A Testing Framework
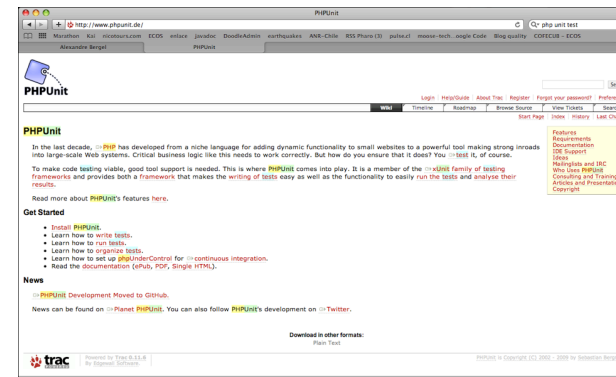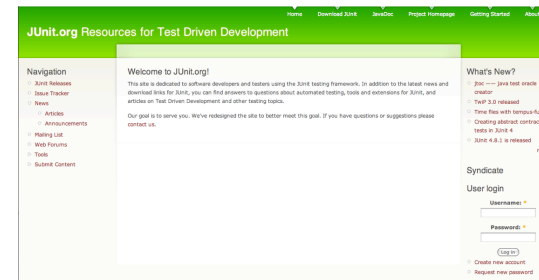
Alexandre Bergel
abergel@dcc.uchile.cl
27/04/2010

A Testing Framework

Source

JUnit 4.0 documentation (from www.junit.org)

PHPUnit (http://www.phpunit.de)

"Software testing used to be an activity for lesser programmers. It was tedious, it was repetitive, it was everything a respectable programmer would hate. It took two guys, a couple of classes and a nice xUnit naming scheme to turn the game around. *Now, you know a respectable programmer by the tests he writes.*"

- Tudor Doru Girba

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

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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.

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
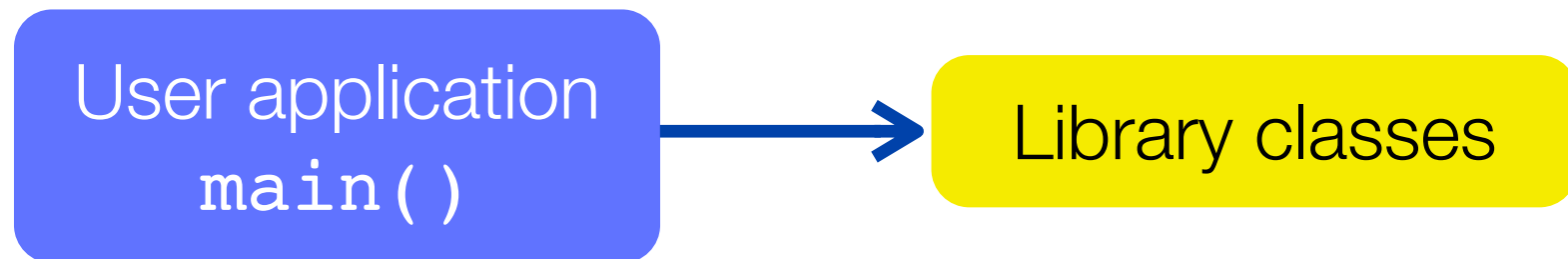
For documentation of how to use JUnit http://junit.sourceforge.net/doc/cookbook/cookbook.htm

Frameworks vs. Libraries

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

```
User application
main()
```

→

```
Library classes
```

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

```
Framework
main()
```

→

```
User classes
```
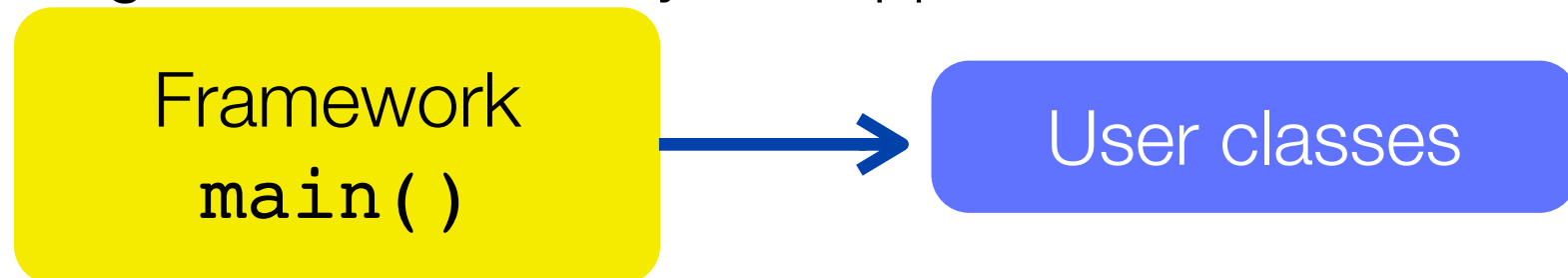
Frameworks vs. Libraries

