Tools for Unit Test - JUnit

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Slides thanks to Stuart Anderson

JUnit

- JUnit is a framework for writing tests
  - Written by Erich Gamma (Design Patterns) and Kent Beck (eXtreme Programming)
  - JUnit uses Java's reflection capabilities (Java programs can examine their own code)
  - JUnit allows us to:
    - define and execute tests and test suites
    - Use test as an effective means of specification
    - write code and use the tests to support refactoring
    - integrate revised code into a build
  - JUnit is available on several IDEs, e.g. BlueJ, JBuilder, and Eclipse have JUnit integration to some extent.

JUnit's Terminology

- A **test runner** is software that runs tests and reports results.
  - Many implementations: standalone GUI, command line, integrated into IDE
- A **test suite** is a collection of test cases.
- A **test case** tests the response of a single method to a particular set of inputs.
- A **unit test** is a test of the smallest element of code you can sensibly test, usually a single class
- A **test fixture** is the environment in which a test is run. A new fixture is set up before each test case is executed, and torn down afterwards.
  - Example: if you are testing a database client, the fixture might place the database **server** in a standard initial state, ready for the client to connect.
- An **integration test** is a test of how well classes work together.
  - JUnit provides some limited support for integration tests.
- **Proper** unit testing would involve **mock objects** – fake versions of the other classes with which the class under test interacts. JUnit doesn't help with this. It's worth knowing about, but not always necessary.

Structure of a JUnit test class

JUnit 3!

- We want to test a class named Triangle
- public class TriangleTest
  extends junit.framework.TestCase {
  - This is the unit test for the Triangle class; it defines objects used by one or more tests.
- public TriangleTest() { }
  - This is the default constructor.
- protected void setUp()
  - Creates a test fixture by creating and initializing objects and values.
- protected void tearDown()
  - Releases any system resources used by the test fixture. Java usually does this for free, but files, network connections etc. might not get tidied up automatically.
- public void testTriangle(), public void testIsScalene(), etc.
  - These methods contain tests for the Triangle constructor and its isScalene() method.

Making Tests: Assert

- Within a test,
  - Call the method being tested and get the actual result.
  - `assert` a property that should hold of the test result.
  - Each assert is a challenge on the test result.
- If the property fails to hold then `assert` fails, and throws an AssertionFailedError:
  - JUnit catches these Errors, records the results of the test and displays them.
- static void assertTrue(boolean ***test***)
  static void assertTrue(String ***message***, boolean ***test***)
  - Throws an AssertionFailedError if the test fails.
  - The optional *message* is included in the Error.
- static void assertFalse(boolean ***test***)
  static void assertFalse(String ***message***, boolean ***test***)
  - Throws an AssertionFailedError if the test succeeds.

Aside: Throwable

- `java.lang.Error`: a problem that an application wouldn't normally try to handle. Don't need to be declared in `throws` clause.
  - e.g. command line application given bad parameters by user.
- `java.lang.Exception`: a problem that the application might reasonably cope with. Need to be declared in `throws` clause.
  - e.g. network connection timed out during connect attempt.
- `java.lang.RuntimeException`: application might cope with it, but rarely. Don't need to be declared in `throws` clause.
  - e.g. I/O buffer overflow.

Example: Triangle class

For the sake of example, we will create and test a trivial "Triangle" class:

- The constructor creates a Triangle object, where only the lengths of the sides are recorded and the private variable p is the longest side.
- The isScalene method returns `true` if the triangle is scalene.
- The isEquilateral method returns `true` if the triangle is equilateral.
- We can write the test methods before the code.
- This has advantages in separating coding from testing.
- But Eclipse helps more if you create the class under test first:
  - Creates test stubs (methods with empty bodies) for all methods and constructors.

Notes on creating tests

- Often the amount of (very routine) test code will exceed the size of the code for small systems.
- Testing complex code can be a complex business and the tests can get quite complex.
- The effort taken in creating test code is repaid in reduced development time, most particularly when we go on to use the test subject in anger (i.e. real code).
- Creating a test often helps clarify our ideas on how a method should behave (particularly in exceptional circumstances).

