Tools for Unit Test — JUnit

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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) and (as of version 4) *annotations*
- 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.

JUnit's Terminology

- 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 does not help with this. It is worth knowing about, but not always necessary.

Structure of a JUnit (4) test class

We want to test a class named `Triangle`

- This is the unit test for the `Triangle` class; it defines objects used by one or more tests.

  ```
  public class TriangleTestJ4{

  }
  ```

- This is the default constructor.

  ```
  public TriangleTest(){ }
  ```

Structure of a JUnit (4) test class

- `@Before` public void init()

  Creates a test fixture by creating and initialising objects and values.

- `@After` public void cleanUp()

  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.

- `@Test` public void noBadTriangles(), `@Test` public void scaleneOk(), 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.

Making Tests: Assert

- `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 would not normally try to handle — does not 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 — needs 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 — does not need to be declared in *throws* clause.

  e.g. I/O buffer overflow.

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

- **Size:** Often the amount of (very routine) test code will exceed the size of the code for small systems.

- **Complexity:** Testing complex code can be a complex business and the tests can get quite complex.

- **Effort:** 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).

- **Behaviour:** 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;

  // Any method named setUp will be executed before each test.
  protected void setUp() {
    t = new Triangle(5,4,3);
  }

  protected void tearDown() {} // tearDown will be executed afterwards

  public void testIsScalene() { // All tests are named test[Something]
    assertTrue(t.isScalene());
  }

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

}
```

A JUnit 4 test for Triangle

```
package st;
```

more imports are necessary ☞

```
import static org.junit.Assert.*;

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

no need to inherit from TestCase ☞

```
public class TestTriangle {

        private Triangle t;
```

Use annotations... ☞

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

...rather than special names ☞

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

The Triangle class itself

- 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: *expected* and *actual* 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 are not 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.

The `assert` statement in Java

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

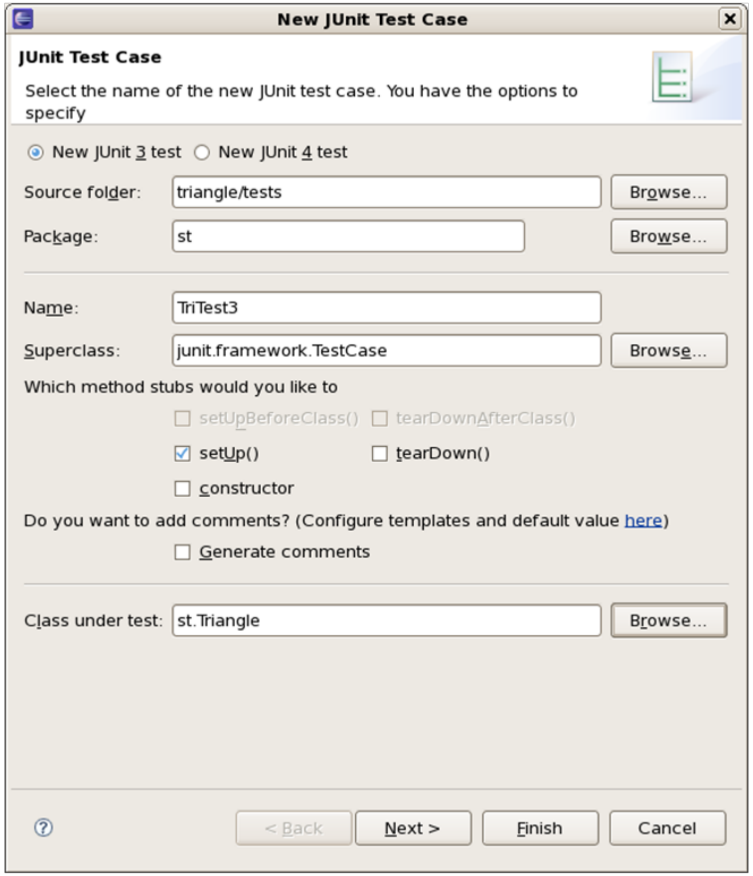
To create a test class, select
`File → New → JUnit Test Case`
and enter the name of your test case

