int x = 0;
    if (c1)
        x++;
    if (c2)
        x--;
    if (c3)
        x+=3;
    return x;
}
```

Types of Coverage

- Statement coverage
  - Check that all statements in the code are executed
  - For 100% coverage single test input required *(true, true, true)*
- Branch coverage
  - Check that all possible results of conditions occur
  - For 100% coverage two test inputs required *(true, true, true)*, *(false, false, false)* or any other combination with both true and false for all conditionals
- Path coverage
  - Every possible path through the code is executed
  - For 100% coverage all possible combinations of inputs (and values for member attributes if there were any) must be used, thats 8 cases for this example

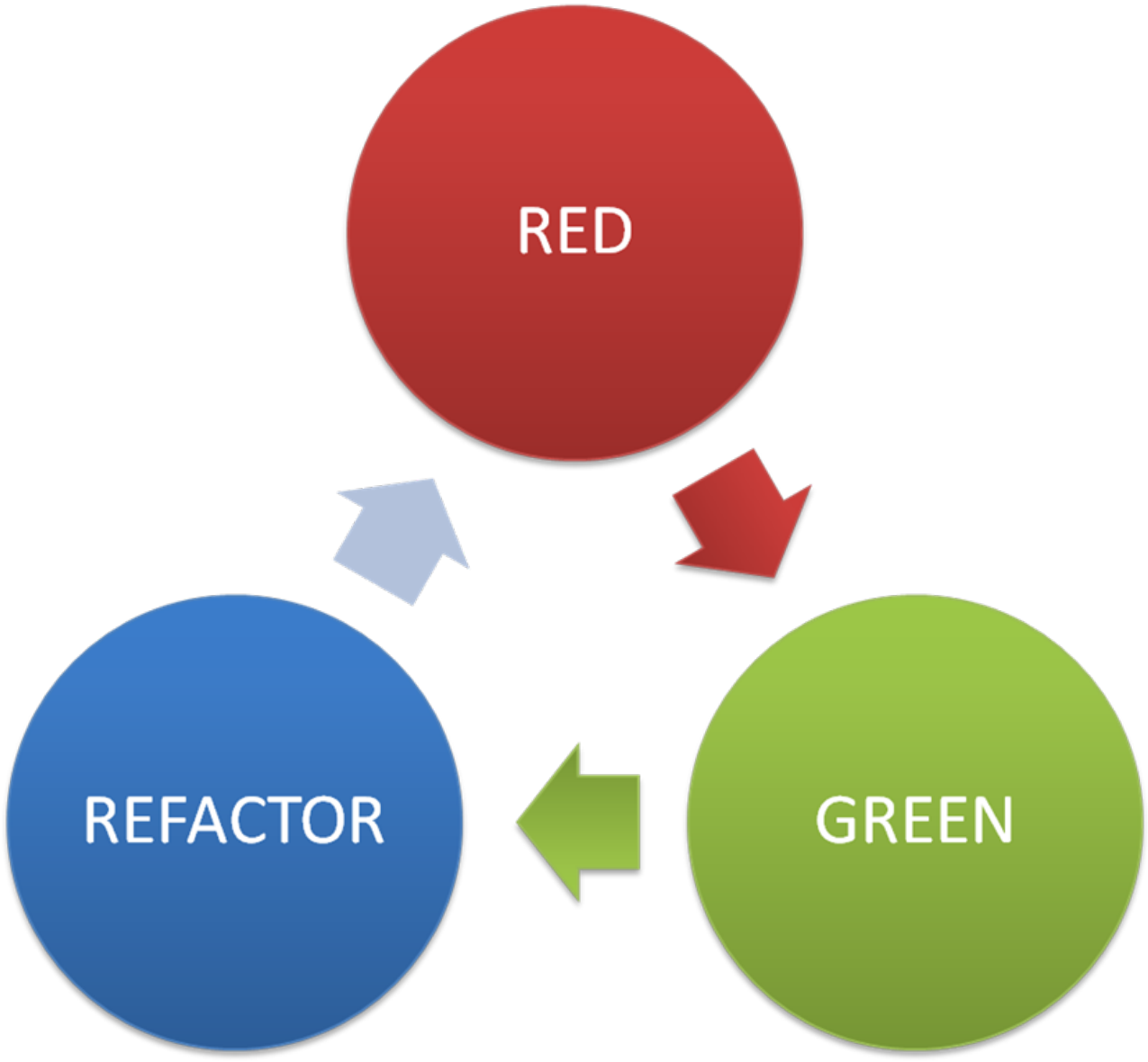
TDD - Overview

Test Driven Development: By Example, Kent Beck

Test-driven development (TDD) is a software development process that relies on the repetition of a very short development cycle: first the developer writes an (initially failing) automated test case that defines a desired improvement or new function, then produces the minimum amount of code to pass that test, and finally refactors the new code to acceptable standards.

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

Red Green Refactor



Tennis Game Kata - Scoring

- Each player starts with 0 points
- The scoring then goes like this $0 \rightarrow 15 \rightarrow 30 \rightarrow 40$
- If `A` has 40 and scores, and `B` doesn't have 40, `A` wins
- If both have 40 and `A` scores, `A` has Advantage
- If `A` has Advantage and scores, they win
- If `A` has Advantage, `B` has 40 and scores, both are at 40 again
- Scores are written in the format 'A - B', e.g. '30 - 15'
- When `A` has Advantage, the score is written as 'A - 40'
- If scores are equal, e.g. both have 30, it is called '30 all'
- If both players have 40 points, it is called 'deuce'

Tennis Game Kata - Task

- Try to not skip ahead and always have passing tests for existing functionality before moving forward
- We want to create a TennisGame which has `scoredA()`, `scoredB()` and `showScore()`
- The show method should return score in format defined above, if there is a winner it gives 'winner: A/B'
- Also if there is a winner already and either `scoredA()` or `scoredB()` is called, exception should be thrown

Java Highlighter - Task

- Download base for the task at `https://github.com/vaclavHala/PV260_Highlighter`
- Using the same technique as before, try to implement as much as you can
- At the end of seminar we evaluate who got the furthest
- No cheating, code test-first!