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
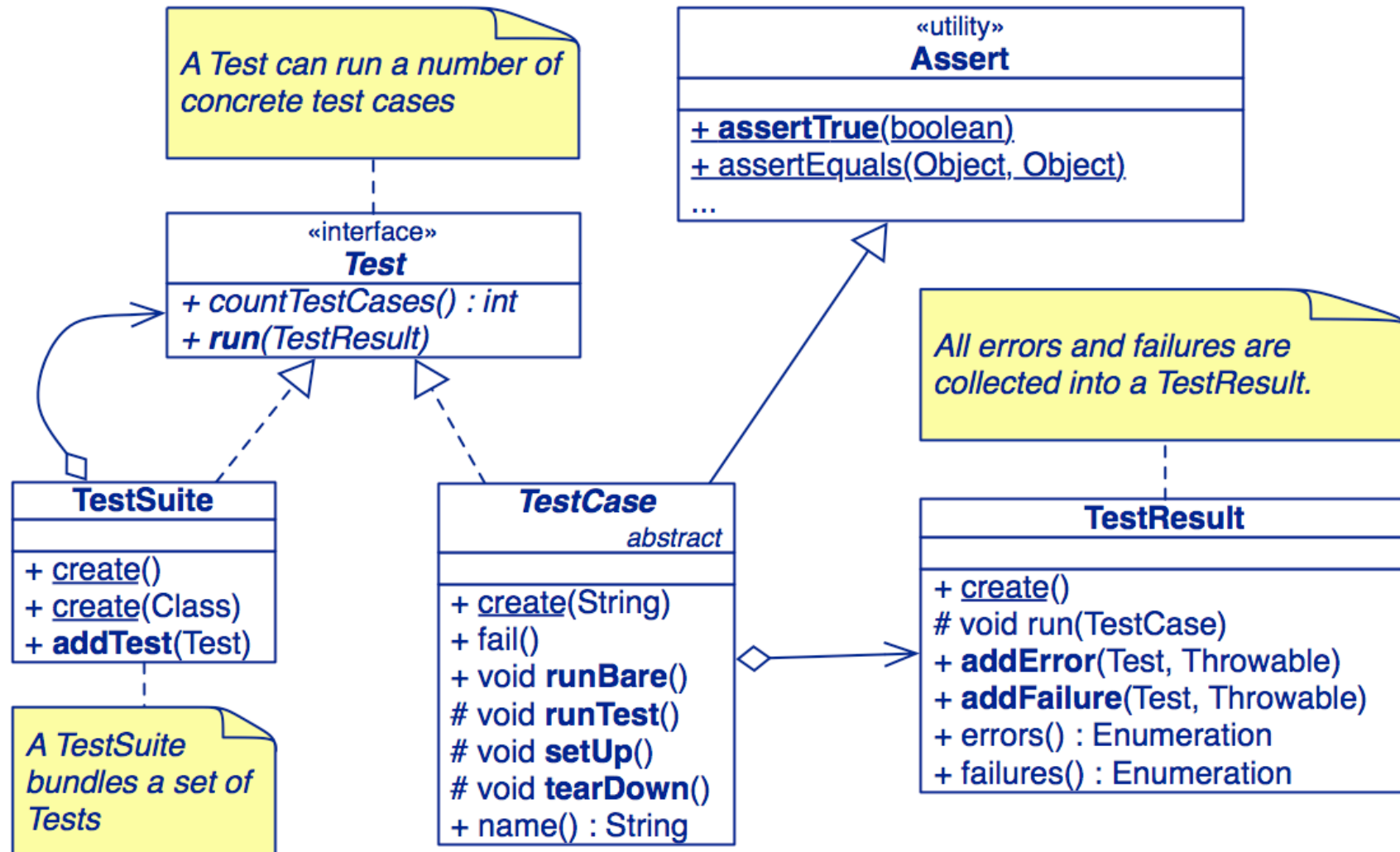
textual and graphical tools for running tests

