Génie Logiciel et Gestion de Projets

Testing

A golden rule...

- Make it Work
- Make it Right
- Make it Fast

How does this work?

- First make sure the software does what you want
  - use unit tests
- Then rework the code until it speaks for itself
  - use refactorings
- Then optimize the performance, if needed
  - use profiling

Roadmap

- What is testing?
- What are tests?
- What is unit testing?
  - Designing unit tests?
- Testing Frameworks
  - Let's go for an example!!

Testing

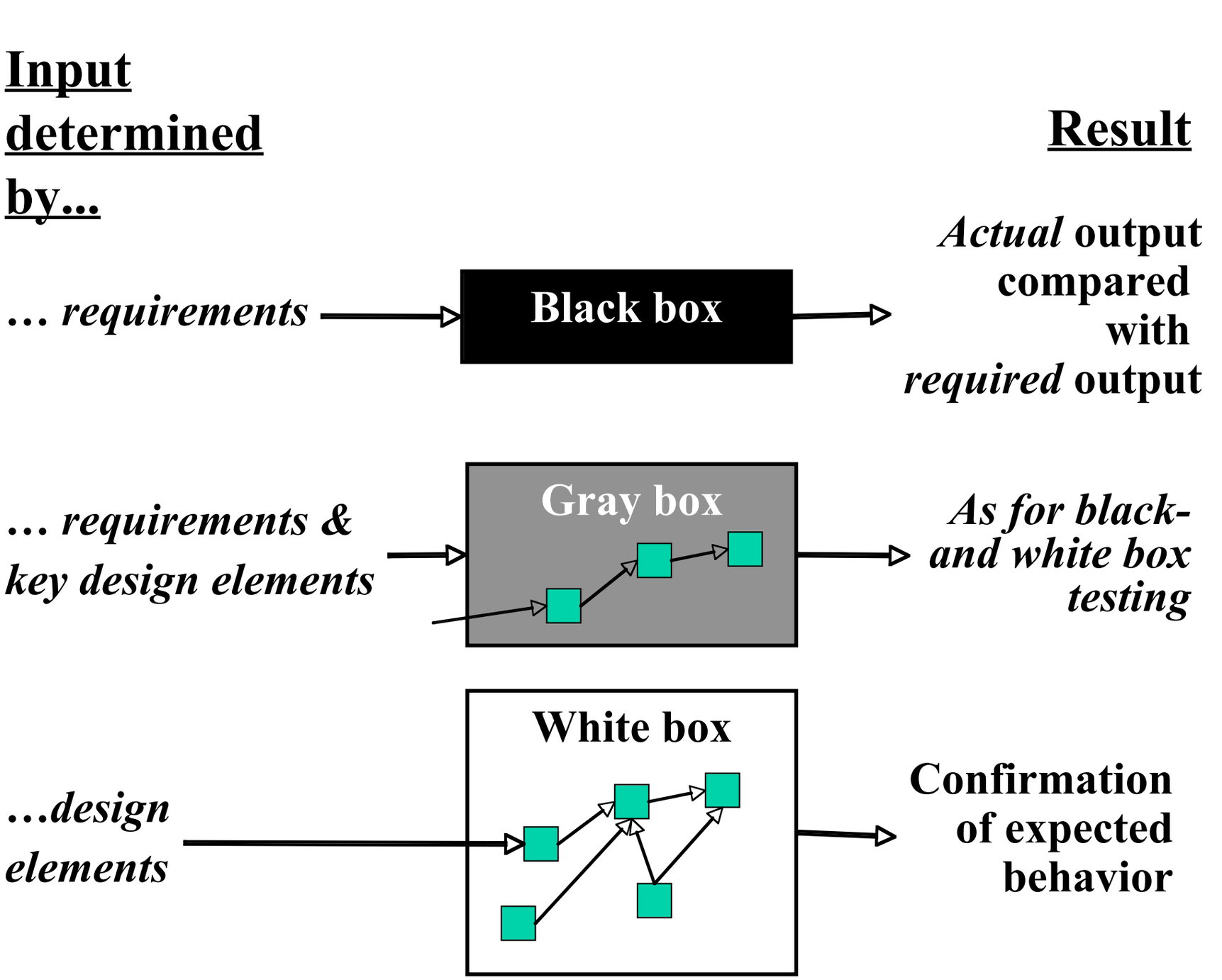
What is testing?