Package ☞

Test class ☞

Decide what stubs you want to create ☞

Identify the class under test ☞



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

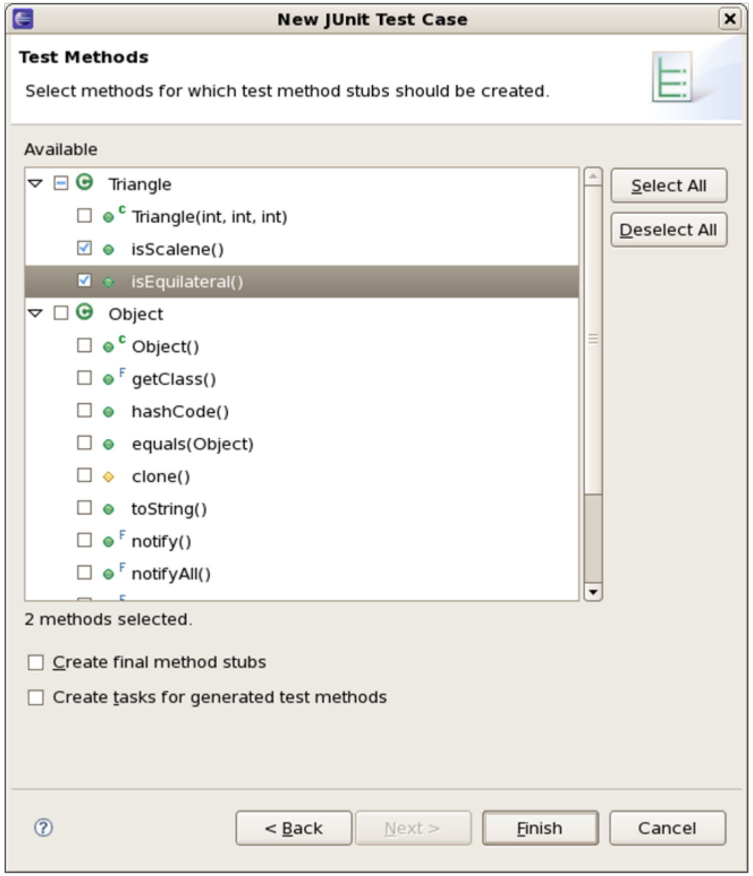
Do you want to add comments? (Configure templates and default value here)

□ Generate comments

Class under test: st.Triangle

Creating a Test

Decide what you want to test ☞



New JUnit Test Case

Test Methods

Select methods for which test method stubs should be created.

Available

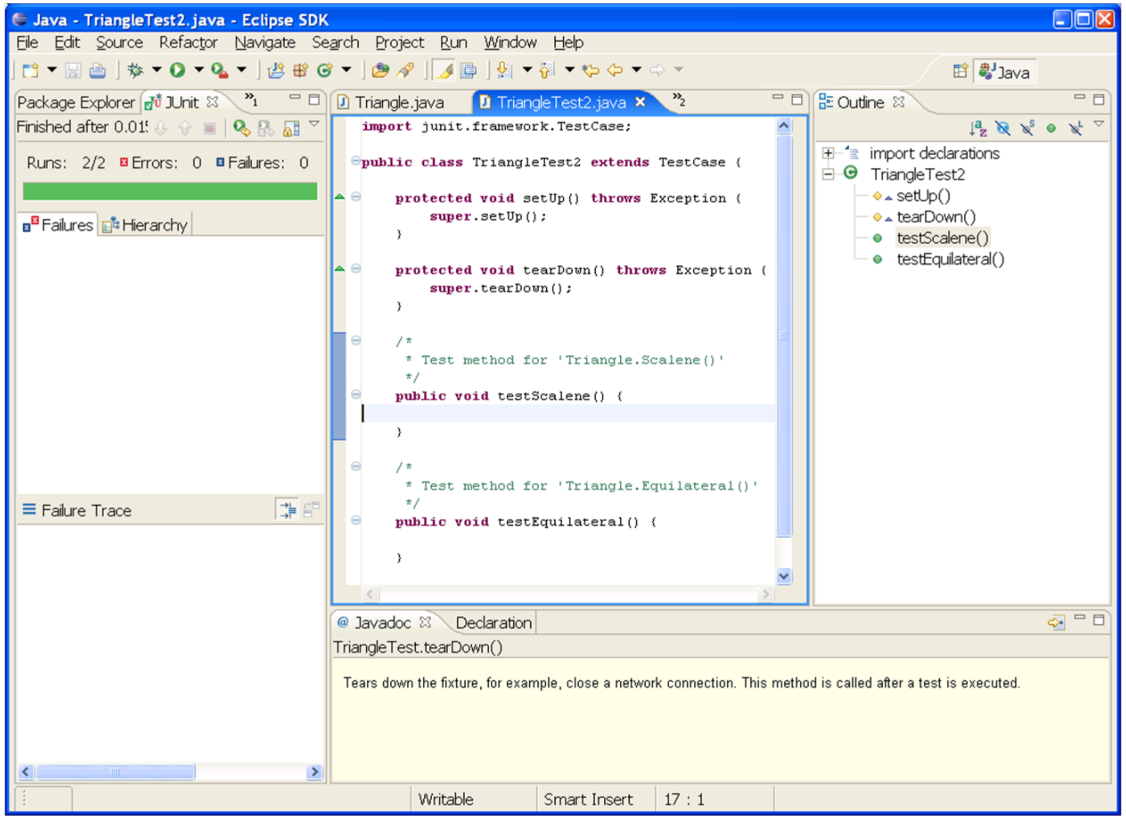
- ▽ ⊟ Triangle
  - □ Triangle(int, int, int)
  - ☑ isScalene()
  - ☑ isEquilateral()
- ▽ □ Object
  - □ Object()
  - □ getClass()
  - □ hashCode()
  - □ equals(Object)
  - □ clone()
  - □ toString()
  - □ notify()
  - □ notifyAll()

