A Testing Framework

Alexandre Bergel
http://bergel.eu
26/03/2018

Goal of today

Having a brief overview of UML class diagram

Expressing requirements using unit test

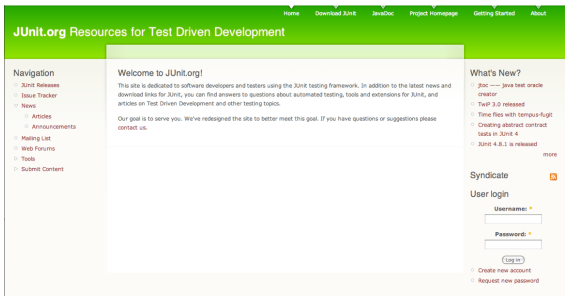
See you first design pattern

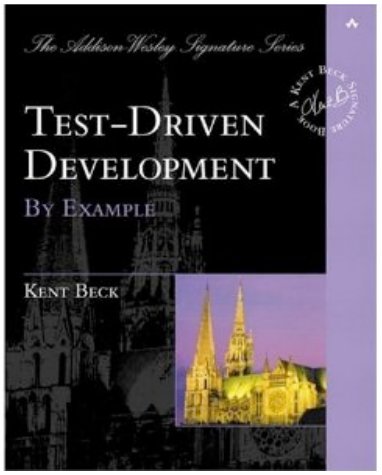
A Testing Framework

Source

JUnit 4.0 documentation (from www.junit.org)

Test-Driven Development, by Kent Beck





Roadmap

1. JUnit - a testing framework
    1. testing practices
    2. frameworks vs. libraries
    3. JUnit 3.x vs. JUnit 4.x (annotations)
2. Money and MoneyBag - a testing case study
3. Double dispatch - how to add different types of objects

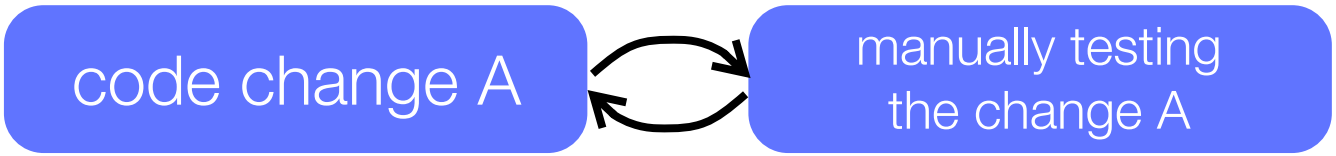
Roadmap

1. **Junit - a testing framework**
    1. testing practices
    2. frameworks vs. libraries
    3. JUnit 3.x vs. JUnit 4.x (annotations)
2. Money and MoneyBag - a testing case study
3. Double dispatch - how to add different types of objects

THE Problem

Testing is often (especially by students) done in an ad-hoc manner

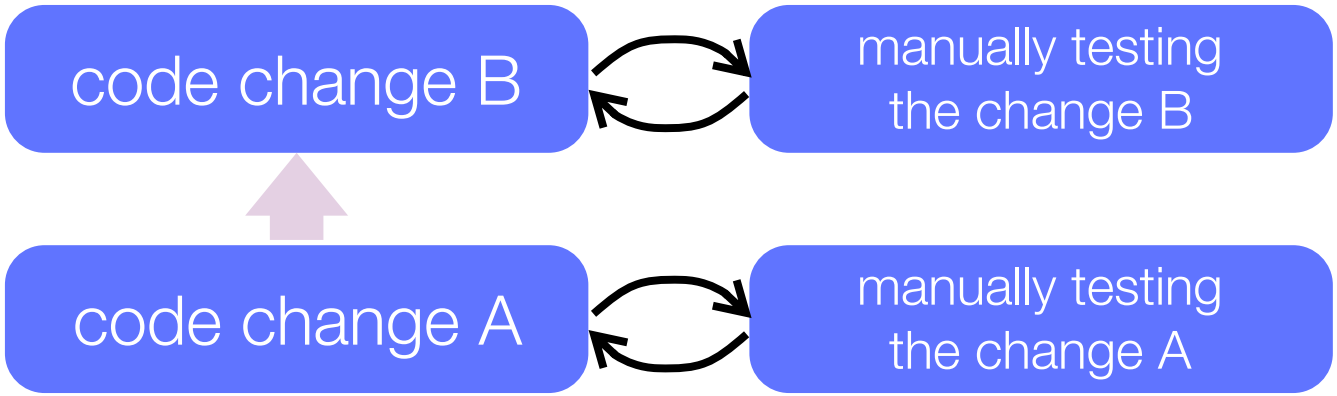
With a succession of code increment, and manual testing



THE Problem

Testing is often (especially by students) done in an ad-hoc manner

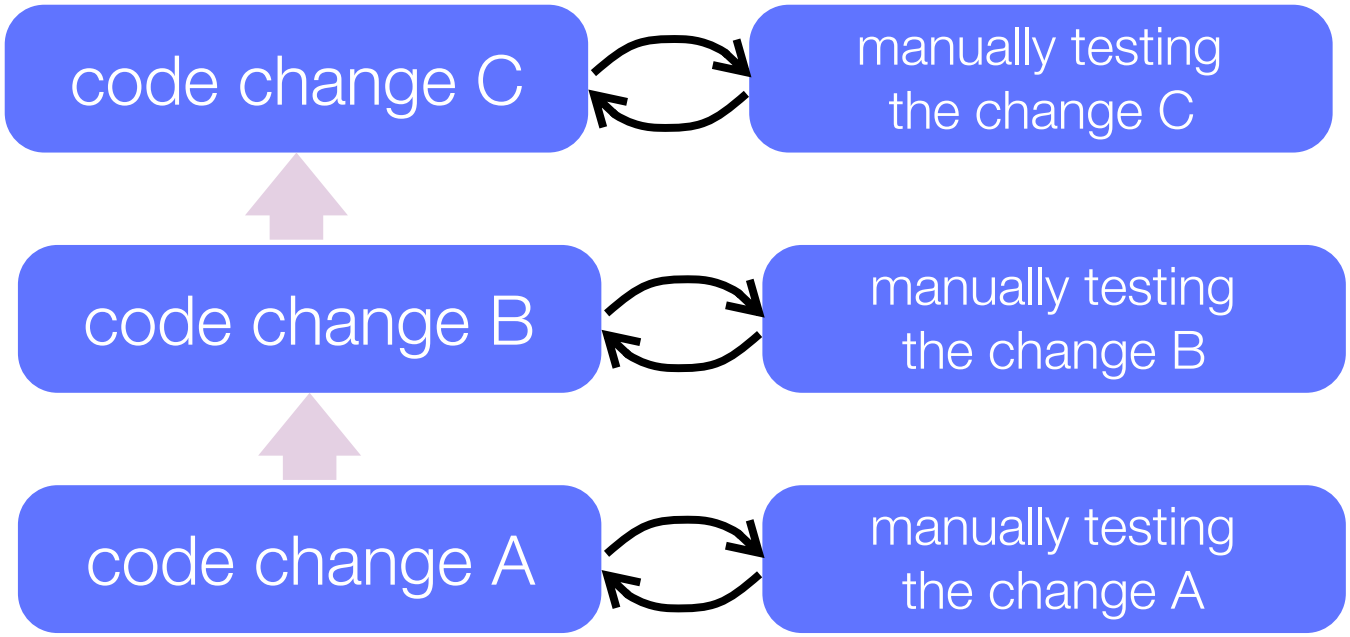
With a succession of code increment, and manual testing