- Testing is the activity of executing a program with the intent of finding a defect
  - a successful test is one that finds a defect!

Golden Rules of Testing

- Goal of testing:
  - maximize the number and severity of defects.
- Limits of testing
  - testing can only determine the presence of defects, never their absence.

Testing Techniques



Adapted from *Software Engineering: An Object-Oriented Perspective* by Eric J. Braude (Wiley 2001).

Testing Strategies

- Testing strategies plans that tell you when you should perform what testing technique.

Testing Strategies

Unit Testing	test individual components
Module Testing	test a collection of related components
Sub-System Testing	test sub-system interface mismatches
System Testing	test interactions between sub-systems tests that the complete system fulfills requirements
Acceptance Testing	test system with real rather than simulated data

Tests

Tests

- Tests represent your trust in the system
- Build them incrementally
  - Do not need to focus on everything
  - When a new bug shows up: write a test
- Even better: test first!
  - Act as your first client
  - Helps finding proper interfaces
- Tests are active documentation: they are always in sync

Testing Style

- "The style here is to write a few lines of code, then a test that should run, or even better, to write a test that won't run, then write the code that will make it run."
  - write unit tests that thoroughly test a single class
  - write tests as you develop (even before you implement)
  - write tests for every new piece of functionality
- "Developers should spend 25-50% of their time developing tests."

But I can't cover anything!

- Sure! Nobody can but:
  - When someone discovers a defect in your code, first write a test that demonstrates the defect.
  - Then debug until the test succeeds.

"Whenever you are tempted to type something into a print statement or a debugger expression, write it as a test instead." Martin Fowler

Unit tests

Unit Testing?

- Why?
  - locate small errors (within a unit) fast.
- Who?
  - Person developing the unit writes the tests
- When?
  - At the latest when a unit is delivered to the rest of the team
    - no test => no unit

