CS 5154: Software Testing

Test Automation Framework

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About this slide deck…

- These slides are posted here for your review

- We cover the material in these slides during the demo

Recall: components of a test

- Test case values (or, input values)
- Expected results
- A test oracle

JUnit: A test automation framework

- JUnit is open source: (https://junit.org)
- JUnit is widely used
- JUnit can be used
  - with standalone Java programs
  - within an IDE
  - within a build system like Maven

Some JUnit features that we saw in the demo

- Assertions for testing expected results
- Parameterized tests for sharing code among different inputs
- Test classes containing
  - a collection of test methods
  - Test fixtures: methods to set up state before, and to update state after tests
- Test runners for running the tests and reporting the results
  - e.g., org.junit.runner.JUnitCore

JUnit Test Fixtures

- A test fixture is the state of the test
  - Objects and variables that are used by more than one test
  - Initializations (*prefix* values)
  - Reset values (*postfix* values)
- Different tests can use the objects without sharing the state
- Objects used in test fixtures should be declared as instance variables
- They should be initialized in a @Before (or @BeforeClass) method
- Can be deallocated or reset in an @After (or @AfterClass) method

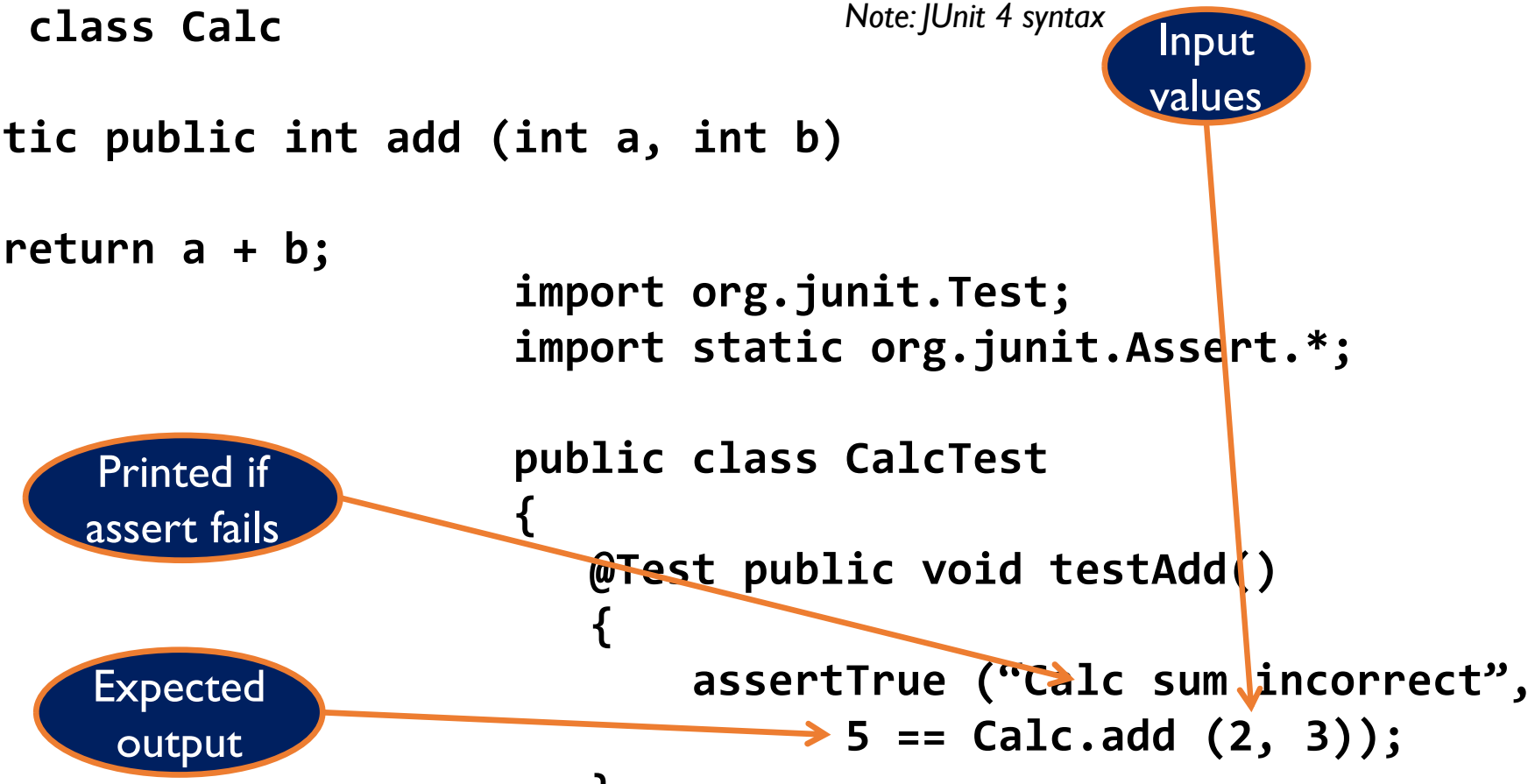
Simple JUnit Example

```
public class Calc
{
   static public int add (int a, int b)
   {
      return a + b;
   }
}
```