2 methods selected.

□ Create final method stubs

□ Create tasks for generated test methods

Template for New Test



Finished after 0.01!

Runs: 2/2 Errors: 0 Failures: 0

```java
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.

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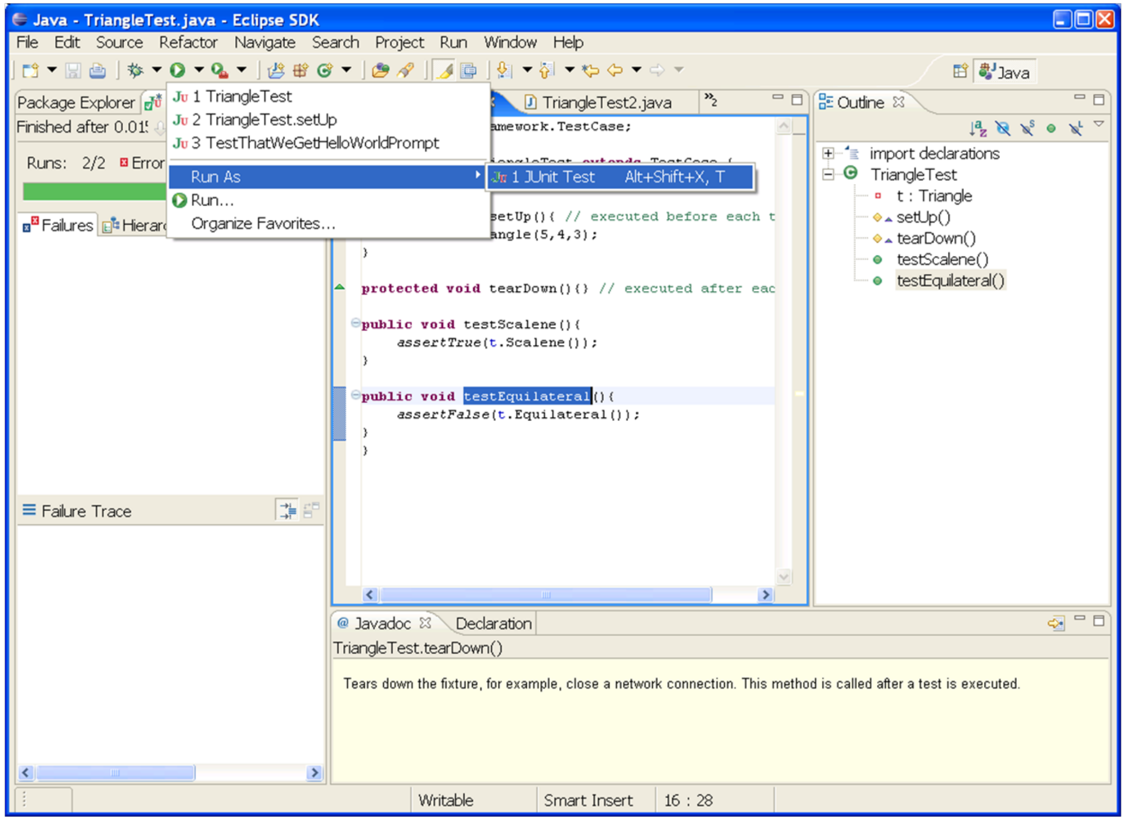
Running JUnit



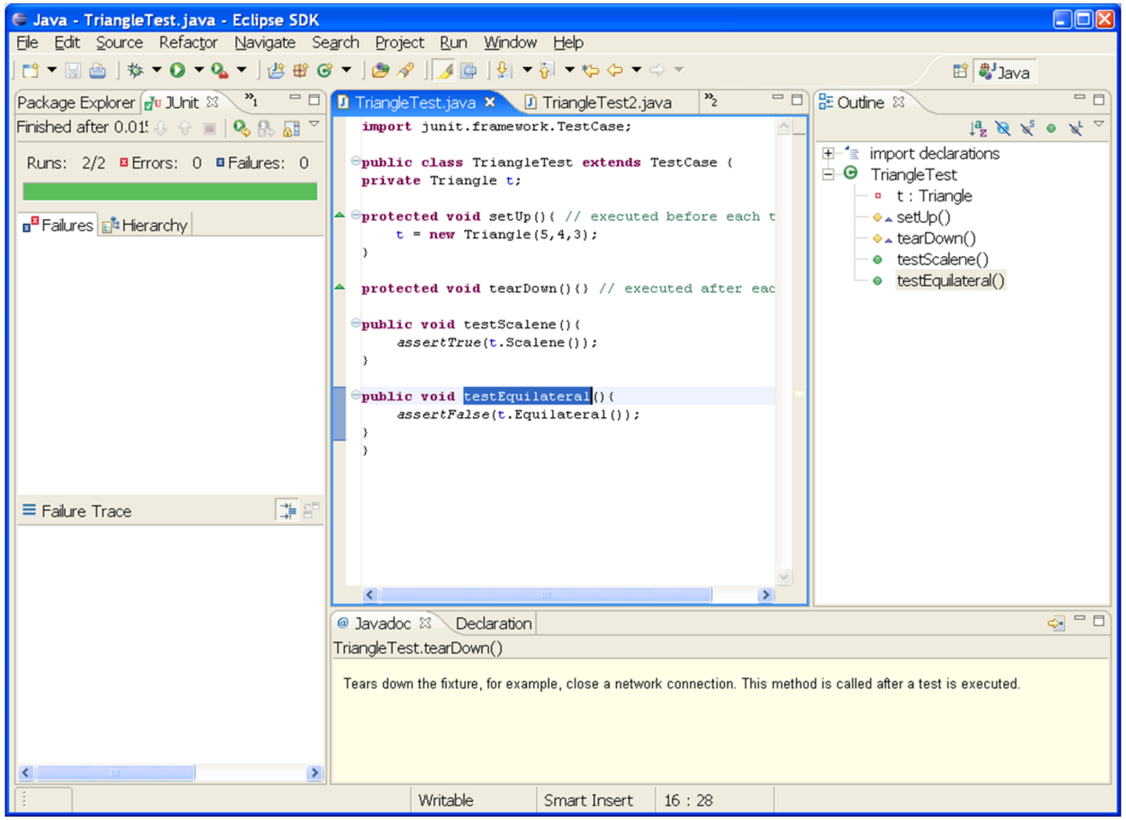
```
amework.TestCase;

