Chapter 3

Test automation

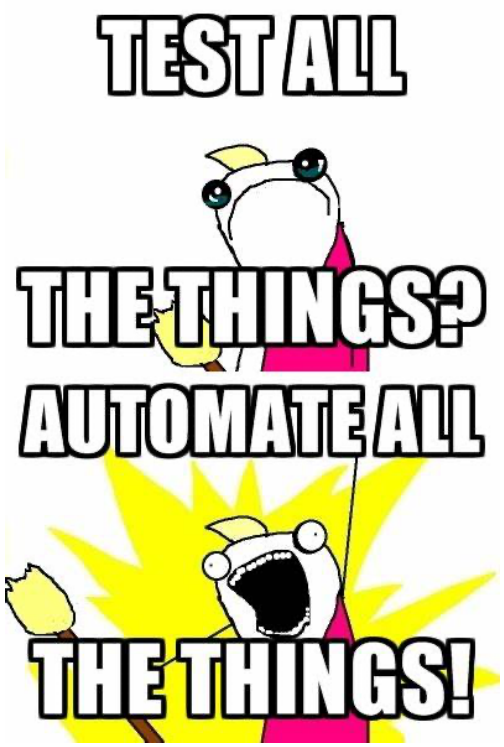
Brittany Johnson
SWE 437

Adapted from slides by Paul Ammann & Jeff Offutt

What is test automation?

Using software to control the testing

- **Setting up** test preconditions
- Test **execution**
- **Comparing** actual results to test results
- Test **reporting**



Reduces **cost**

Reduces **human error**

Reduces **variance** in test quality from different individuals

Significantly reduces the cost of **regression** testing

Software testability (3.1)

The degree to which a system or component facilitates the establishment of test criteria and the performance of tests to determine whether those criteria have been met.

How hard is it to find faults in the software

Testability is dominated by **two** practical problems:

- How to **observe the results** of test execution
- How to **provide test values** to the software

Observability and controllability

Observability

How easy it is to observe the behavior of a program in term of its outputs, effects on the environment, and other hardware and software components

- Software that affects hardware devices, databases, or remote files have low observability

Controllability

How easy it is to provide a program with the needed inputs, in terms of values, operations, and behaviors

- Easy to control software with inputs from keyboards
- Inputs from hardware sensors or distributed software is harder

Data abstraction reduces controllability and observability

Components of a test case (3.2)

A test case is a **multipart artifact** with a definite structure

Test case values

The input values needed to complete an execution of the software under test

Expected results

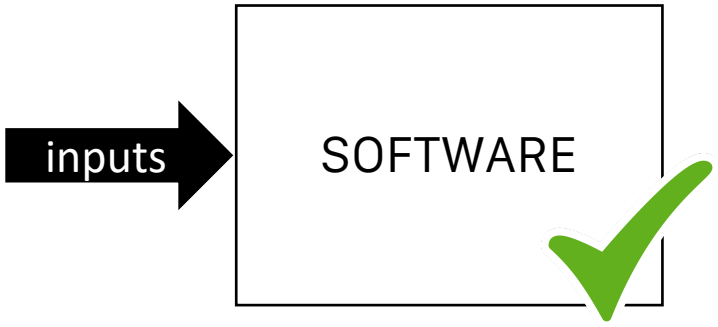
The result that will be produced by the test if the software behaves as expected

- A *test oracle* uses expected results to decide whether a test passed or failed