Example Unit Test

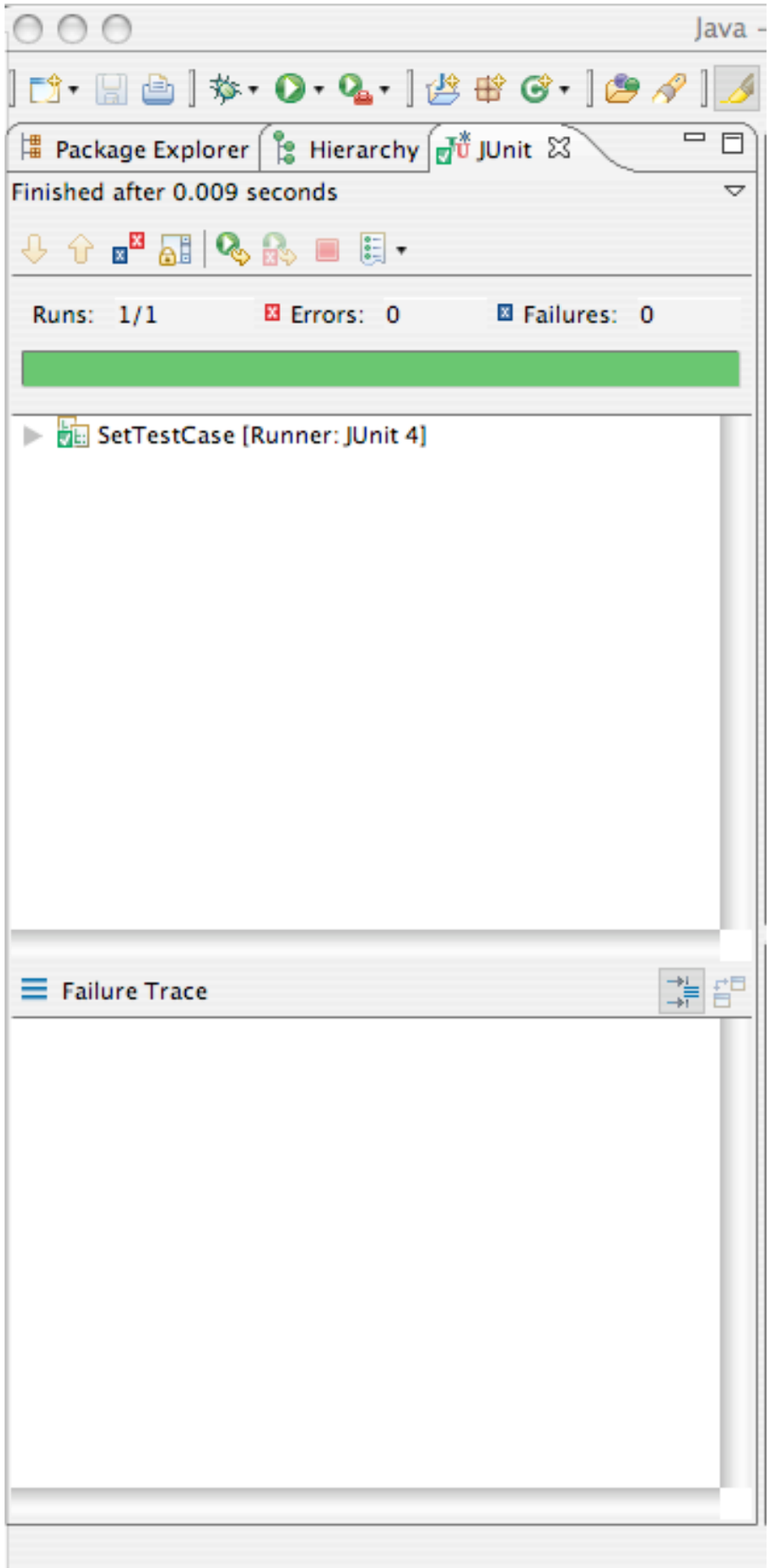
```
public class SetTestCase extends TestCase{

  public SetTestCase(String name) {
      super(name);
  }

  public void testAdd() {
    Set<Integer> empty = new HashSet<Integer>();
    empty.add(5);
    assertTrue(empty.contains(5));
  }

  public static void main(String[] args) {
    junit.textui.TestRunner.run(SetTestCase.class);
  }

}
```


Java
Package Explorer
Hierarchy
JUnit
Finished after 0.009 seconds
Runs: 1/1
Errors: 0
Failures: 0
SetTestCase [Runner: JUnit 4]
Failure Trace

Designing tests

- Build simple tests
- Check that failures are caught
- Run tests frequently (every couple of minutes)
- Test Infrastructure code first, then application-specific code
- Reuse as much test code as you can (tests are code!)
- Write small tests that test one particular aspect
- Make sure the tests are deterministic

Designing tests

- Checklists for method and class testing in [Braude].
- Cookbook by [Beck].

Checklists by [Braude]

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One way to... perform Method Testing (1/2)

1. Verify operation at *normal parameter* values.
2. Verify operation at *limit parameter* values.
3. Verify operation *outside parameter* values.
4. Ensure that *all instructions* execute.
5. Check all *paths*, including both sides of all branches.
6. Check the *use of all called objects*.
7. Verify the handling of all *data structures*.
8. Verify the handling of all *files*.

One way to... perform Method Testing (2/2)

9. Check *normal* termination of all *loops*.
10. Check *abnormal* termination of all *loops*.
11. Check *normal* termination of all *recursion*.
12. Check *abnormal* termination of all *recursions*.
13. Verify the *handling* of all *error* conditions.
14. Check *timing* and *synchronization*.
15. Verify all *hardware dependencies*.