THE Problem

Testing is often (especially by students) done in an ad-hoc manner

With a succession of code increment, and manual testing



THE Problem

"Testing is not closely integrated with development. This prevents you from measuring the progress of development — you can't tell when something starts working or when something stops working."

Interactive testing is tedious and seldom exhaustive.

Automated tests are better, but,

how to introduce tests interactively?

how to organize suites of tests?

3 Testing Practices...

1 - During Development

When you need to add new functionality, *write the tests first*

You will be done when the test runs

2 - When you need to redesign your software to

add new features, refactor in small steps, and *run the (regression) tests after each step*

Fix what's broken before proceeding.

3 Testing Practices

3 - During Debugging

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

JUnit - A Testing Framework

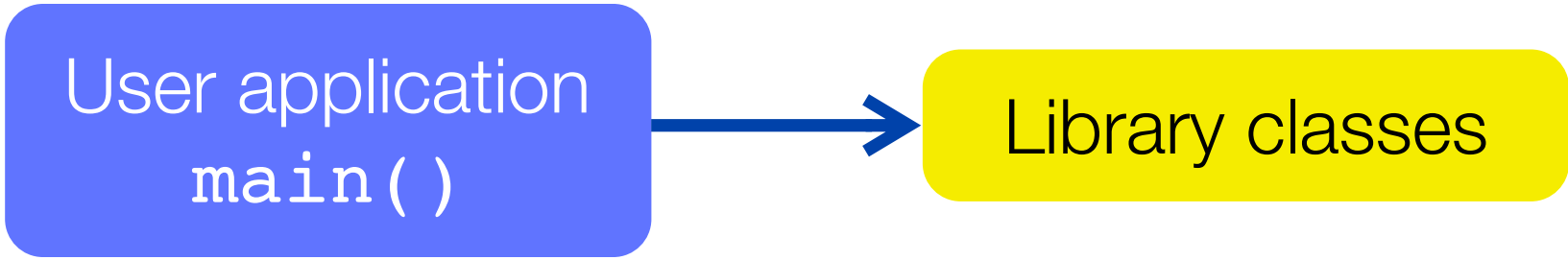
JUnit is a simple *framework* to write repeatable tests. It is an instance of the xUnit architecture for unit testing frameworks written by Kent Beck and Erich Gamma

For documentation of how to use JUnit:

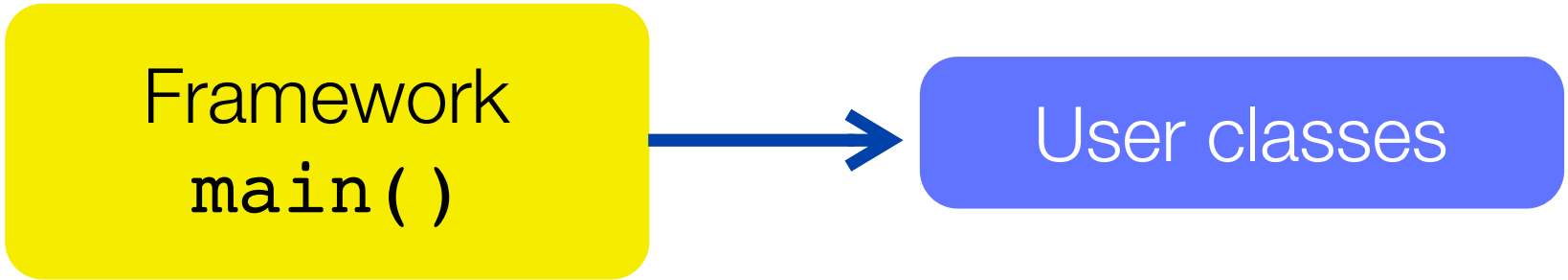
http://junit.sourceforge.net/doc/cookbook/cookbook.htm

Frameworks vs. Libraries

In traditional application architectures, user code makes use of library functionality in the form of procedures or classes:



A framework *reverses* the usual relationship between generic and application code. Frameworks provide both generic functionality and application architecture:



Frameworks vs. Libraries

Essentially, a framework says: “Don’t call me — I’ll call you.”

JUnit 3.8...