A JUnit 3 test for Triangle

```
import junit.framework.TestCase;

public class TriangleTest extends TestCase {
private Triangle t;

protected void setUp() { // executed before each test
        t = new Triangle(5,4,3);
}

protected void tearDown() {} // executed after each test

public void testIsScalene() {
        assertTrue(t.isScalene());
}

public void testIsEquilateral() {
        assertFalse(t.isEquilateral());
}
}
```

A JUnit 4 test for Triangle

```
package st;

import static org.junit.Assert.*;

import org.junit.Before;
import org.junit.Test;

public class TestTriangle {

        private Triangle t;

        @Before public void setUp() throws Exception {
                t = new Triangle(3, 4, 5);
        }

        @Test public void scaleneOk() {
                assertTrue(t.isScalene());
        }
}
```

More imports

No need to inherit from TestCase

Use annotations …

… rather than special names

The Triangle class itself

```
public class Triangle {
private int p; // Longest edge
private int q;
private int r;

public Triangle(int s1, int s2, int s3) {
        if (s1>s2) {
                p = s1; q = s2;
        } else {
                p = s2; q = s1;
        }
        if (s3>p) {
                r = p; p = s3;
        } else {
                r = s3;
        }
}

public boolean isScalene() {
        return p>0 && q>0 && r>0 && p<(q+r) &&
                q != r && r != p && p != q;
}

public boolean isEquilateral() {
        return p == q && q == r;
}
}
```

- Is JUnit too much for small programs?
- Not if you think it will reduce errors.
- Tests on this scale of program often turn up errors or omissions – construct the tests working from the specification
- Sometimes you can omit tests for some particularly straightforward parts of the system

Assert methods II

- assertEquals(***expected***, ***actual***)
  assertEquals(String ***message***, ***expected***, ***actual***)
  - This method is heavily overloaded: *arg1* and *arg2* must be both objects *or* both of the same primitive type
  - For objects, uses your equals method, ***if*** you have defined it properly, as public boolean equals(Object o)—otherwise it uses ==

- assertSame(Object ***expected***, Object ***actual***)
  assertSame(String ***message***, Object ***expected***, Object ***actual***)
  - Asserts that two objects refer to the same object (using ==)

- assertNotSame(Object ***expected***, Object ***actual***)
  assertNotSame(String ***message***, Object ***expected***, Object ***actual***)
  - Asserts that two objects do not refer to the same object

Assert methods III

- assertNull(Object ***object***)
  assertNull(String ***message***, Object ***object***)
  - Asserts that the object is null

- assertNotNull(Object ***object***)
  assertNotNull(String ***message***, Object ***object***)
  - Asserts that the object is null

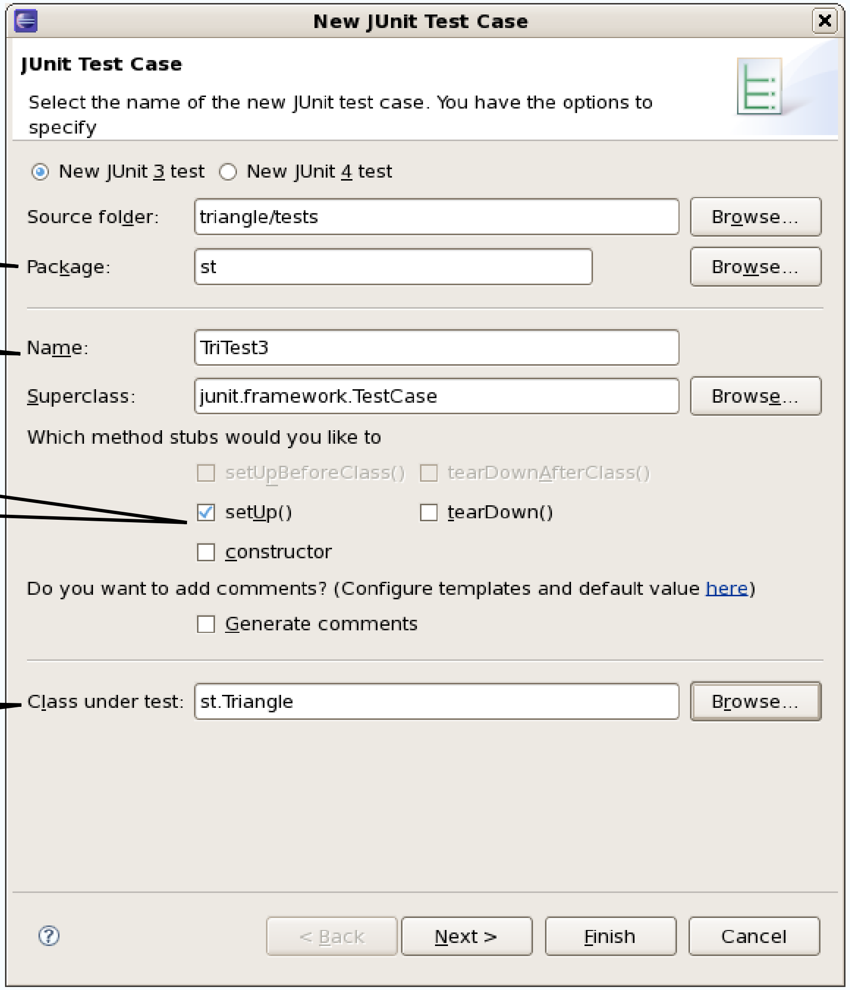
- fail()
  fail(String ***message***)
  - Causes the test to fail and throw an AssertionFailedError
  - Useful as a result of a complex test, when the other assert methods aren't quite what you want