JUnit 3.8

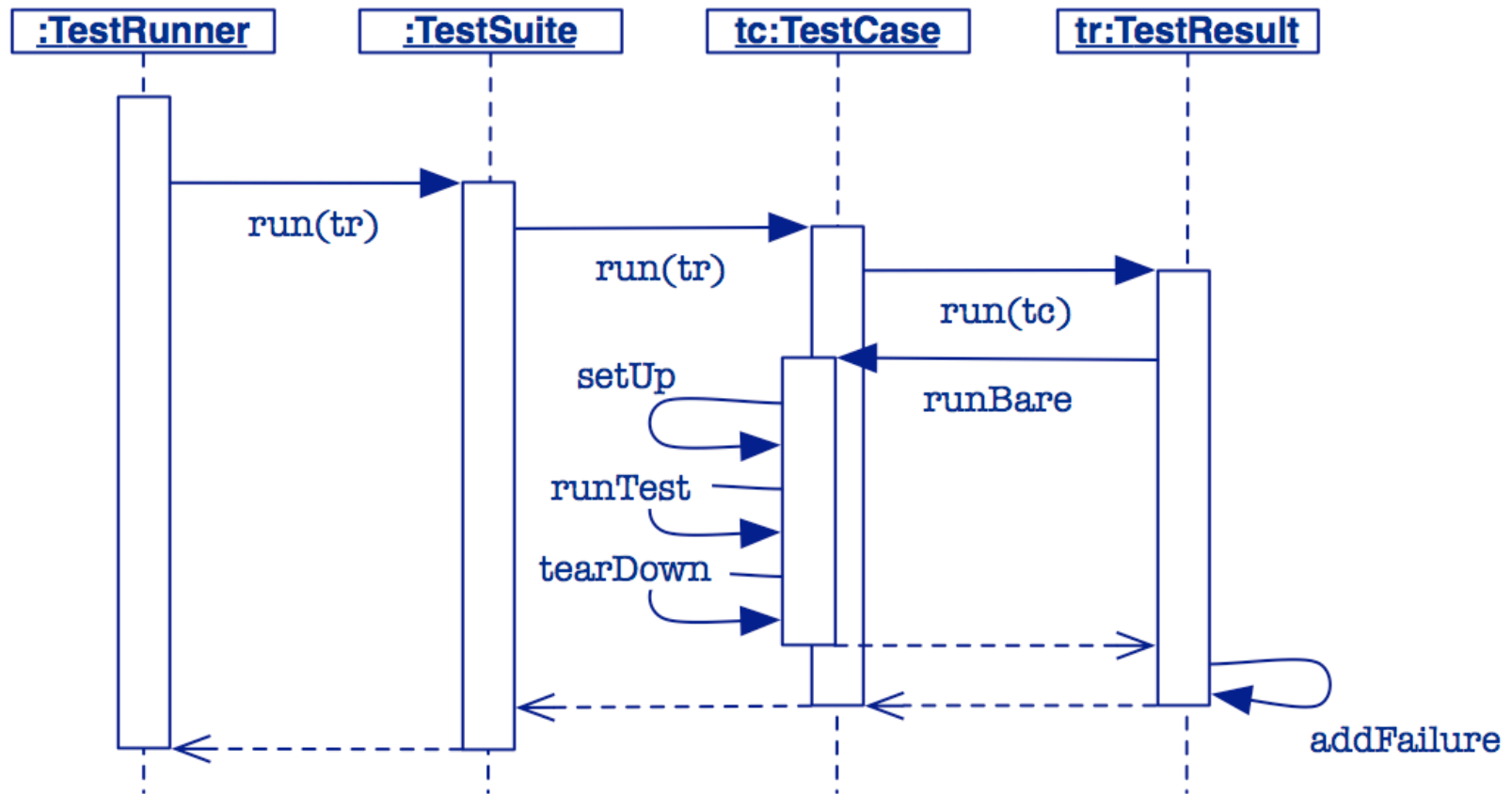JUnit distinguishes between failures and errors:

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

A Test can run a number of concrete test cases

«interface»
Test
+ countTestCases() : int
+ **run**(TestResult)

«utility»
Assert

+ **assertTrue**(boolean)
+ assertEquals(Object, Object)
...