Affecting controllability and observability

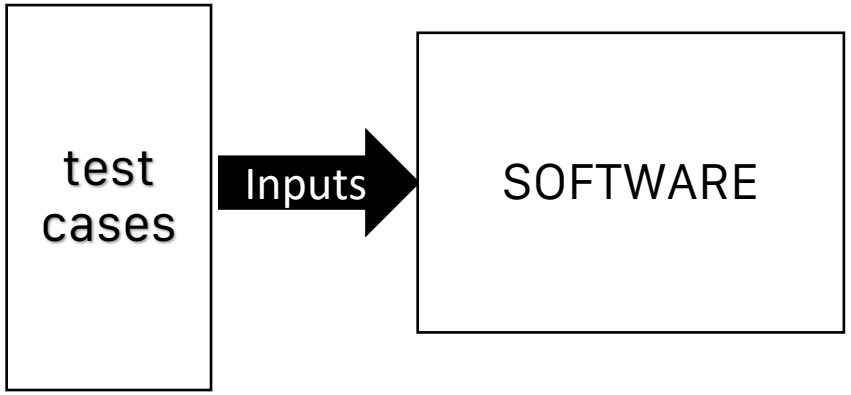
Prefix values

Inputs to put the software into the correct state to receive the test case values



Postfix values

Inputs that must be sent to the software after the test case values



Putting tests together

Test case

The test case values, prefix values, postfix values, and expected results necessary for a complete execution and evaluation of the software under test

Test set (or suite)

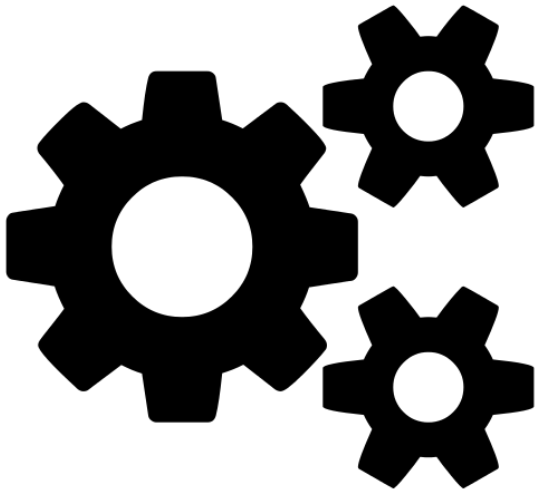
A set of test cases

Executable test script

A test case that is prepared in a form to be executed automatically on the test software and produce a report

Test automation framework (3.3)

A set of assumptions, concepts, and tools that support test automation



JUnit test framework

Junit can be used **to test**...

- ...an entire object
- ...part of an object – a method or some interacting methods
- ...interaction between several objects

It is primarily intended for **unit and integration testing**, not systems testing

Each test is embedded into one **test method**

A **test class** contains one or more test methods

Test classes **include**:

- A collection of **test methods**
- Methods to **set up** the state before and **update** the state after each test and before and after all tests

Get started at **junit.org**

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** method

Can be deallocated or reset in an **@After** method

Simple JUnit example

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

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

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

Test values

Printed if assert fails

Expected output

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

```
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;
}

}
```

In-class exercise

Write test inputs for the Min class

Be sure to include expected outputs

Once you have enough tests, write one in JUnit.
If you're not sure how, ask for help.

If you have written JUnit tests, help somebody who has not.

You do not need to execute the tests.

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 every 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 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 uses the fail assertion

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

This NullPointerException test catches an easily overlooked special case

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!

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

Special case: Testing for the empty list

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"));
 }
```

Finally! A couple of "Happy Path" tests

Summary: Seven tests for Min

Five tests for exceptions

1. null list
2. null element with multiple elements
3. null single element
4. incomparable types
5. empty elements

Two without exceptions

1. single element
2. two elements

JUnit resources

Some JUnit tutorials

- http://open.ncsu.edu/se/tutorials/junit/

  (Laurie Williams, Dright Ho, and Sarah Heckman)

- http://www.laliluna.de/eclipse-junit-testing-tutorial.html

  (Sascha Wolski and Sebastian Hennebrueder)

- http://www.diasparsoftware.com/template.php?content=jUnitStarterGuide

  (Diaspar software)

- http://www.clarkware.com/articles/JUnitPrimer.html

  (Clarkware consulting)

JUnit: download and documentation

- http://www.junit.org

Summary

The only way to make testing **efficient** as well as **effective** is to automate as much as possible

Test frameworks provide very simple ways to automate our tests

It is no "**silver bullet**" however…it does not solve the hard problem of testing:

What test values to use?

This is test design – the purpose of **test criteria**