The **assert** statement in Java

- Earlier versions of JUnit had an assert method instead of an assertTrue method
  - The name had to be changed when Java 1.4 introduced the assert statement
- There are two forms of the assert statement:
  - assert ***boolean_condition***;
  - assert ***boolean_condition***: ***error_message***;
  - Both forms throw an AssertionFailedError if the ***boolean_condition*** is false
  - The second form, with an explicit error message, is seldom necessary
- When to use an assert statement:
  - Use it to document a condition that you “know” to be true
  - Use assert false; in code that you “know” cannot be reached (such as a default case in a switch statement)
  - Do **not** use assert to check whether parameters have legal values, or other places where throwing an Exception is more appropriate
  - Can be dangerous: customers are not impressed by a library bombing out with an assertion failure.

JUnit in Eclipse

- To create a test class, select File → New → JUnit Test Case and enter the name of your test case



New JUnit Test Case

JUnit Test Case

Select the name of the new JUnit test case. You have the options to specify

● New JUnit 3 test ○ New JUnit 4 test

Source folder: triangle/tests

Package: st

Name: TriTest3

Superclass: junit.framework.TestCase

Which method stubs would you like to

□ setUpBeforeClass() □ tearDownAfterClass()

☑ setUp() □ tearDown()

□ constructor

Do you want to add comments? (Configure templates and default value here)