All errors and failures are collected into a TestResult.

TestSuite

+ create()
+ create(Class)
+ **addTest**(Test)

A TestSuite bundles a set of Tests

TestCase
abstract

+ create(String)
+ fail()
+ void **runBare**()
# void **runTest**()
# void **setUp**()
# void **tearDown**()
+ name() : String

TestResult

+ create()
# void run(TestCase)
+ **addError**(Test, Throwable)
+ **addFailure**(Test, Throwable)
+ errors() : Enumeration
+ failures() : Enumeration

A Testing Scenario

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

JUnit 3.x Example Code

```java
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");
    }
    void testAdd() {               // create the test data
        Money expected = new Money(26, "CHF");
        assertEquals("amount not equal",
                      expected,f12CHF.add(f14CHF);
    }
    ...
}
```

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

```java
import junit.framework.*;
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 testadd() {        // create the test data
        Money expected = new Money(26, "CHF");
        assertEquals("amount not equal",
                    expected,f12CHF.add(f14CHF));
    }
    ...
}
```

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."

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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:

```java
import org.junit.*;
import static org.junit.Assert.*;
public class MoneyTest {
    private Money f12CHF;
    private Money f14CHF;
    public MoneyTest(String name) { super(name); }

    @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 ...

```java
@Test public void testEquals() {
    assertNotNull(f12CHF);
    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(...);
   }
   ...
}
```
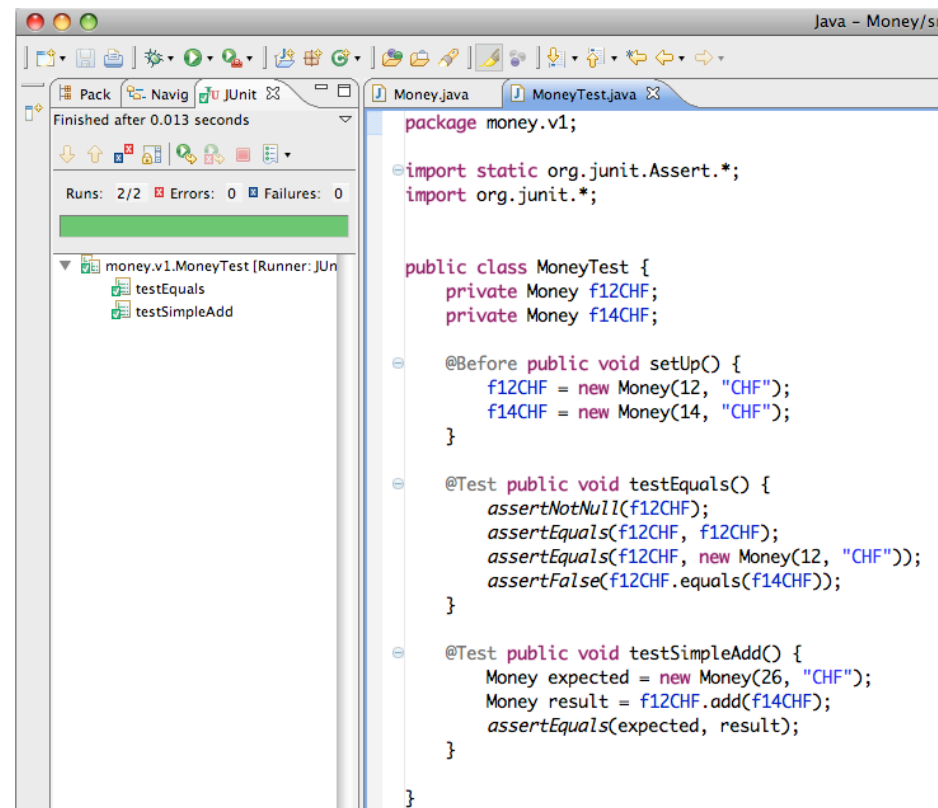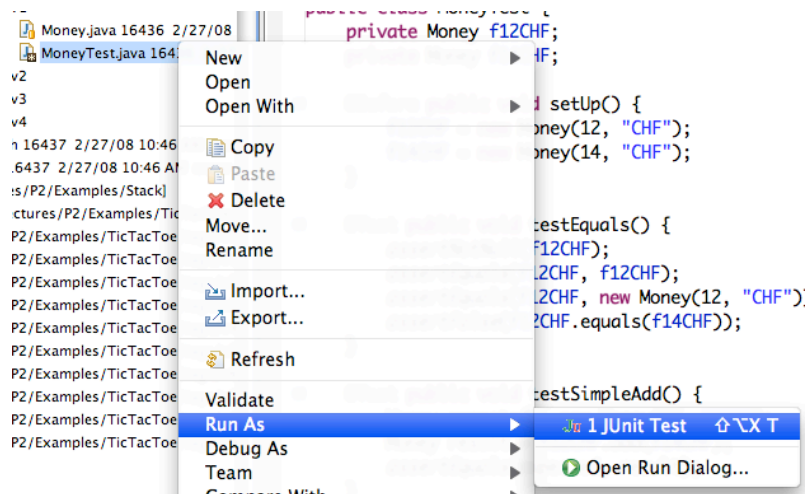
Money
- fAmount : int
- fCurrency : String
+ create(int, String)
+ amount() : int
+ currency() : String
+ add(Money) : Money
+ equals(Object) : boolean
+ toString() : String

Note how the test case drives the design!

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

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:

```java
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() {
    assertNotNull(fMB1);
    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:

```
class MoneyBag {
    private Hashtable monies = new Hashtable(5);
    MoneyBag(Money m1, Money m2) { ... }
    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);
    }
}
```

MoneyBag

- fMonies : HashTable
+ create(Money, Money)
+ create(Money [ ])
- appendMoney(Money)
+ toString() : String

Testing MoneyBags (III)

and we run the tests.
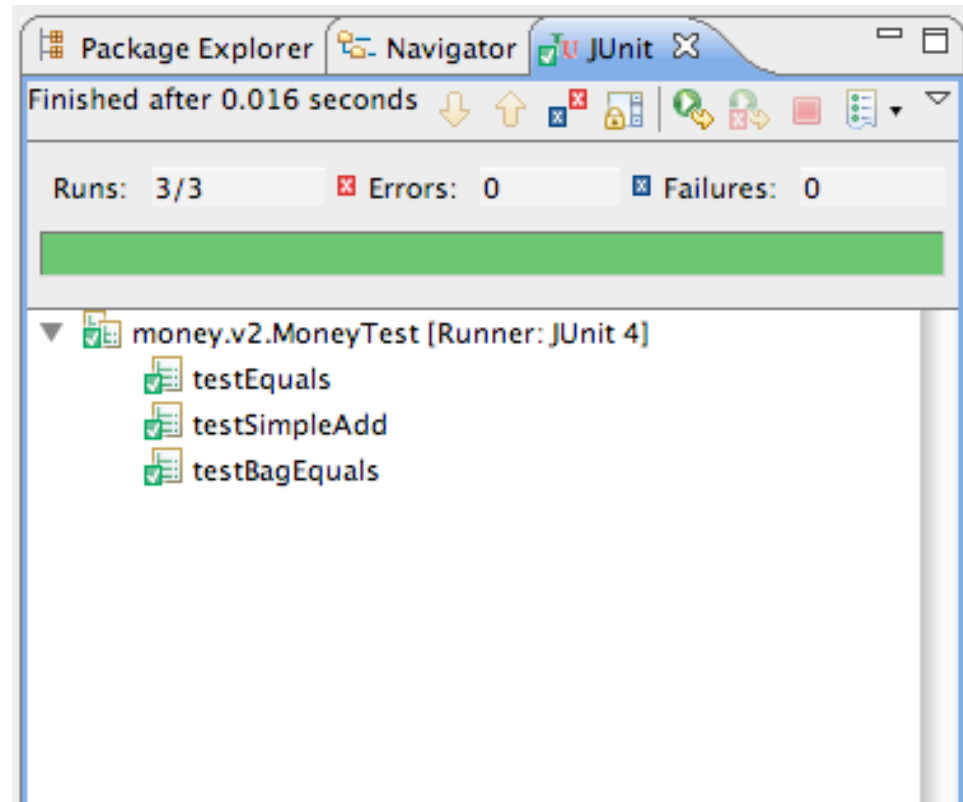
Roadmap

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Adding MoneyBags

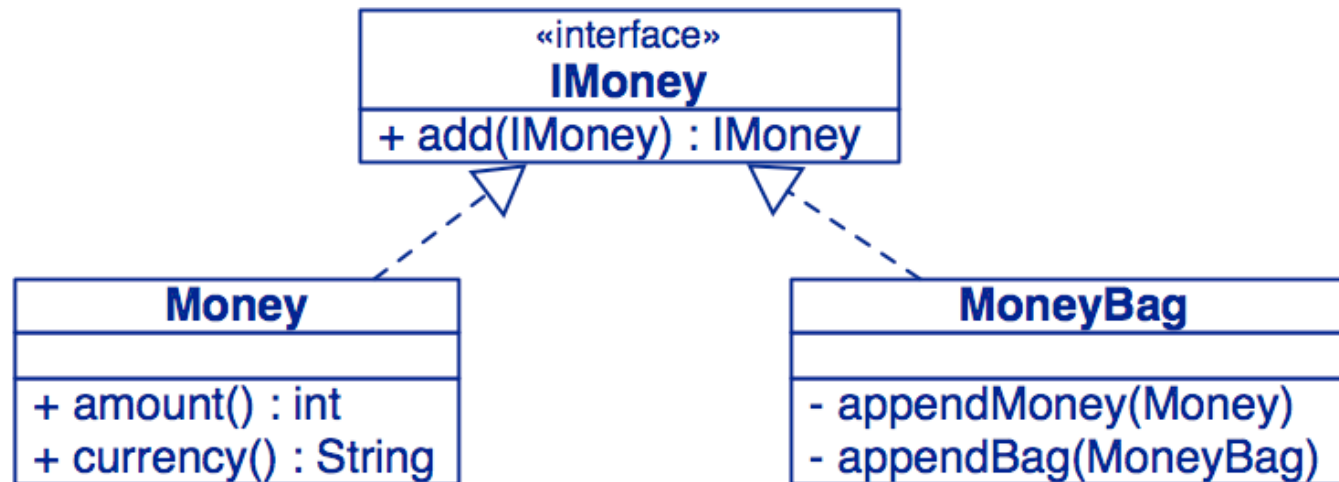We would like to freely add together arbitrary Monies and MoneyBags, and be sure that *equals behave as equals*:

```java
@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 ...
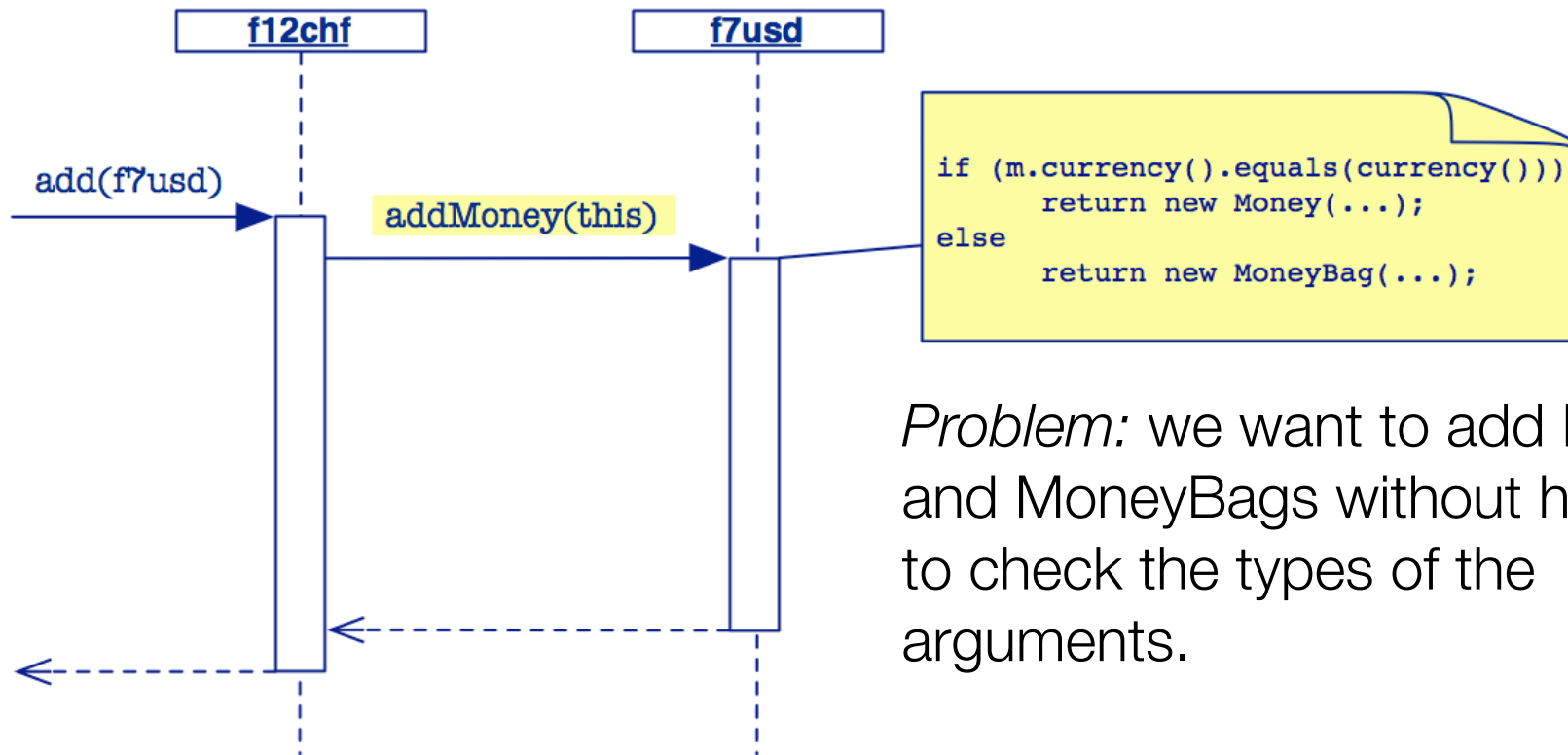
The IMoney interface (I)

Monies know how to be added to other Monies

Do we need anything else in the IMoney interface?

Double Dispatch (I)