iangleTest extends TestCase {

etUp(){ // 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;

protected void setUp(){ // executed before each t
    t = new Triangle(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.

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 observations changes what is observed).

Issues with JUnit

- 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.g. 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.

Another Framework for Testing

- Framework for Integrated Test (FIT), 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 practitioners seem to think it is revolutionary.

Readings

Required Readings

- JUnit Test Infected: Programmers Love Writing Tests
  an introduction to JUnit.
- Using JUnit With Eclipse IDE
  an O'Reilly article
- Unit Testing in Jazz Using JUnit
  an NCSU Open Lab article on using JUnit with Eclipse

Suggested Readings

- Michael Olan. 2003. Unit testing: test early, test often. J. Comput. Small Coll. 19, 2 (December 2003), 319-328.

Resources

Getting started with Eclipse and JUnit

Activity: to start using JUnit within Eclipe review and try the example of defining tests for a Triangle class.

[link to Activity]

Video: this video tutorial shows how to create a new Eclipse project and start writing JUnit tests first.

[link to Video]

Get testing!

Start up Eclipse and:

1. Create a new Java project
2. Add a new package, ``st''
3. Create `st.Triangle`; grab the source from the Junit lecture's Activity in the resources
4. Create a new source folder called ``tests'' if you like (with a new ``st'' package)
5. Create a new JUnit test for `st.Triangle`
6. And get testing!