□ Generate comments

Class under test: st.Triangle

Package

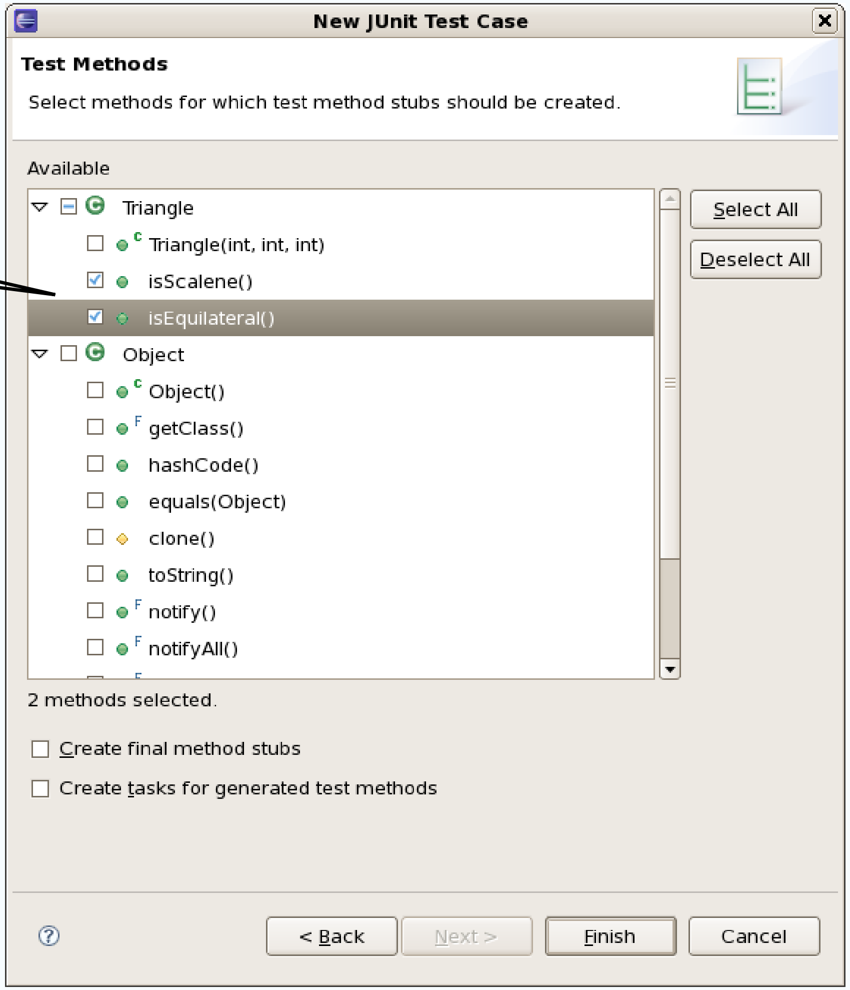
Test class

Decide what stubs you want to create

Identify the class under test

Creating a Test

Decide what you want to test



Test Methods

Select methods for which test method stubs should be created.

Available

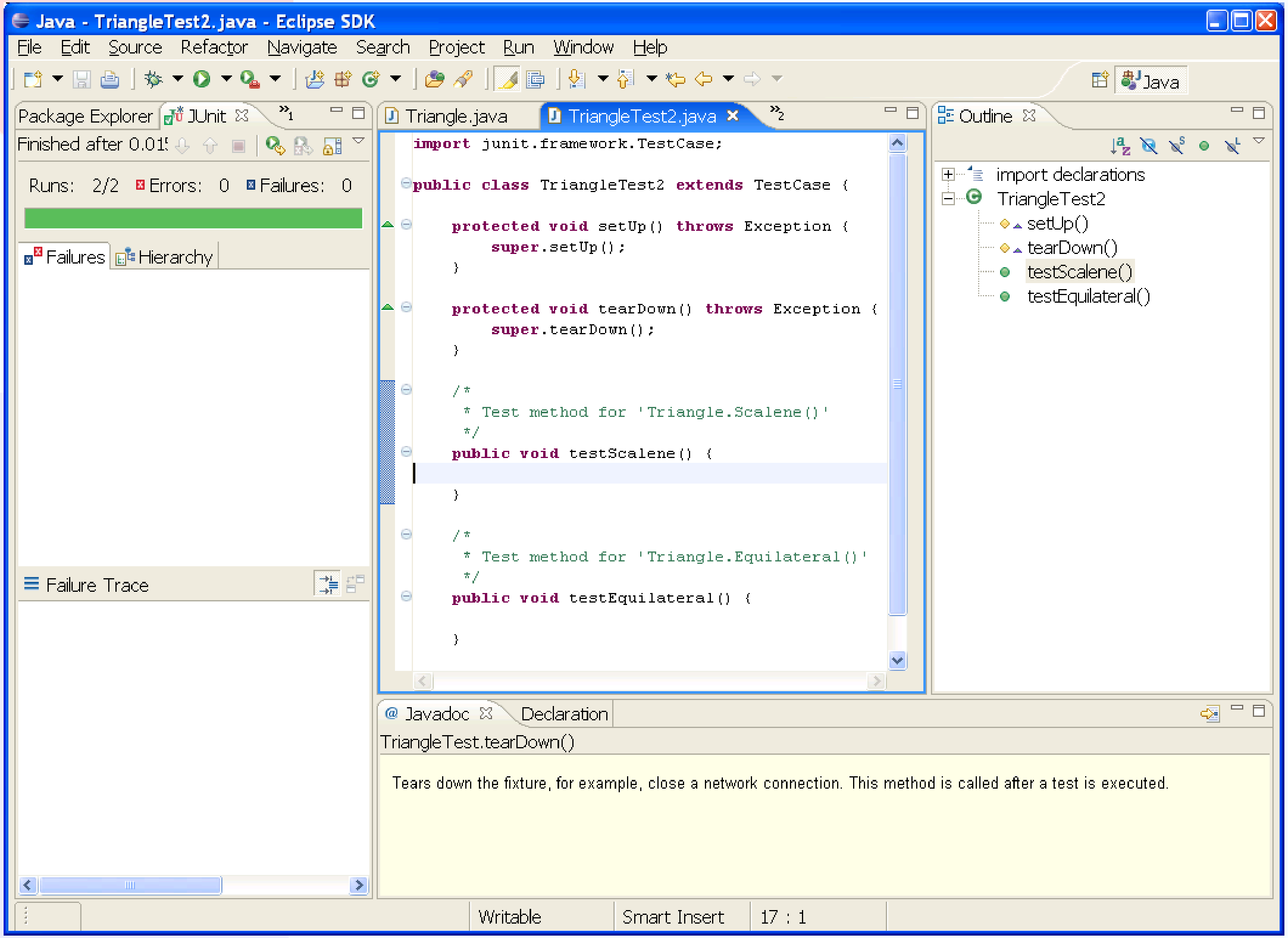
- ▽ ⊟ Triangle
  - □ Triangle(int, int, int)
  - ☑ isScalene()
  - ☑ isEquilateral()
- ▽ □ Object
  - □ Object()
  - □ getClass()
  - □ hashCode()
  - □ equals(Object)
  - □ clone()
  - □ toString()
  - □ notify()
  - □ notifyAll()