JUnit 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*

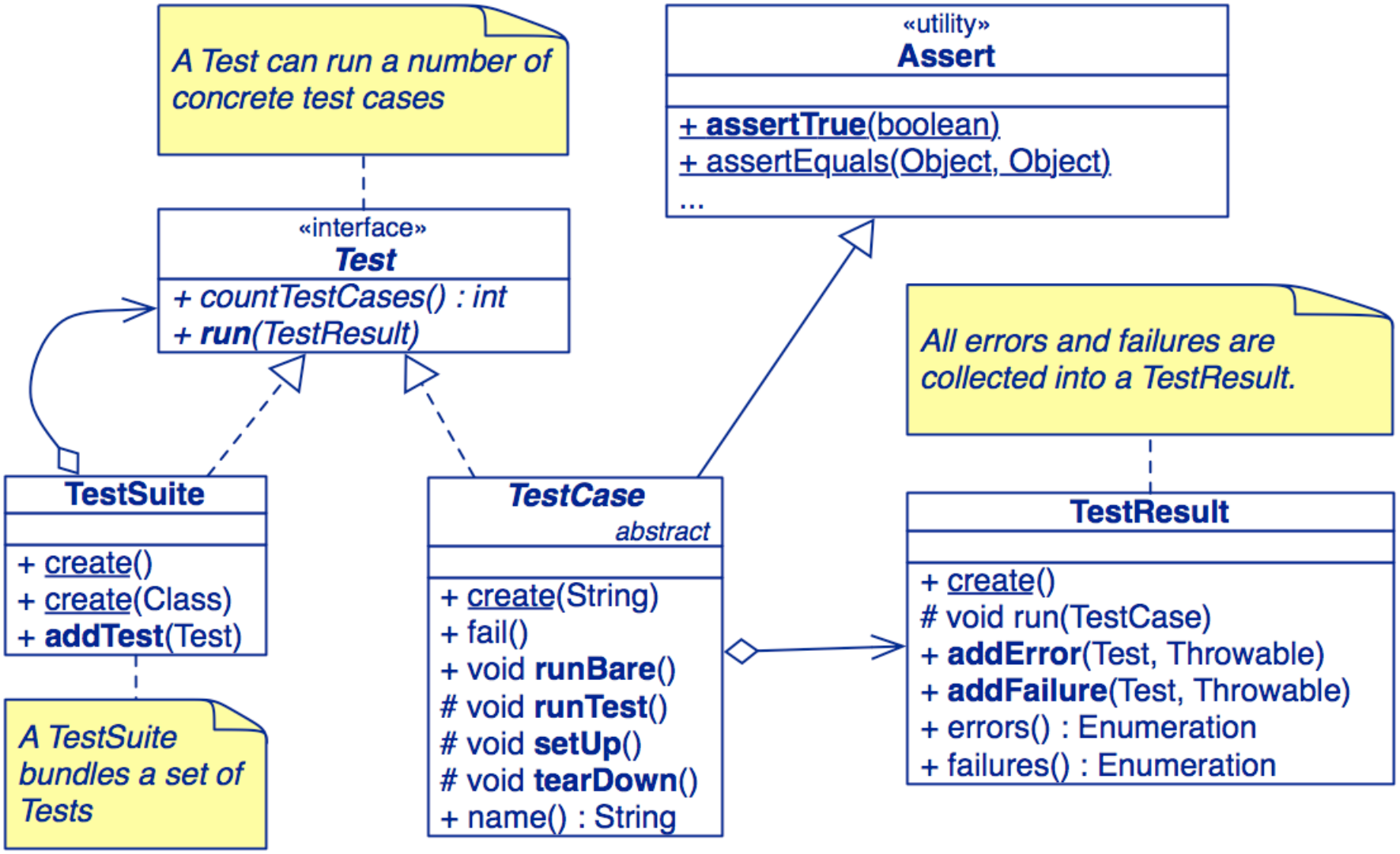
JUnit 3.8

JUnit distinguishes between failures and errors:

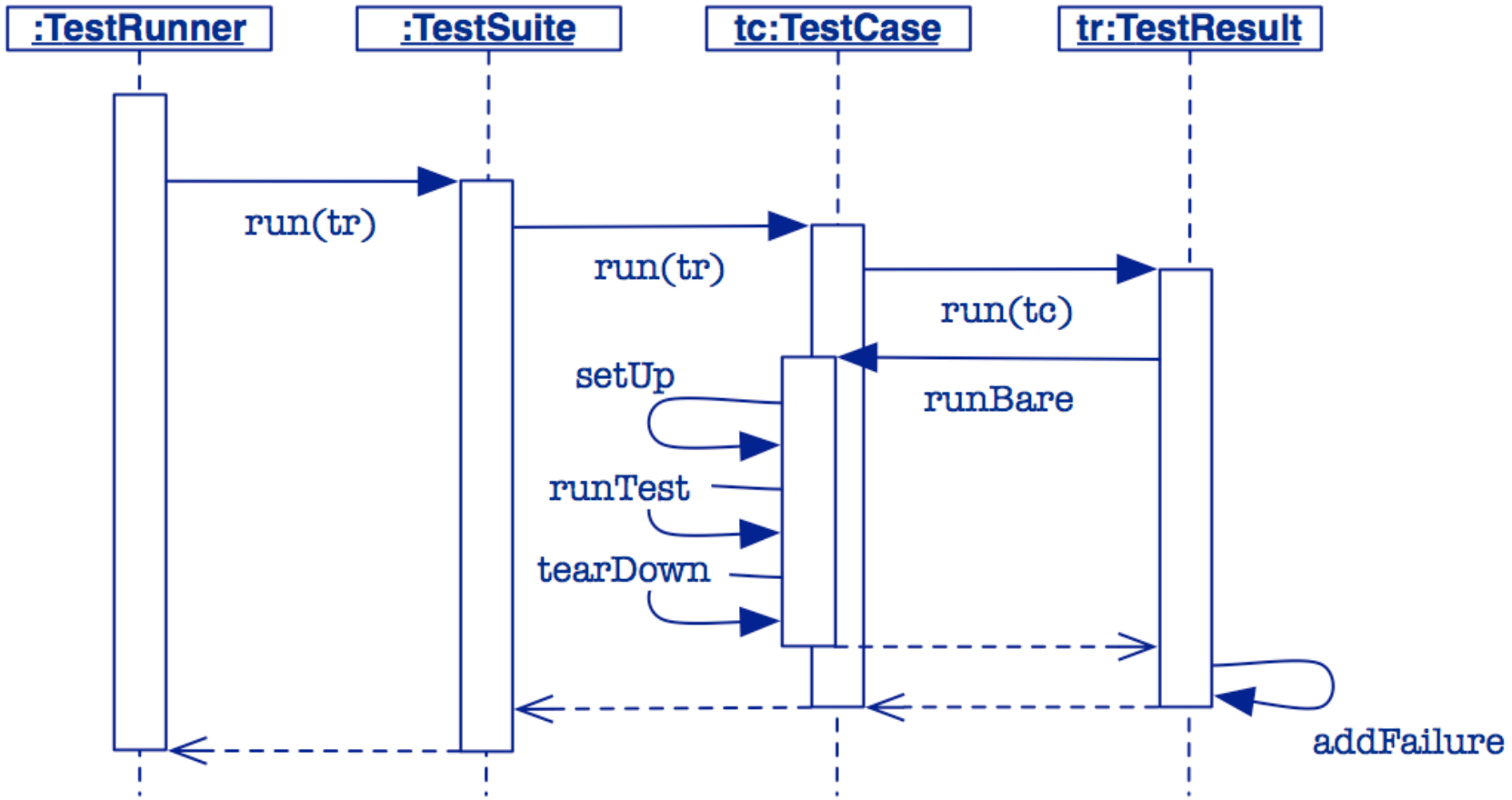
A failure is a *failed assertion*, i.e., an anticipated problem that you test.

An error is a *condition you didn't check for*, i.e., a runtime error.

The JUnit 3.x Framework: Class diagram



A Testing Scenario: Sequence diagram



The framework calls the test methods that you define for your test cases.