Note: JUnit 4 syntax

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

public class CalcTest
{
   @Test public void testAdd()
   {
      assertTrue ("Calc sum incorrect",
                  5 == Calc.add (2, 3));
   }
}
```



Testing the Min Class

```
import java.util.*;

public class Min
{
  /**
    * Returns the mininum element in a list
    * @param list Comparable list of elements to search
    * @return the minimum element in the list
    * @throws NullPointerException if list is null or
    *         if any list elements are null
    * @throws ClassCastException if list elements are
              not mutually comparable
    * @throws IllegalArgumentException if list is empty
    */
     …
}
```

Testing the Min Class (2)

```
public static <T extends Comparable<? super T>> T min (List<? extends T> list)
{
       if (list.size() == 0)
       {
          throw new IllegalArgumentException ("Min.min");
       }
       Iterator<? extends T> itr = list.iterator();
       T result = itr.next();

       if (result == null) throw new NullPointerException ("Min.min");

       while (itr.hasNext())
       {   // throws NPE, CCE as needed
           T comp = itr.next();
           if (comp.compareTo (result) < 0)
           { result = comp; }   }
       return result;
}
```

MinTest Class

Standard imports for all JUnit classes :

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

Test fixture and pre-test setup method (prefix) :

```
private List<String> list;   // Test fixture

// Set up - Called before each test method
@Before
 public void setUp() {
     list = new ArrayList<String>();
 }
```

Post test teardown method (postfix) :

```
// Tear down - Called after every test method.
@After
public void tearDown(){
   list = null;   // redundant in this example
}
```

Min Test Cases: NullPointerException

```
@Test public void testForNullList()
{
    list = null;
    try {
        Min.min (list);
    } catch (NullPointerException e) {
        return;
    }
    fail ("NullPointerException expected");
}
```

This NullPointerException test uses the fail assertion

This NullPointerException test decorates the @Test annotation with the class of the exception

```
@Test (expected =
NullPointerException.class)
public void testForNullElement()
{
     list.add (null);
     list.add ("cat");
     Min.min (list);
}
```

This NullPointerException test catches an easily overlooked special case

```
@Test (expected =
NullPointerException.class)
public void testForSoloNullElement()
{
     list.add (null);
     Min.min (list);
}
```

More Exception Test Cases for Min

```
@Test (expected =
ClassCastException.class)
@SuppressWarnings ("unchecked")
public void
testMutuallyIncomparable()
{
   List list = new ArrayList();
   list.add ("cat");
   list.add ("dog");
   list.add (1);
   Min.min (list);
}
```

Note that Java generics don't prevent clients from using raw types!

Special case: Testing for the empty list

```
@Test (expected =
IllegalArgumentException.class)
public void testEmptyList()
{
      Min.min (list);
}
```

Finally! A couple of “Happy Path” tests

Remaining Test Cases for Min

```
@Test
public void testSingleElement() {
     list.add ("cat");
     Object obj = Min.min (list);
     assertTrue ("Single Element List", obj.equals ("cat"));
}

@Test
 public void testDoubleElement(){
     list.add ("dog");
     list.add ("cat");
     Object obj = Min.min (list);
     assertTrue ("Double Element List", obj.equals ("cat"));
 }
```

Data-Driven Tests

- **Problem** : Testing a function multiple times with similar values
  - How to avoid test code bloat?
- **Simple example** : Adding two numbers
  - Adding a given pair of numbers is just like adding any other pair
  - You only want to write one test
- **Parameterized** unit tests call a constructor for each collection of test values
  - Same tests are then run on each set of data values
  - Collection of data values defined by method tagged with **@Parameters** annotation

Example JUnit parameterized unit test

```
import org.junit.*;
import org.junit.runner.RunWith;
import org.junit.runners.Parameterized;
import org.junit.runners.Parameterized.Parameters;
import static org.junit.Assert.*;
import java.util.*;

@RunWith (Parameterized.class)
public class DataDrivenCalcTest
{  public int a, b, sum;

   public DataDrivenCalcTest (int v1, int v2, int expected)
   { this.a = v1; this.b = v2; this.sum = expected; }

  @Parameters public static Collection<Object[]> parameters()
  { return Arrays.asList (new Object [][] {{1, 1, 2}, {2, 3, 5}});
}

  @Test public void additionTest()
  { assertTrue ("Addition Test", sum == Calc.add (a, b)); }
}
```

Constructor is called for each triple of values

Test 1
Test values: 1, 1
Expected: 2

Test 2
Test values: 2, 3
Expected: 5

Test method

How to Run Tests

- JUnit provides test drivers
  - Character-based test driver runs from the command line
  - GUI-based test driver-*junit.swingui.TestRunner*
    - Not covered in this course

- If a test fails, JUnit gives the location of the failure and any exceptions that were thrown

JUnit Resources

- There are many JUnit tutorials on the Internet

- JUnit: Download, Documentation
  - https://junit.org/junit4

Summary on Test Automation

- Automation makes testing efficient and effective
- Test frameworks provide very simple ways to automate our tests
- Not a "silver bullet" … it does not solve a hard problem in testing:

What test values to use ?

- This is test design … the purpose of test criteria