2 methods selected.

□ Create final method stubs

□ Create tasks for generated test methods

Template for New Test

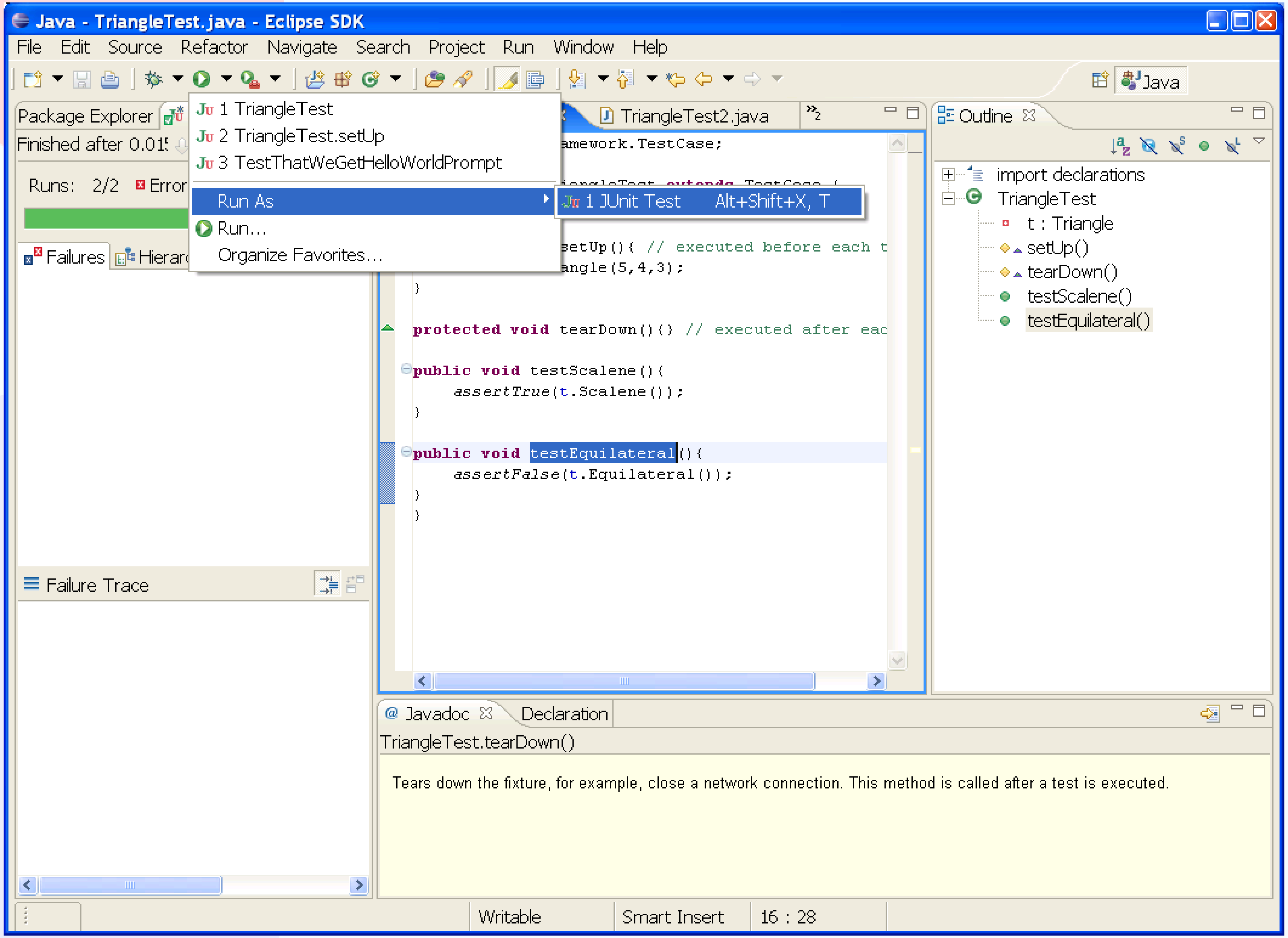


```
import junit.framework.TestCase;

public class TriangleTest2 extends TestCase {

    protected void setUp() throws Exception {
        super.setUp();
    }

    protected void tearDown() throws Exception {
        super.tearDown();
    }

    /*
     * Test method for 'Triangle.Scalene()'
     */
    public void testScalene() {

    }

    /*
     * Test method for 'Triangle.Equilateral()'
     */
    public void testEquilateral() {

    }
```

