Automated GUI testing

How to test an interactive application automatically?

Some GUI facts

- Software testing accounts for 50-60% of total software development costs
- GUIs can constitute as much as 60% of the code of an application
- GUI development frameworks such as Swing make GUI development easier
- Unfortunately, they make GUI testing much harder

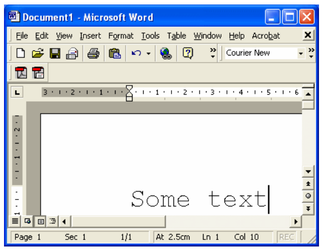
Why is GUI testing difficult?

- Event-driven architecture
  - User actions create events
  - An automatic test suite has to simulate these events somehow
- Large space of possibilities
  - The user may click on any pixel on the screen
  - Even the simplest components have a large number of attributes and methods
    - JButton has more than 50 attributes and 200 methods
  - The state of the GUI is a combination of the states of all of its components

Challenges of GUI testing

- **Test case generation**: What combinations of user actions to try?
- **Oracles**: What is the expected GUI behaviour?
- **Coverage**: How much testing is enough?
- **Regression testing**: Can test cases from an earlier version be re-used?
- **Representation**: How to represent the GUI to handle all the above?

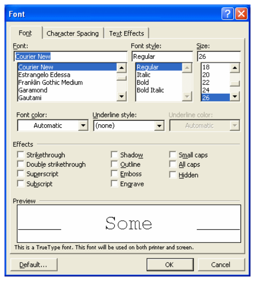
A GUI test case


Document1 - Microsoft Word
File Edit View Insert Format Tools Table Window Help Acrobat
Courier New
Page 1 Sec 1 1/1 At 2.5cm Ln 1 Col 10 REC

Some text

1. Select text "Some"
2. Menu "Format"
3. Option "Font"

A GUI Test Case



Font: Courier New
Font style: Regular
Size: 26
Font color: Automatic
Underline style: (none)
Underline color: Automatic

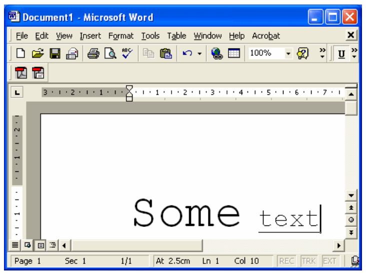
Some

This is a TrueType font. This font will be used on both printer and screen.

4. Combobox "Size"
5. Click on 26
6. Click OK

A GUI Test Case

7. Select "text"
8. Click **U**
9. Verify that the output looks like this


Document1 - Microsoft Word
File Edit View Insert Format Tools Table Window Help Acrobat
Some text
Page 1 Sec 1 1/1 At 2.5cm Ln 1 Col 10

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GUI vs. business model testing

- GUI testing
  - The look of the text in the editor window corresponds to the operations performed
  - The **U** button is selected
  - All appropriate actions are still enabled, i.e. we can italicize the underlined text
- Business model testing
  - Word's internal model reflects the text formatting we performed

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Two approaches to GUI testing

1. Black box
   - Launch application
   - Simulate mouse and keyboard events
   - Compare final look to an existing screen dump
     - Very brittle test cases
     - Cannot test business model
     - Framework independent

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Two approaches to GUI testing

2. Glass box
   - Launch application in the testing code
   - Obtain references to the various components and send events to them
   - Assert the state of components directly
     - Test cases harder to break
     - Business model can be tested
     - Framework dependent

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A first approach

- The Java API provides a class called java.awt.Robot
- It can be used to generate native system input events
  - Different than creating Event objects and adding them to the AWT event queue
  - These events will indeed move the mouse, click, etc.

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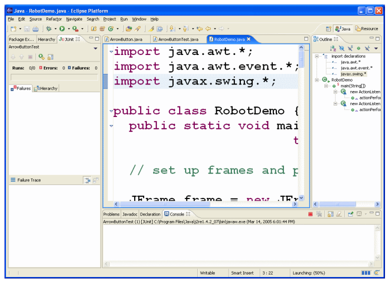
RobotDemo


Java - RobotDemo.java - Eclipse Platform
File Edit Source Refactor Navigate Search Project Run Window Help
Package Ex... Hierarchy JUnit
ArrowButtonTest
Runs: 0/0 Errors: 0 Failures: 0
Failures Hierarchy
Failure Trace
ArrowButton.java ArrowButtonTest.java RobotDemo.java
Outline
import declarations
java.awt.*
java.awt.event.*
javax.swing.*
RobotDemo
main(String[])
new ActionListen
actionPerfo
new ActionListen
actionPerfo
Problems Javadoc Declaration Console
Writable Smart Insert 3 : 22 Launching: (50%)

```
import java.awt.*;
import java.awt.event.*;
import javax.swing.*;

public class RobotDemo {
  public static void mai
                        t

  // set up frames and p

  JFrame frame = new JFr
```

```
ArrowButtonTest (1) [JUnit] C:\Program Files\Java\j2re1.4.2_07\bin\javaw.exe (Mar 14, 2005 6:01:44 PM)
```

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Testing with Robot

- User input can be simulated by the robot
- How to evaluate that the correct GUI behaviour has taken place?
  - Robot includes method public BufferedImage **createScreenCapture**(Rectangle screenRect)
  - Creates an image containing pixels read from the screen

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Problems with this approach

- Low-level
  - Would rather say "Select "blue" from the colour list" than

```
Move to the colour list
     co-ordinates
Click
Press ↓ 5 times
Click
```