JUnit 3.x Example Code

```
import junit.framework.*;
public class MoneyTest extends TestCase {
   private Money f12CHF;        // fixtures
   private Money f14CHF;


   protected void setUp() {     // create the test data
      f12CHF = new Money(12, "CHF");
      f14CHF = new Money(14, "CHF");
   }
   public void testAdd() {             // create the test data
      Money expected = new Money(26, “CHF”);
      assertEquals(“amount not equal”,
                   expected,f12CHF.add(f14CHF);
   }
   ...
}
```

In PHP

```php
<?php
class MoneyTest extends PHPUnit_Framework_TestCase
{
    // ...

    public function testCanBeNegated()
    {
        // Arrange
        $a = new Money(1);

        // Act
        $b = $a->negate();

        // Assert
        $this->assertEquals(-1, $b->getAmount());
    }

    // ...
}
```

PHPUnit is very close to

JUnit 3.8

In Ruby

```ruby
# File:  tc_simple_number2.rb

require_relative "simple_number"
require "test/unit"

class TestSimpleNumber < Test::Unit::TestCase

  def test_simple
    assert_equal(4, SimpleNumber.new(2).add(2) )
    assert_equal(4, SimpleNumber.new(2).multiply(2) )
  end

  def test_typecheck
    assert_raise( RuntimeError ) { SimpleNumber.new('a') }
  end

  def test_failure
    assert_equal(3, SimpleNumber.new(2).add(2), "Adding doesn't work" )
  end

end
```

Same thing in Ruby

Annotations in J2SE 5

J2SE 5 introduces the *Metadata* feature (data about data)

Annotations allow you to add *decorations* to your code (remember javadoc tags: `@author`)

Annotations are used for code documentation, compiler processing (`@Deprecated`), code generation, runtime processing

http://java.sun.com/docs/books/tutorial/java/javaOO/annotations.html

JUnit 4.x

JUnit is a simple “testing framework” that provides:

- Annotations for marking methods as *tests*
- Annotations for marking methods that *setting up and cleaning up test data* (“fixtures”)
- methods for making *assertions*
- textual and graphical tools for *running tests*

JUnit 4.x Example Code

```
import org.junit.*;
import static org.junit.Assert.*;
public class MoneyTest {
    private Money f12CHF;
    private Money f14CHF;

    @Before public void setUp() {   // create the test data
       f12CHF = new Money(12, "CHF");       // - the fixture
       f14CHF = new Money(14, "CHF");
    }
    @Test public void add() {       // create the test data
       Money expected = new Money(26, “CHF”);
       assertEquals(“amount not equal”,
                     expected,f12CHF.add(f14CHF));
    }
    ...
}
```

In C#

```
[TestMethod]
public void Withdraw_ValidAmount_ChangesBalance()
{
    // arrange
    double currentBalance = 10.0;
    double withdrawal = 1.0;
    double expected = 9.0;
    var account = new CheckingAccount("JohnDoe", currentBalance);
    // act
    account.Withdraw(withdrawal);
    double actual = account.Balance;
    // assert
    Assert.AreEqual(expected, actual);
}

[TestMethod]
[ExpectedException(typeof(ArgumentException))]
public void Withdraw_AmountMoreThanBalance_Throws()
{
    // arrange
    var account = new CheckingAccount("John Doe", 10.0);
    // act
    account.Withdraw(1.0);
    // assert is handled by the ExpectedException
}
```

Unit testing in C# is similar

to JUnit 4.X

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."

Roadmap

1. JUnit - a testing framework
    1. testing practices
    2. frameworks vs. libraries
    3. JUnit 3.x vs. JUnit 4.x (annotations)
2. **Money and MoneyBag - a testing case study**
3. Double dispatch - how to add different types of objects

Representing multiple currencies

The problem ...

> "The program we write will solve the problem of *representing arithmetic with multiple currencies*. Arithmetic between single currencies is trivial, you can just add the two amounts. ... Things get more interesting once multiple currencies are involved."

MoneyTest

We start by defining a TestCase that exercises the interface we would like our Money class to support:

```
import org.junit.*;
import static org.junit.Assert.*;
public class MoneyTest {
   private Money f12CHF;
   private Money f14CHF;

   @Before public void setUp() {   // create the test data
      f12CHF = new Money(12, "CHF");
      f14CHF = new Money(14, "CHF");
   }
   ...
}
```

Some basic tests...

We define methods to test what we expect to be true ...

```
@Test public void testEquals() {
    assertEquals(f12CHF, f12CHF);
    assertEquals(f12CHF, new Money(12, "CHF"));
    assertFalse(f12CHF.equals(f14CHF));
}

@Test public void testSimpleAdd() {
    Money expected = new Money(26, "CHF");
    Money result = f12CHF.add(f14CHF);
    assertEquals(expected, result);
}
```

Some basic tests

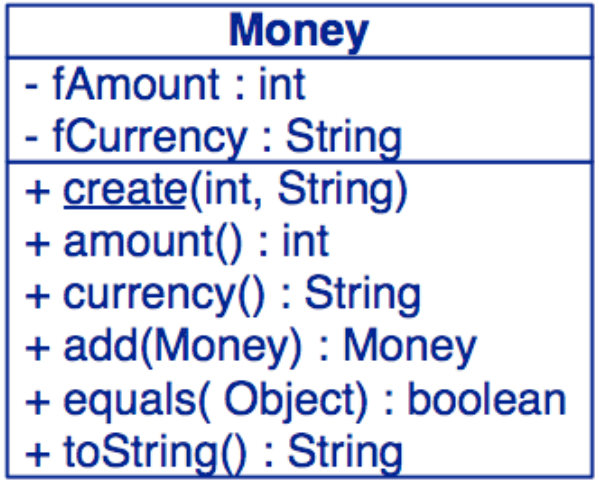
NB: assertTrue, etc. are static imported methods of the Assert class of the JUnit 4.x Framework and raise an AssertionError if they fail.

Junit 3.x raises a JUnit AssertionFailedError (!)

Money

We now implement a Money class that fills our first few requirements:

```
public class Money {
   ...
   public Money add(Money m) {
      return new Money(...);
   }
   ...
}
```



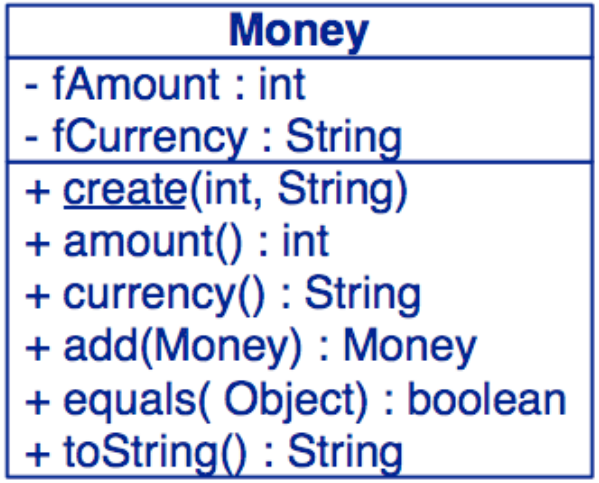
Note how the test case drives the design!