TriangleTest.tearDown()

Tears down the fixture, for example, close a network connection. This method is called after a test is executed.

Running JUnit



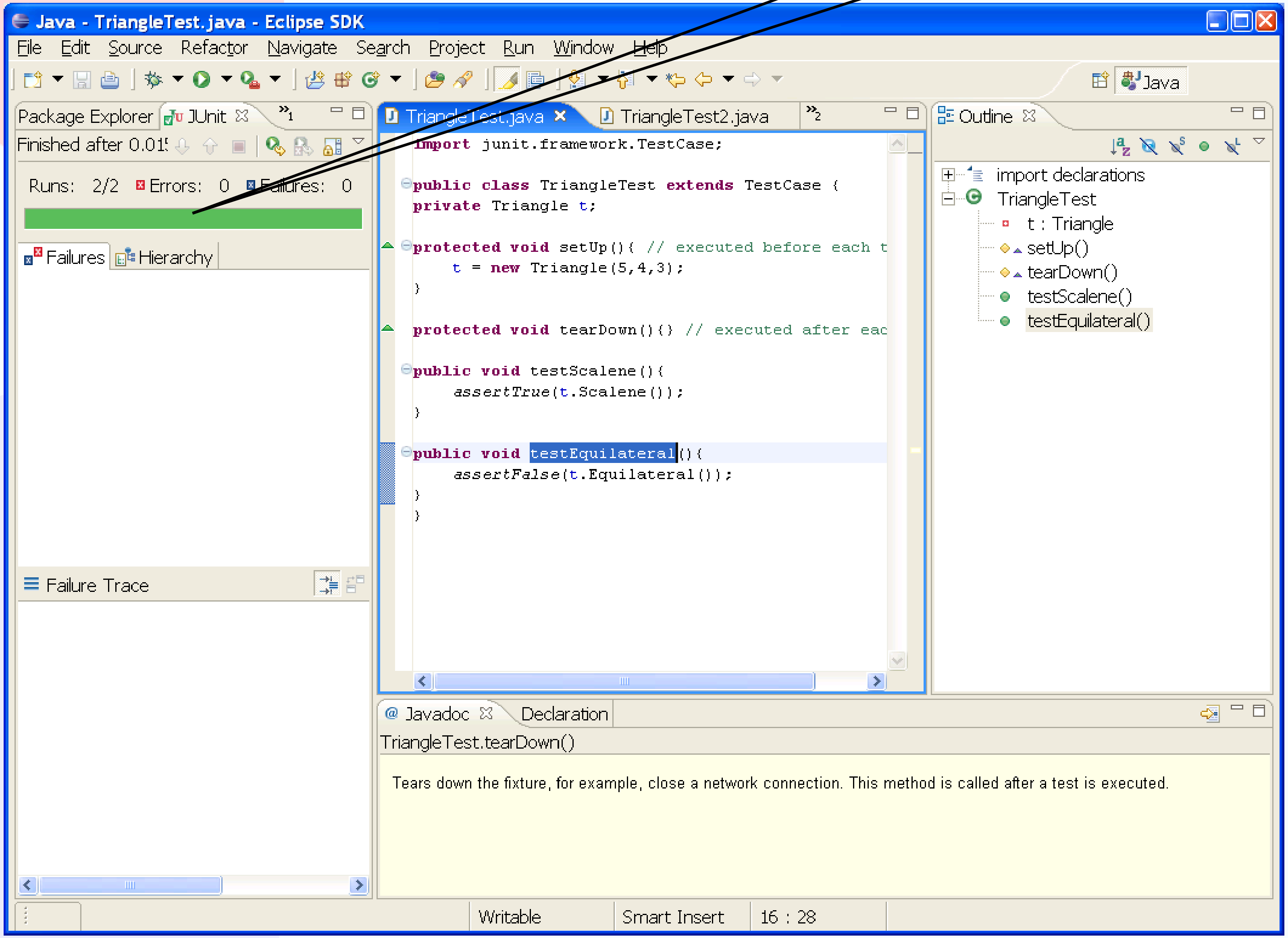
```
amework.TestCase;

iangleTest extends TestCase {

setUp(){ // executed before each t
angle(5,4,3);
}

protected void tearDown(){} // executed after eac

public void testScalene(){
    assertTrue(t.Scalene());
}

public void testEquilateral(){
    assertFalse(t.Equilateral());
}
}
```