One way to... perform Class Unit Testing (1/2)

1. Exercise methods in combination

- 2-5, usually
- choose most common sequences first
- include sequences likely to cause defects
- requires hand-computing the resulting attribute values

2. Focus unit tests on each attribute

- initialize, then execute method sequences that affect it

3. Verify that each class invariant is unchanged

1. verify that the invariant is true with initial values
2. execute a sequence (e.g., the same as in 1.)
3. verify that the invariant still true

One way to... perform Class Unit Testing

4. Verify that objects transition among expected states

- plan the state / transition event sequence
- set up the object in the initial state by setting variables
- provide first event & check that transition occurred etc.

Cookbook by [Beck]

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Unit Testing Cookbook

- Developers write their own tests, one per class.
- Ensure that you get the specified behaviour of the public interface of a class.
- General setup of a test:
  - Create a context,
  - Send a stimulus,
  - Check the results

Example Unit Test

```
public class SetTestCase extends TestCase{

  public SetTestCase(String name) {
      super(name);
  }

  public void testAdd() {
    Set<Integer> empty = new HashSet<Integer>();
    empty.add(5);
    assertTrue(empty.contains(5));
  }

  public static void main(String[] args) {
    junit.textui.TestRunner.run(SetTestCase.class);
  }

}
```

Context

Stimulus

Check

Testing Frameworks

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Testing Frameworks

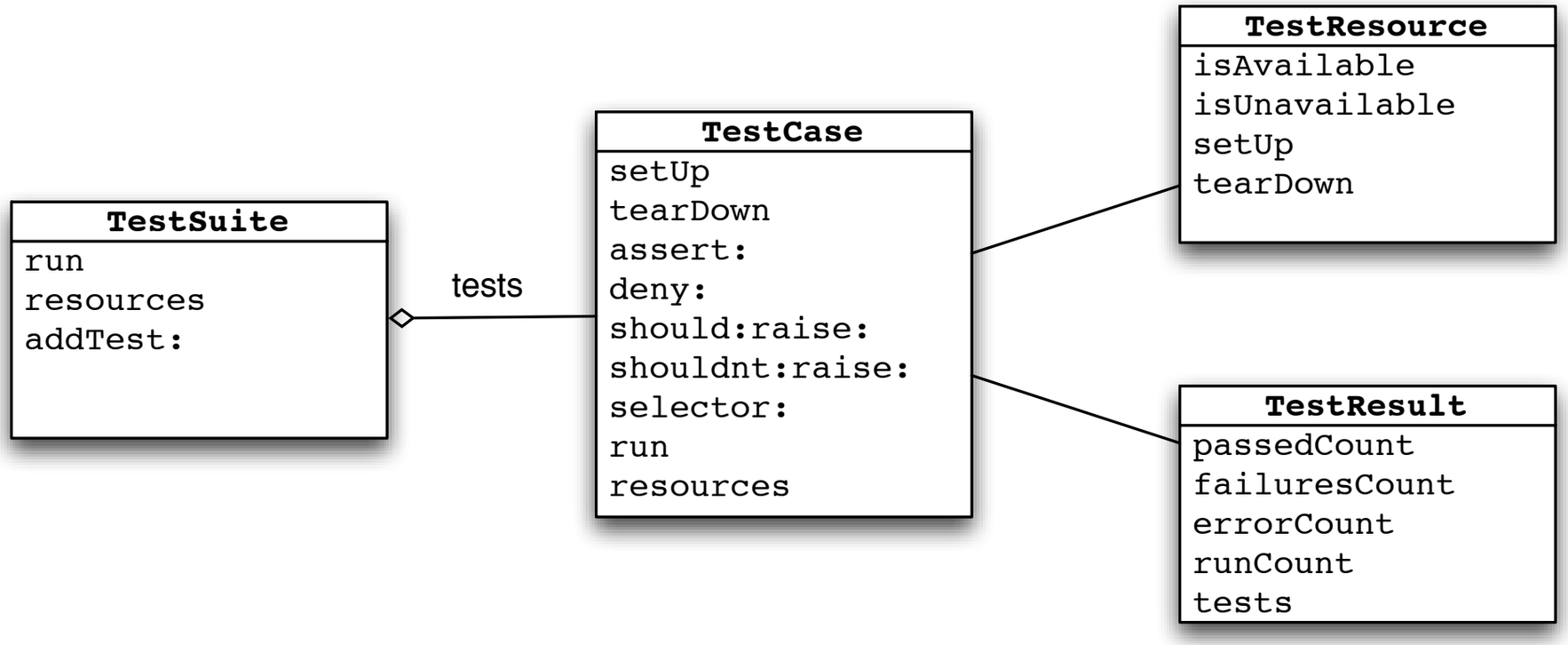
- Tests have to be repeatable.
- Unit Testing Frameworks implement necessary infrastructure so that you can set up your tests, run them frequently, and see the results.
- SUnit is "the mother of all unit test frameworks".
  - started in Smalltalk,
  - fanned out to all kinds of other languages
    - JUnit, CppUnit, ...