- Brittle test cases (regression impossible)

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A better approach

- Every GUI component should provide a public API which can be invoked in the same manner via a system user event or programmatically
- Component behaviour should be separated from event handling code
- For example, class JButton contains the doClick() method

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Unfortunately…

- Most GUI development frameworks are not designed in this fashion
- In Swing, event handling is mixed with complex component behaviour in the Look and Feel code
- Few components offer methods such as doClick()

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Abbot – A Better ' Bot

- A GUI testing framework for Swing
- Works seamlessly with Junit
  - Uses some Junit 3 features
- Can be used to create
  - Unit tests for GUI components
  - Functional tests for existing GUI apps
- Open source
  - http://abbot.sourceforge.net/

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Goals of the Abbot framework

- Reliable reproduction of user input
- High-level semantic actions
- Scripted control of actions
- Loose component bindings

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Abbot overview

- A better Robot class is provided
  - abbot.tester.Robot includes events to click, drag, type on any component
- For each Swing widget a corresponding Tester class is provided
  - E.g. JPopupMenuTester provides a method called getMenuLabels()
- Components can be retrieved from the component hierarchy
  - No direct reference to any widget is necessary

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A typical test case

```
JButton button = (JButton)getFinder().find(
  new Matcher() {
    public boolean matches(Component c) {
      return c instanceof JButton &&
          ((JButton)c).getText().equals("OK");
    }});
AbstractButtonTester tester =
                   new AbstractButtonTester();
Tester.actionClick(button);
assertEquals("Wrong button tooltip",
  "Click to accept", button.getToolTipText());
```

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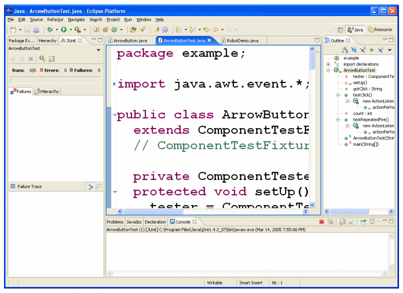
Testing with Abbot demo



```
package example;

import java.awt.event.*;

public class ArrowButton
  extends ComponentTestF
  // ComponentTestFixtur

  private ComponentTeste
  protected void setUp()
    tester = ComponentTe
```

```
ArrowButtonTest (1) [JUnit] C:\Program Files\Java\j2re1.4.2_07\bin\javaw.exe (Mar 14, 2005 7:55:06 PM)
```

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JUnit 3 features

- Abbot requires JUnit 3
- Only the differences between JUnit 3 and JUnit 4 are presented in the next slides
- The JUnit 3 jar file is included in the abbot distribution

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Extending TestCase

- Each test class needs to extend class junit.framework.TestCase

```
public class SomeClassTest
    extends junit.framework.TestCase {
              …
}
```

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Naming vs. Annotations

- protected void setUp()
  - The @Before method must have this signature
- protected void tearDown()
  - The @After method must have this signature
- public void testAdd()
  public void testToString()
  - All @Test methods must have names that start with test
- Do not include any annotations

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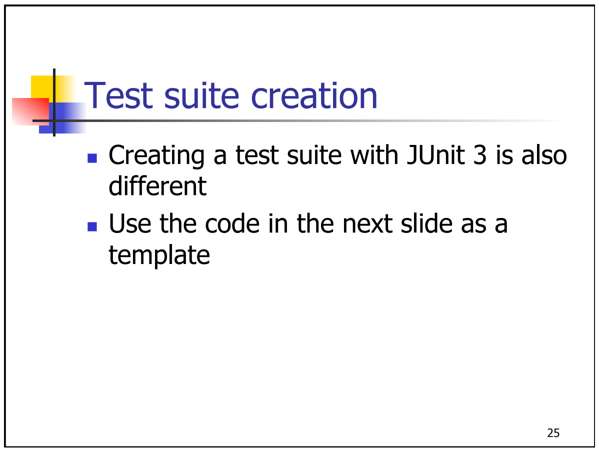

Test suite creation

- Creating a test suite with JUnit 3 is also different
- Use the code in the next slide as a template

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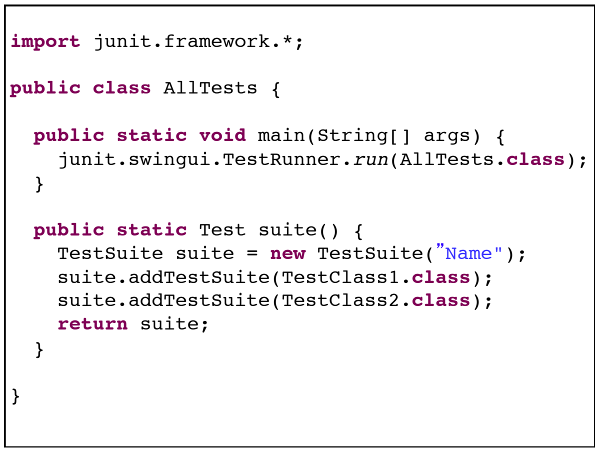

```
import junit.framework.*;

public class AllTests {

  public static void main(String[] args) {
    junit.swingui.TestRunner.run(AllTests.class);
  }

  public static Test suite() {
    TestSuite suite = new TestSuite("Name");
    suite.addTestSuite(TestClass1.class);
    suite.addTestSuite(TestClass2.class);
    return suite;
  }

}
```