```
if (m.currency().equals(currency()))
        return new Money(...);
else
        return new MoneyBag(...);
```

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 ...

```java
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)

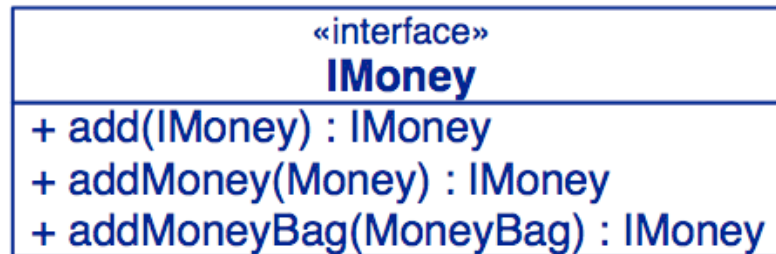Smaller methods; easier to debug

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:

«interface»
IMoney
+ add(IMoney) : IMoney + addMoney(Money) : IMoney + addMoneyBag(MoneyBag) : IMoney

```
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
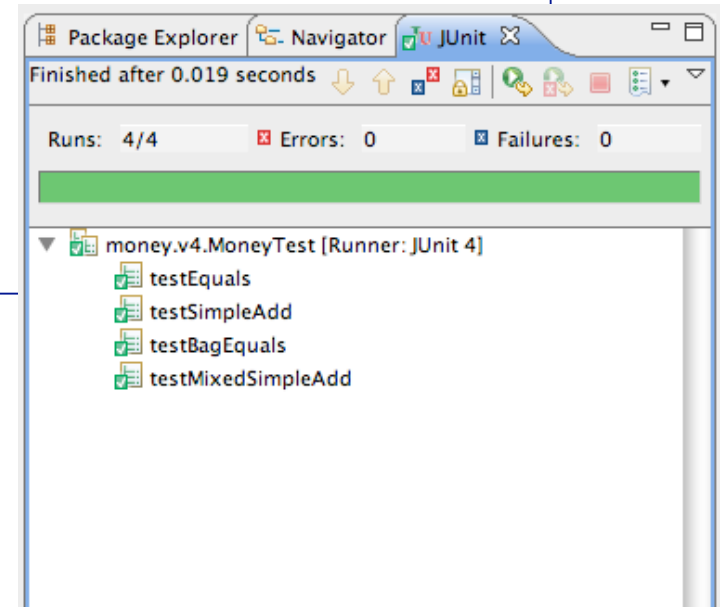
This time we are not so lucky ...
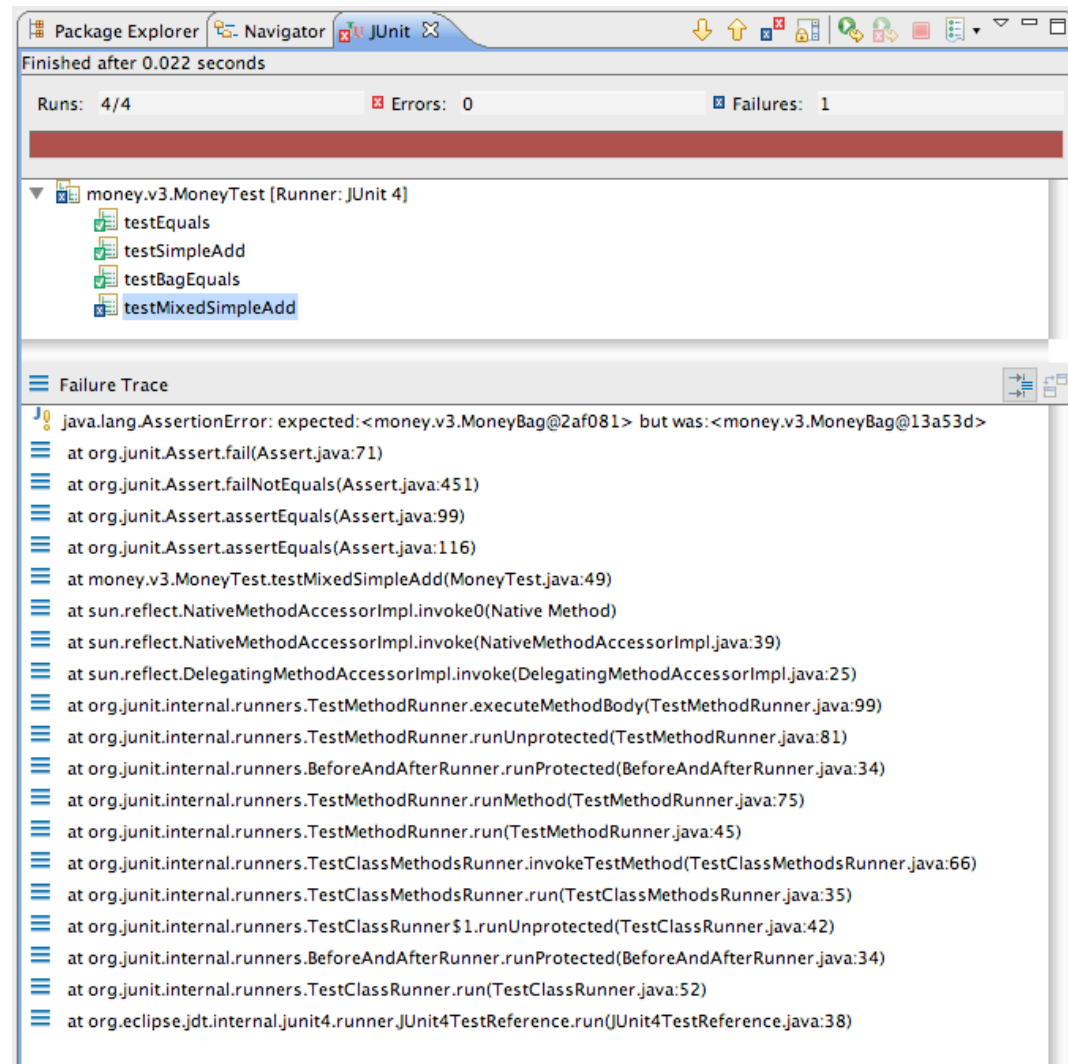
The fix ...

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;
        }
    }
}
```

Package Explorer | Navigator | JUnit ✕

Finished after 0.019 seconds

Runs: 4/4   ☒ Errors: 0   ☒ Failures: 0

▼ money.v4.MoneyTest [Runner: JUnit 4]
  testEquals
  testSimpleAdd
  testBagEquals
  testMixedSimpleAdd

... 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?

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