TriangleTest.tearDown()

Tears down the fixture, for example, close a network connection. This method is called after a test is executed.

Results

Results are here



Finished after 0.01!

Runs: 2/2 Errors: 0 Failures: 0

```
import junit.framework.TestCase;

public class TriangleTest extends TestCase {
private Triangle t;

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public void testScalene(){
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    assertFalse(t.Equilateral());
}
}
```

TriangleTest.tearDown()

Tears down the fixture, for example, close a network connection. This method is called after a test is executed.

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Aside: FIT

- Framework for Integrated Tests, by Ward Cunningham (inventor of wiki)
- Allows closed loop between customers and developers:
  - Takes HTML tables of expected behaviour from customers or spec.
  - Turns those tables into test data: inputs, activities and assertions regarding expected results.
  - Runs the tests and produces tabular summaries of the test runs.
- Only a few years old, but lots of people seem to like it; various commercial folk I've introduced it to still seem to think it's revolutionary.
- http://fit.c2.com/

Issues with JUnit

JUnit has a model of calling methods and checking results against the expected result. Issues are:

- State: objects that have significant internal state (e.g. collections with some additional structure) are harder to test because it may take many method calls to get an object into a state you want to test. Solutions:
  - Write long tests that call some methods many times.
  - Add additional methods in the interface to allow observation of state (or make private variables public?)
  - Add additional methods in the interface that allow the internal state to be set to a particular value
  - Heisenbugs can be an issue in these cases (changing the observerations changes what is observed).
- Other effects, e.g. output can be hard to capture correctly.
- JUnit tests of GUIs are not particularly helpful (recording gestures might be helpful here?)

Positives

- Using JUnit encourages a “testable” style, where the result of a calling a method is easy to check against the specification:
  - Controlled use of state
  - Additional observers of the state (testing interface)
  - Additional components in results that ease checking
- It is well integrated into a range of IDEs (e.f. Eclipse)
- Tests are easy to define and apply in these environments.
- JUnit encourages frequent testing during development (e.g. XP (eXtreme Programming) “test as specification”)
- JUnit tends to shape code to be easily testable.
- JUnit supports a range of extensions that support structured testing (e.g. coverage analysis) – we will see some of these extensions later.

Get testing!

- Start up Eclipse and:
  - Create a new Java project
  - Add a nw package, "st"
  - Create st.Triangle; use File->Import (from File System) to copy **~chughes1/shared/Triangle.java** into **Triangle/src/st**
  - Create a new source folder called "tests" if you like (with a new "st" package)
  - Create a new JUnit test for st.Triangle
  - And get testing!