SUnit

- Simple unit testing framework for Smalltalk
- Smalltalk-dialect independent
  - you find the same thing for different Smalltalk environments (VisualWorks, Squeak, VisualAge, Dolphin, ...)
- Simple GUI
  - Again, dialect-independent
  - More refined GUI's exist for most platforms

SUnit core classes

- a TestCase represents one test
- A testSuite is a group of tests
- SUnit automatically builds a suite from the methods starting with ‘test*’
- TestResult represents a test execution result



Basic usage

- Make a subclass from class TestCase
- Create methods where the name starts with ‘test’
  - if not, they are not run as tests
    - means that you can add auxiliary methods that do not start with ‘test’ !

Example

```
Class: SetTestCase

    superclass: TestCase


SetTestCase>>testAdd                                    “one test”
            | empty |
            empty := Set new.
            empty add: 5.
            self assert: (empty includes: 5).


SetTestCase>>testOccurrences                        “other test”
            | empty |
            empty := Set new.
            self assert: (empty occurrencesOf: 0) = 0.
            empty add: 5; add:5.
            self assert: (empty occurrencesOf: 5) = 1
```

Example: Let's take a closer look

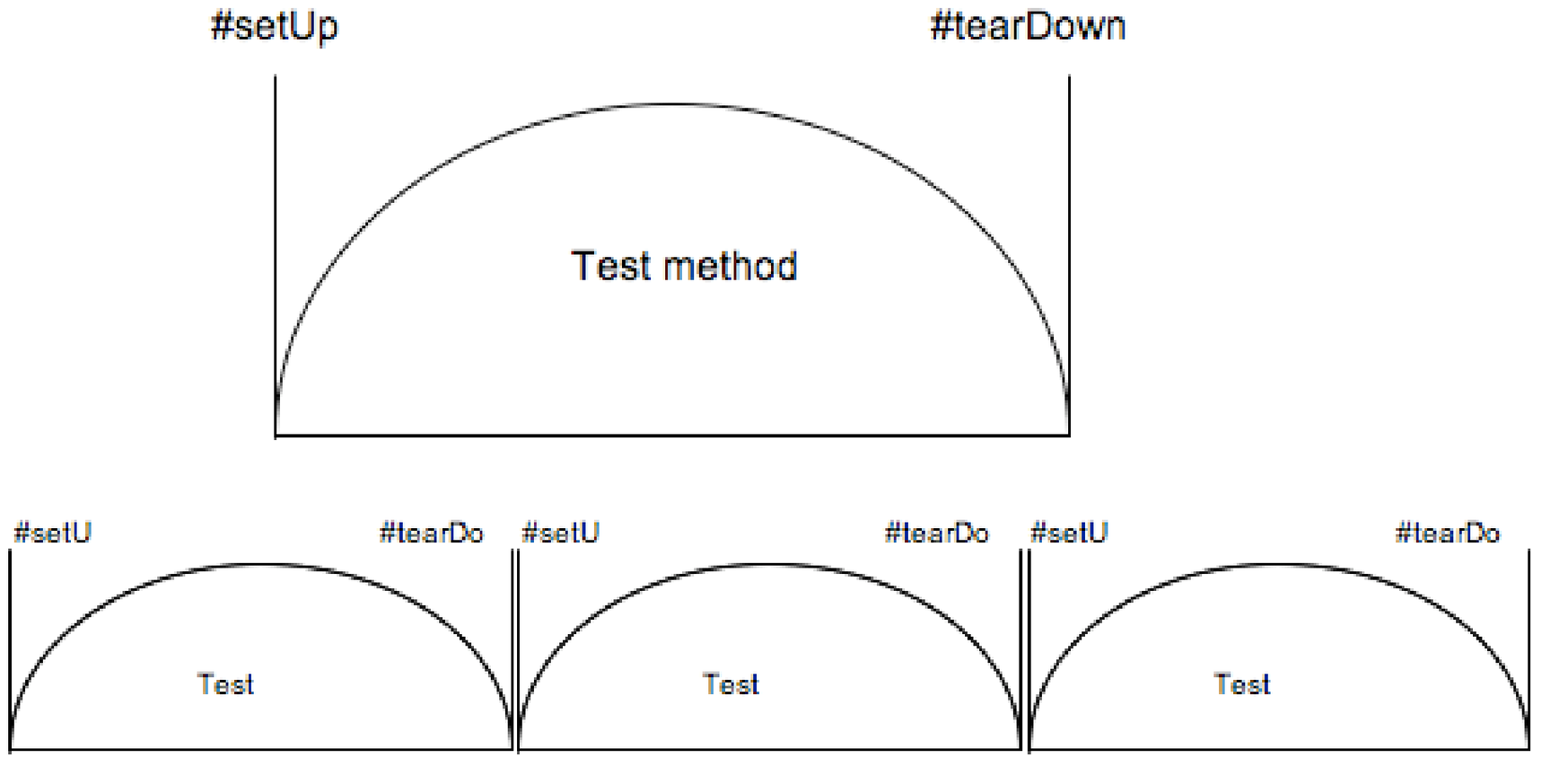
- What bothers you if you inspect these two methods?

```
SetTestCase>>testAdd                                    "one test"
        | empty |
        empty := Set new.
        empty add: 5.
        self assert: (empty includes: 5).

SetTestCase>>testOccurrences                        "other test"
        | empty |
        empty := Set new.
        self assert: (empty occurrencesOf: 0) = 0.
        empty add: 5; add:5.
        self assert: (empty occurrencesOf: 5) = 1
```

Setup and TearDown

- Executed before and after each test
  - *setUp* allows us to specify and reuse the context
  - *tearDown* makes us clean-up afterwards



Set Example Revisited

```
Class: SetTestCase
    superclass: TestCase
    instance variable: 'empty full'

SetTestCase>>setUp
     empty := Set new.
     full := Set with: #abc with: 5

SetTestCase>>testAdd                    "one test method"
  empty add: 5.
  self assert: (empty includes: 5).

SetTestCase>>testOccurrences     "other test method"
 self assert: (empty occurrenceOf: 0) = 0.
 self assert: (full occurrencesOf: 5) = 1.
 full add: 5. self assert: (full occurrencesOf: 5) = 1

SetTestCase>>testRemove    "yet another test method"
full remove: 5.
self assert: (full includes: #abc).
self deny: (full includes: 5)
```