NB: The first version does not consider how to add different currencies!

Money

We now implement a Money class that fills our first few requirements:

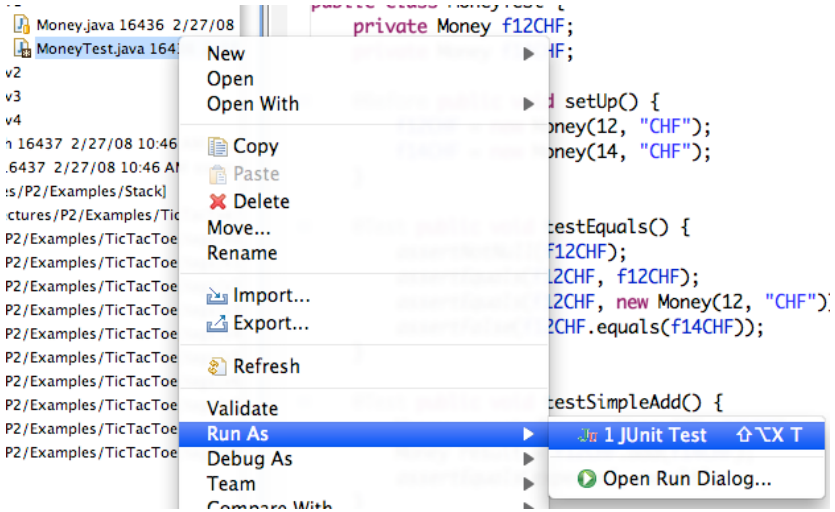
```
public class Money {
   ...
   public Money add(Money m) {
      return new Money(...);
   }
   ...
}
```

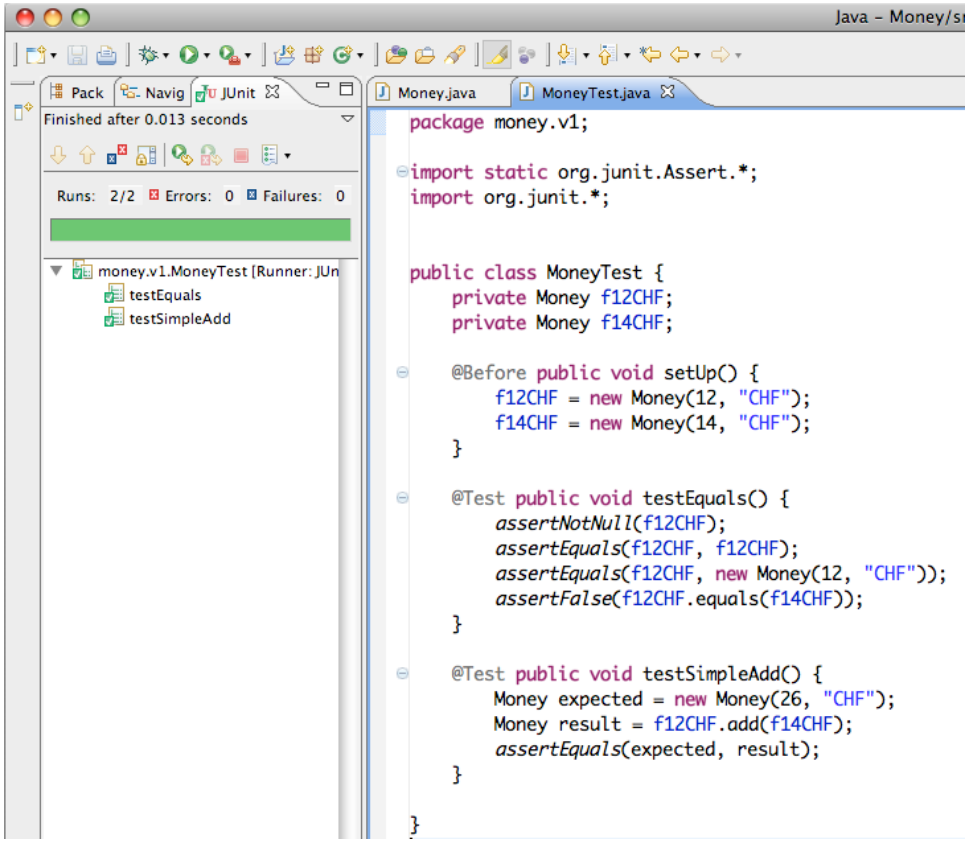


What should the class invariant be? (i.e., what are the conditions to have an object Money well formed?)

Running tests from eclipse

Right-click on the class (or package) to run the tests





Testing MoneyBags (I)

To handle multiple currencies, we introduce a MoneyBag class that can hold several instances of Money:

```
import static org.junit.Assert.*;
public class MoneyTest {
   ...
   @Before public void setUp() {
      f12CHF = new Money(12, "CHF");
      f14CHF = new Money(14, "CHF");
      f7USD = new Money( 7, "USD");
      f21USD = new Money(21, "USD");
      fMB1 = new MoneyBag(f12CHF, f7USD);
      fMB2 = new MoneyBag(f14CHF, f21USD);
   }
```

Testing MoneyBags (II)

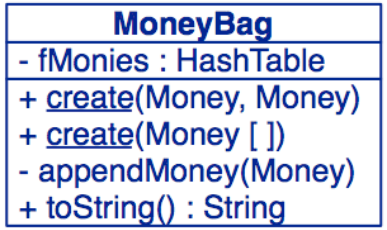
... and define some new (obvious) tests ...

```
@Test public void testBagEquals() {
   assertEquals(fMB1, fMB1);
   assertFalse(fMB1.equals(f12CHF));
   assertFalse(f12CHF.equals(fMB1));
   assertFalse(fMB1.equals(fMB2));
}
```