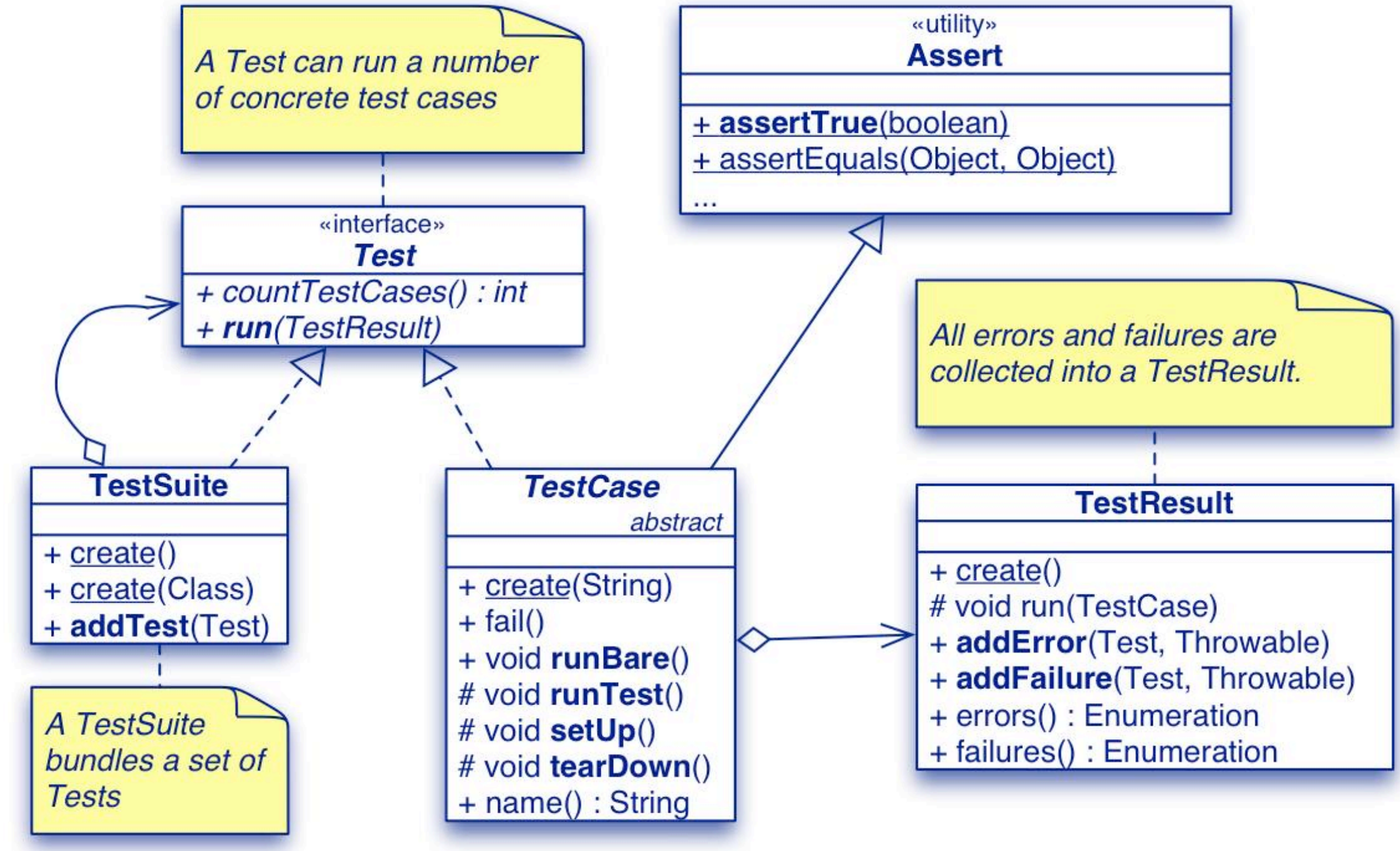
cppUnit

- testClass derived from TestFixture
- macro's for initiating and finishing a test suite (CPPUNIT_TEST_SUITE and CPPUNIT_TEST_SUITE_END)
- method setUp and tearDown (cf. SUnit)
- actual tests are defined with the help of CppUnit macros (e.g. CPPUNIT_ASSERT_EQUAL, CPPUNIT_ASSERT,...)