MoneyBags

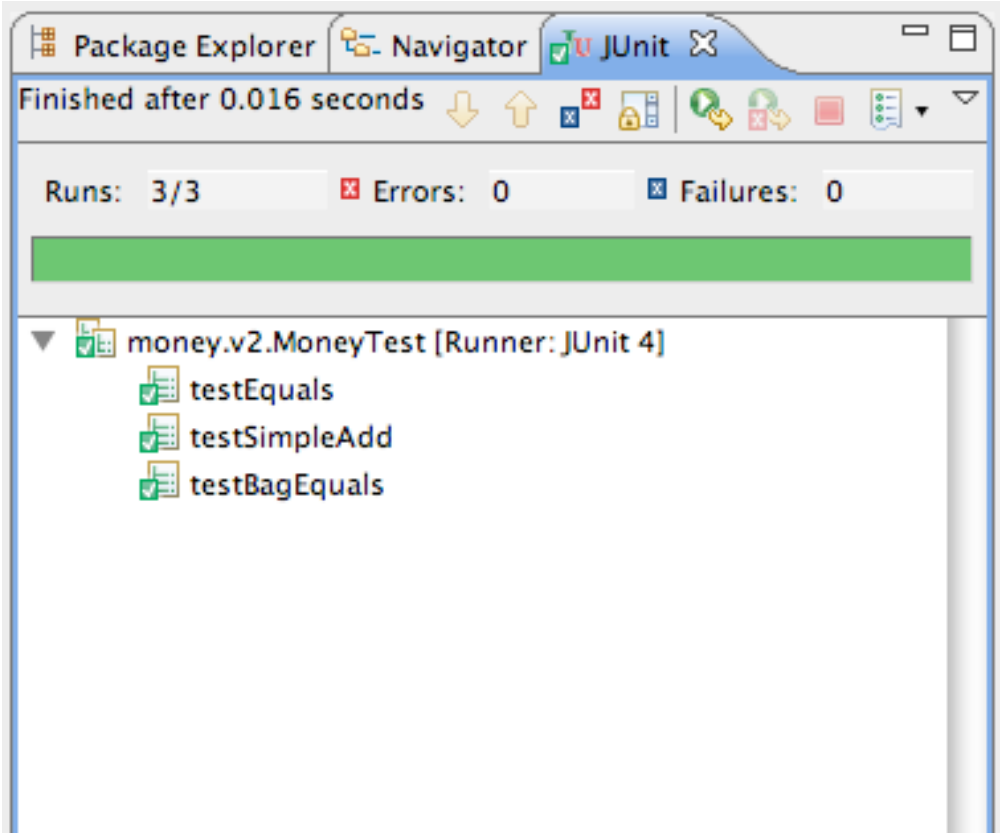
We can use a HashTable to keep track of multiple Monies:

```
public class MoneyBag {

   private Hashtable monies = new Hashtable();

   public MoneyBag(Money m1, Money m2) { ... }
   public MoneyBag(Money bag[]) {
      for (int i= 0; i < bag.length; i++)
         appendMoney(bag[i]);
   }

   private void appendMoney(Money aMoney) {
      Money m = (Money) monies.get(aMoney.currency());
      if (m != null) { m = m.add(aMoney); }
      else { m = aMoney; }
      monies.put(aMoney.currency(), m);
   }
}
```



Testing MoneyBags (III)

and we run the tests.



Roadmap

1. JUnit - a testing framework
    1. testing practices
    2. frameworks vs. libraries
    3. JUnit 3.x vs. JUnit 4.x (annotations)
2. Money and MoneyBag - a testing case study
3. **Double dispatch - how to add different types of objects**

Adding MoneyBags

We would like to freely add together arbitrary Monies and MoneyBags, and be sure that *equals behave as equals*:

```
@Test public void mixedSimpleAdd() {
   // [12 CHF] + [7 USD] == {[12 CHF][7 USD]}
   Money[] bag = { f12CHF, f7USD };
   MoneyBag expected = new MoneyBag(bag);
   assertEquals(expected, f12CHF.add(f7USD));
}
```

That implies that Money and MoneyBag should implement a common interface ...

Adding MoneyBags

```
f12CHF.add(f7USD) “=> return a money bag”

new MoneyBag().add(f12CHF) “=> return a money bag”

f12CHF.add(f12CHF) “=> return a money”

...
```

A possible solution

```
public class Money {
  public Object add(Object m) {
    if (m instanceof Money) { ... }
    if (m instanceof MoneyBag) { ... }
    // error here?
  }
}
```

```
public class MoneyBag {
  public Object add(Object m) {
    if (m instanceof Money) { ... }
    if (m instanceof MoneyBag) { ... }
    // error here?
  }
}
```

A possible solution

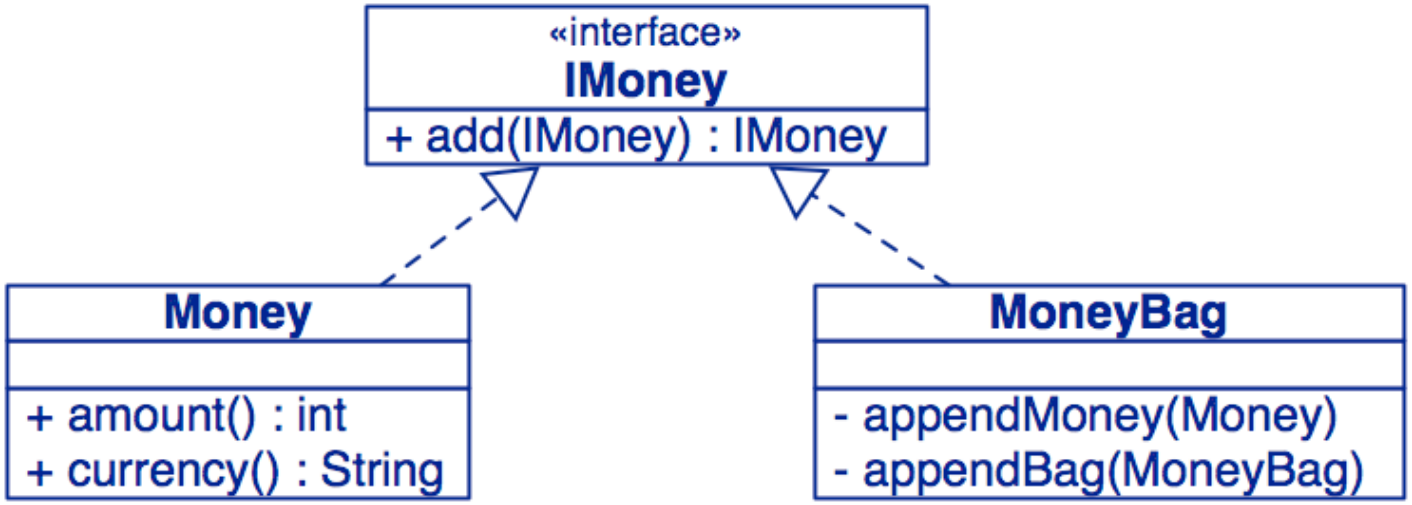
```
public class Money {
  public Object add(Object m) {
    if (m instanceof Money) { ... }
    if (m instanceof MoneyBag) { ... }
    // error here?
  }
}
```

```
public class MoneyBag {
  public Object add(Object m) {
    (m instanceof Money) { ... }
    instanceof MoneyBag) { ... }
    here?
```

no no, we do not want that!