JUnit overview

- Junit (inspired by Sunit) is a simple "testing framework" that provides:
  - classes for writing Test Cases and Test Suites
  - methods for setting up and cleaning up test data ("fixtures")
  - methods for making assertions
  - textual and graphical tools for running tests

JUnit(<4) Framework



JUnit 4 Annotations

- `@BeforeClass`:
  Methods that are called before any test runs. Test parameters can be set and objects can be instantiated here if they do not change in later tests.
- `@AfterClass`:
  Methods that are called at the end of a testsuite after all tests have been run. Resources that have been used during the tests (like network connections or streams) can be freed here.
- `@Before`:
  Methods that are executed before every test.
- `@After`:
  Methods that are executed after every test.
- `@Test`:
  The actual test methods.
- `@Ignore`:
  Methods, testing features that are still to be implemented, can be disabled temporarily.

JUnit 4 Assertions

- `assertEquals(a, b)`
- `assertTrue(a, b)`
- `assertFalse(a, b)`
- `assertNull(a, b)`
- `assertNotNull(a, b)`
- `assertSame(a, b)`
- `assertNotSame(a, b)`

JUnit 4 Example

```
public class SimpleFraction {

      private int numerator,
      private int denominator;

      public SimpleFraction(int num, int den) {
          numerator = num;
          denominator = den;
      }

      public void simplify() {
          long gcd = gcd(denominator, numerator);
          denominator /= gcd;
          numerator /= gcd;
          if(denominator < 0) {
              denominator = -denominator;
              numerator = -numerator;
          }
              }

    private static int gcd(int a, int b) {
          return b == 0 ? a : gcd(b, a % b);
    }
```

```
public int getDenominator() {
   return denominator;
 }

 public int getNumerator() {
   return numerator;
 }

 public void setDenominator(int i) {
   denominator = i;
 }

   public void setNumerator(int i) {
      numerator = i;
   }
   public static void main(String[] args) {
      SimpleFraction fract = new SimpleFraction(10, 3);
      System.out.println(fract.getNumerator() +" "
+fract.getDenominator());
   }
}
```

```
import junit.framework.TestCase;
import org.junit.Test;

public class SimpleFractionTest extends TestCase{

    private SimpleFraction f1, f2;

    public SimpleFractionTest(String arg0){
        super(arg0);
    }

    @Before
    protected void setUp(){
        super.setUp();
        f1 = new SimpleFraction(15, 25);
        f2 = new SimpleFraction(-27, 6);
    }

    @Test
    public void testGetDenominator() {
     int result = f1.getDenominator();
     assertTrue("getDenominator() returned" +result +" instead of 25.",
                              result==25);
     result = f2.getDenominator();
     assertEquals(6, result);}
```

```
    @Test
public void testSimplify() {
            f1.simplify();
            assertEquals(3, f1.getNumerator());
            assertEquals(5, f1.getDenominator());

            f2.simplify();
            assertEquals(-9, f2.getNumerator());
            assertEquals(2, f2.getDenominator());
        }
    }
```

```
import junit.framework.Test;
import junit.framework.TestSuite;

import org.junit.runner.RunWith;
import org.junit.runners.Suite;
import org.junit.runners.Suite.SuiteClasses;

@RunWith(value=Suite.class)
@SuiteClasses(value={SimpleFractionTest.class})
public class AllTests {

	public static Test suite() {
		TestSuite suite = new TestSuite("Test for default package");
		//$JUnit-BEGIN$
		suite.addTest(new TestSuite(SimpleFractionTest.class));
		//$JUnit-END$
		return suite;
	}
}
```

Conclusion: Why spending time testing?

- Find problems soon.
  - in context of what you were doing!
- Serve as documentation.
- Ease maintenance and evolution.
  - new developers jump in anytime.
- Have something to show all the time.

References

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