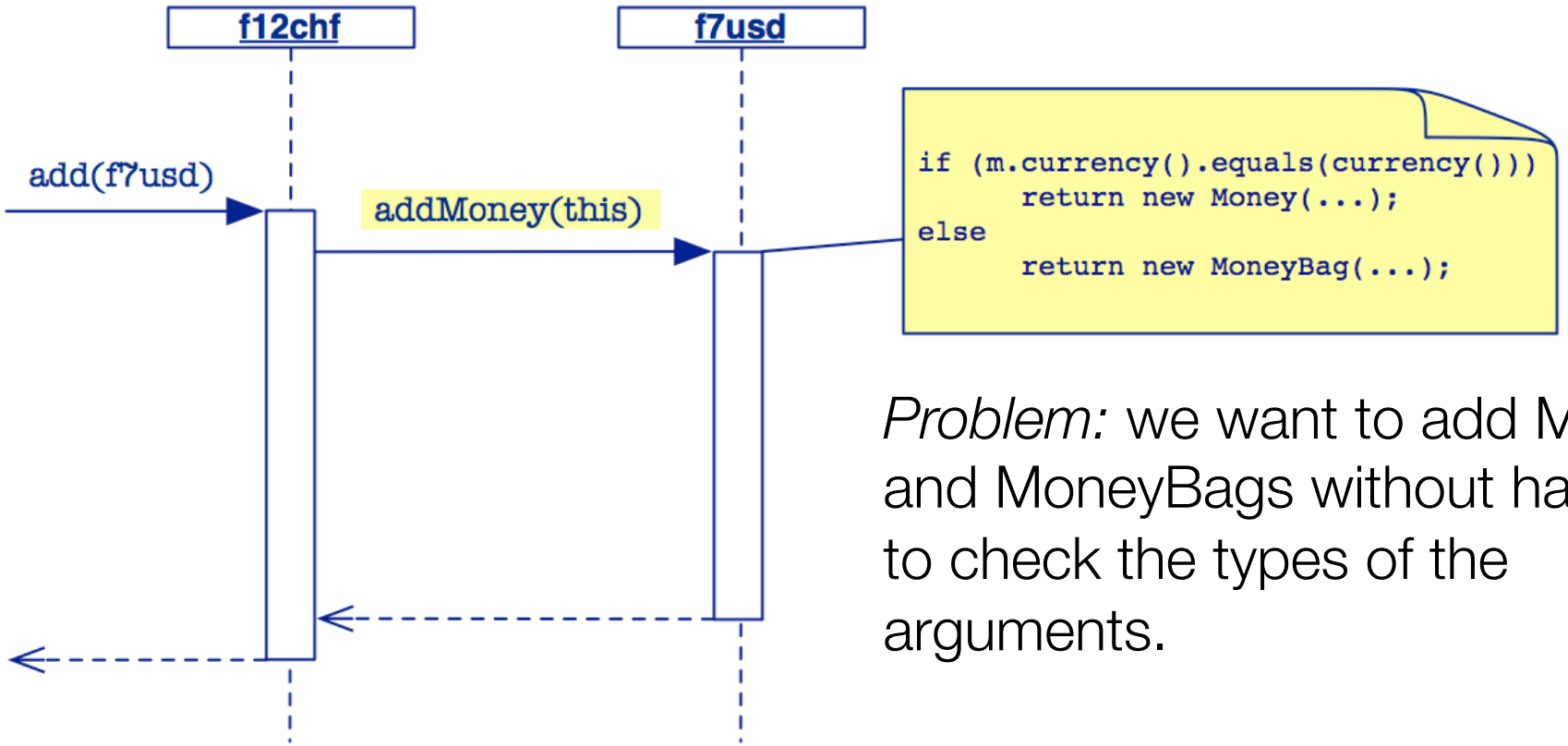
The IMoney interface (I)

Monies know how to be added to other Monies



Do we need anything else in the IMoney interface?

Double Dispatch (I)



Problem: we want to add Monies and MoneyBags without having to check the types of the arguments.

Solution: use *double dispatch* to expose more of your own interface.

Double Dispatch (II)

How do we implement add() without breaking encapsulation?

```
class Money implements IMoney { ...
   public IMoney add(IMoney m) {
      return m.addMoney(this);          // add me as a Money
   } ...
}
class MoneyBag implements IMoney { ...
   public IMoney add(IMoney m) {
      return m.addMoneyBag(this);       // add as a MoneyBag
   } ...
}
```

"The idea behind double dispatch is to use an additional call to discover the kind of argument we are dealing with..."

Double Dispatch (III)

The rest is then straightforward ...

```
class Money implements IMoney { ...
   public IMoney addMoney(Money m) {
      if (m.currency().equals(currency())) {
         return new Money(amount()+m.amount(),currency());
      } else {
         return new MoneyBag(this, m);
      }
   }
   public IMoney addMoneyBag(MoneyBag s) {
      return s.addMoney(this);
   } ...
```

and MoneyBag takes care of the rest.

Double Dispatch (IV)

Pros

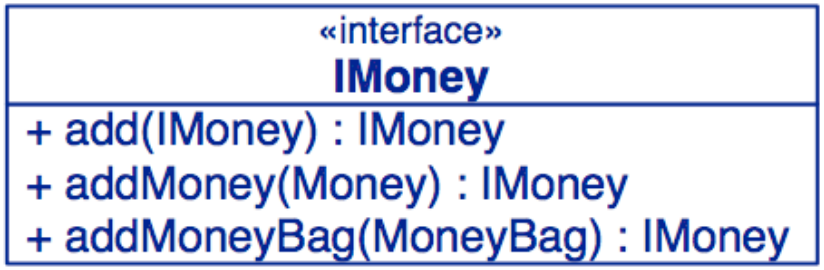
- No violation of encapsulation (no downcasting)
- Smaller methods; easier to debug
- Easy to add a new type

Cons

- No centralized control
- May lead to an explosion of helper methods

The IMoney interface (II)

So, the common interface has to be:

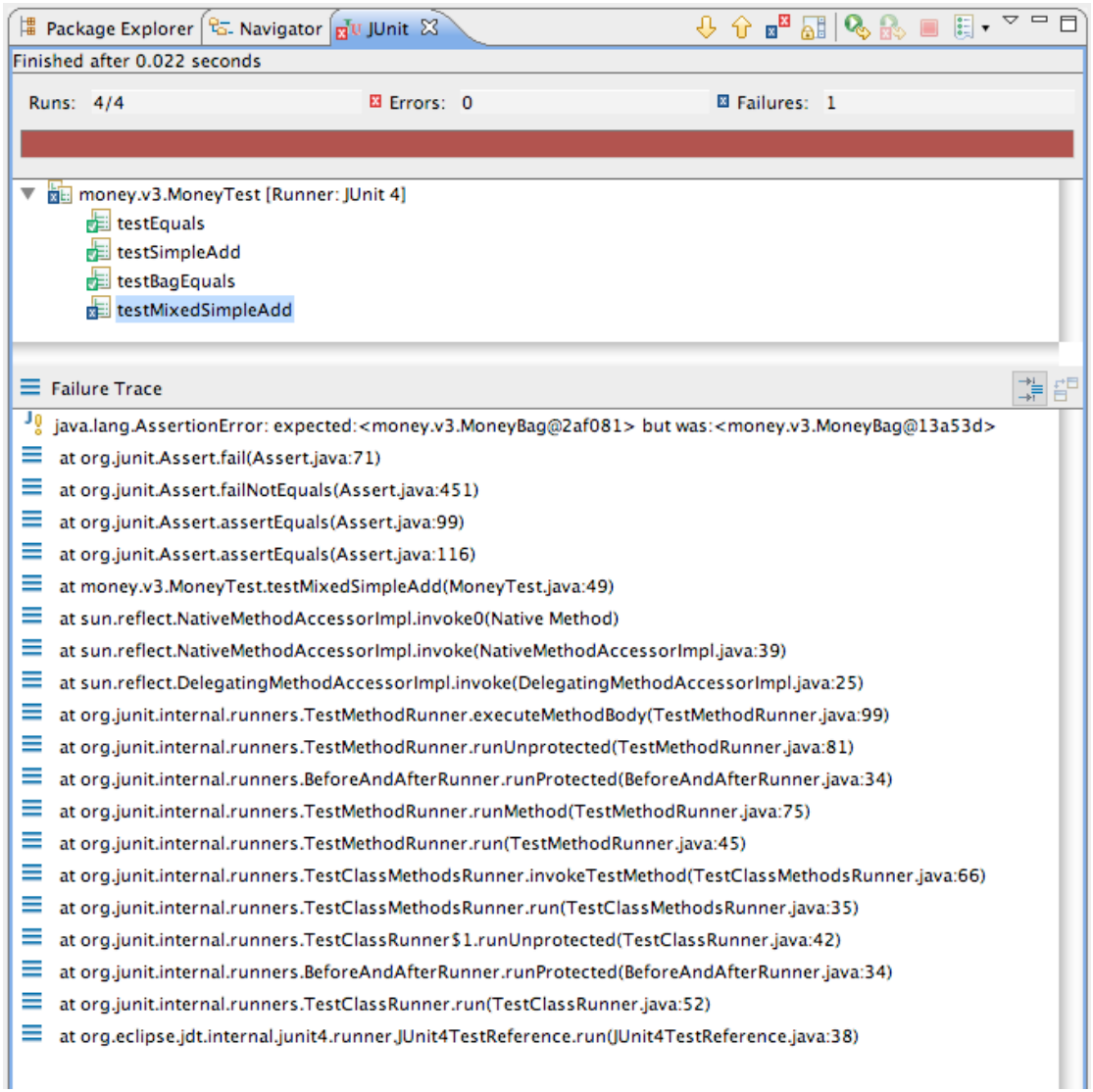



```
public interface IMoney {
   public IMoney add(IMoney aMoney);
   IMoney addMoney(Money aMoney);
   IMoney addMoneyBag(MoneyBag aMoneyBag);
}
```

NB: addMoney() and addMoneyBag() are only needed within the Money package.

A Failed test

This time we are not so lucky ...

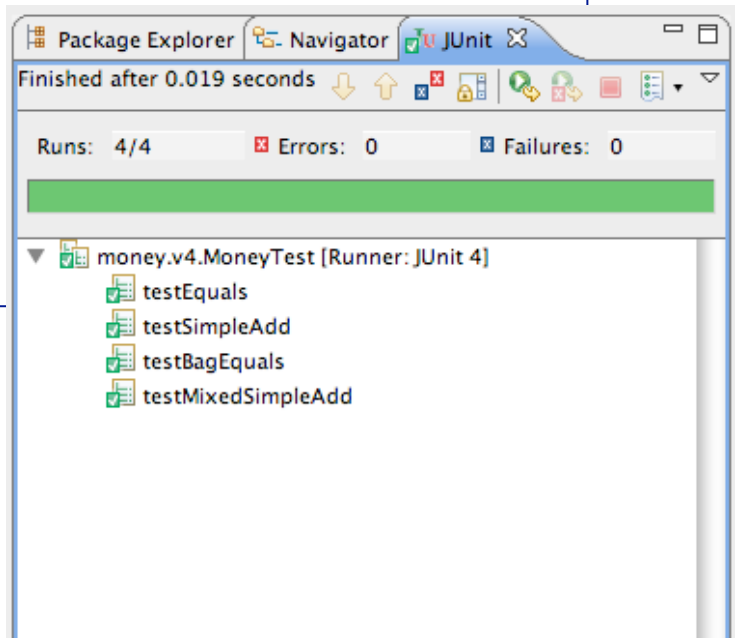


The fix ...

It seems we forgot to implement MoneyBag.equals()!

We fix it:

```
class MoneyBag implements IMoney { ...
   public boolean equals(Object anObject) {
      if (anObject instanceof MoneyBag) {
         ...
      } else {
         return false;
      }
   }
```



... test it, and continue developing.

What you should know!

How does a *framework* differ from a library?

What is a *unit test*?

What is an *annotation*?

How does *JUnit 3.x* differ from *JUnit 4.x*?

What is a test "*fixture*"?

What should you test in a *TestCase*?

How can testing *drive* design?

What is "*double dispatch*"? What does the name mean?

Can you answer these questions?

How does implementing toString() help in debugging?

How does the MoneyTest suite know which test methods to run?

How does the TestRunner invoke the right suite() method?

Why doesn't the Java compiler complain that MoneyBag.equals() is used without being declared?

License

http://creativecommons.org/licenses/by-sa/2.5

creative commons

COMMONS DEED

Attribution-ShareAlike 2.5

You are free:

- to copy, distribute, display, and perform the work
- to make derivative works
- to make commercial use of the work

Under the following conditions:

Attribution. You must attribute the work in the manner specified by the author or licensor.

Share Alike. If you alter, transform, or build upon this work, you may distribute the resulting work only under a license identical to this one.

- For any reuse or distribution, you must make clear to others the license terms of this work.
- Any of these conditions can be waived if you get permission from the copyright holder.

Your fair use and other rights are in no way affected by the above.