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 more difficult

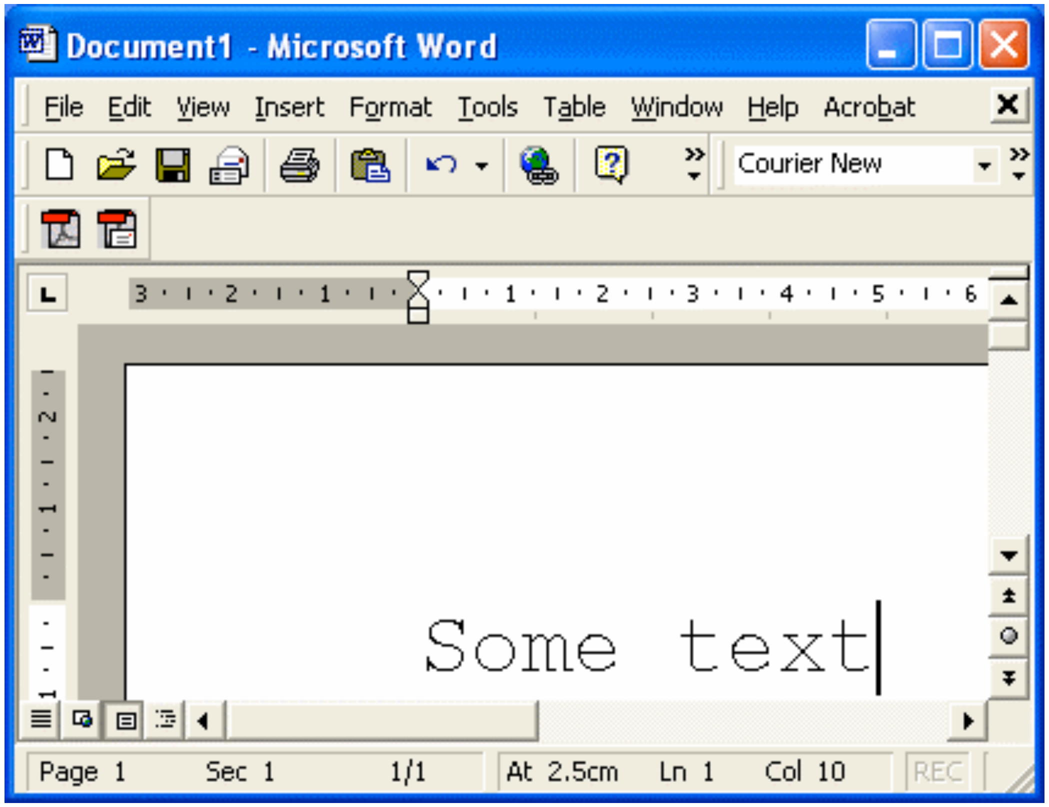
Why is GUI testing difficult?

- 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?

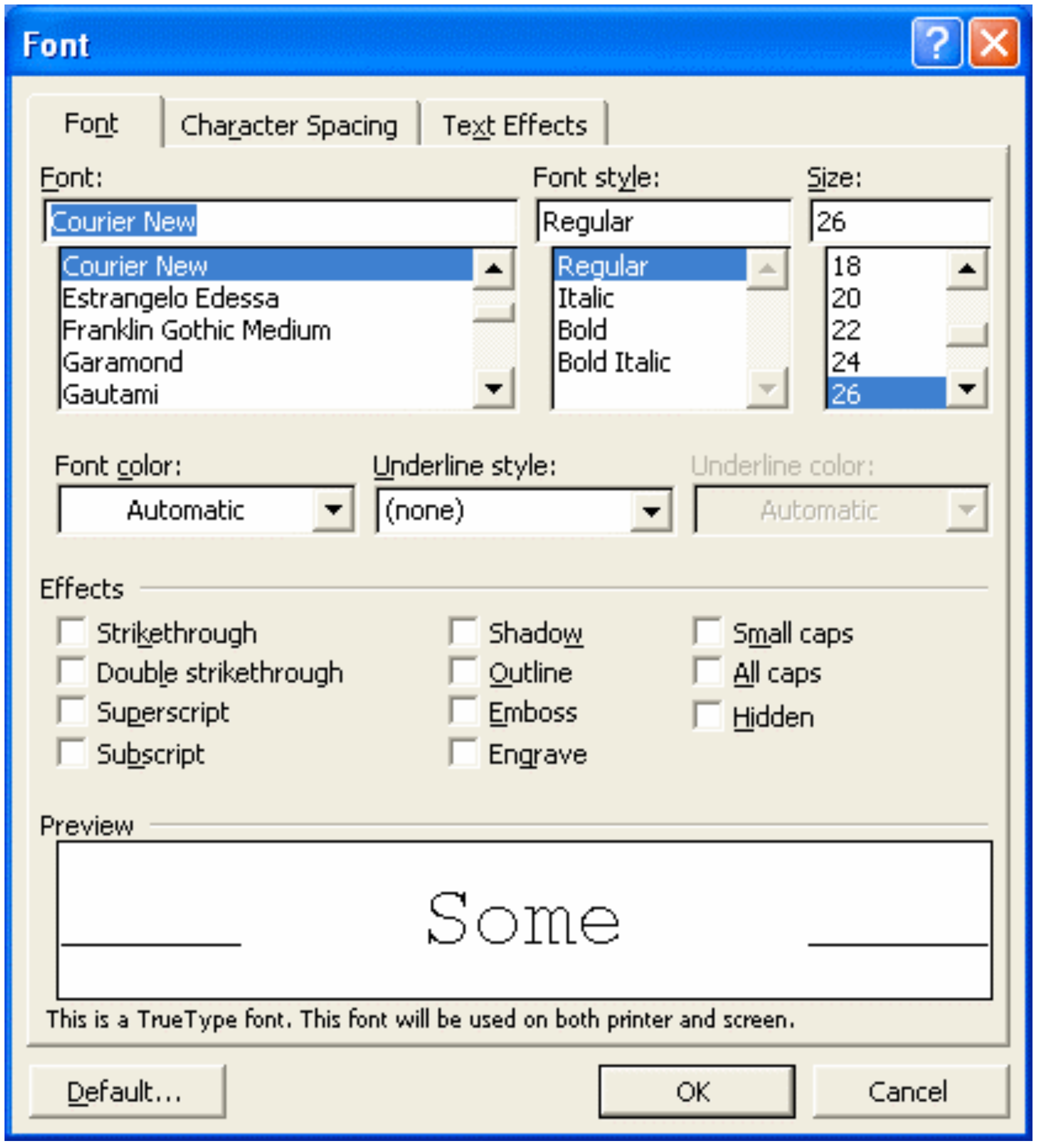
A GUI test case


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

Font | Character Spacing | Text Effects

Font: Courier New
Courier New
Estrangelo Edessa
Franklin Gothic Medium
Garamond
Gautami

Font style: Regular
Regular
Italic
Bold
Bold Italic

Size: 26
18
20
22
24
26

Font color: Automatic

Underline style: (none)

Underline color: Automatic

Effects

- [ ] Strikethrough
- [ ] Double strikethrough
- [ ] Superscript
- [ ] Subscript
- [ ] Shadow
- [ ] Outline
- [ ] Emboss
- [ ] Engrave
- [ ] Small caps
- [ ] All caps
- [ ] Hidden

Preview

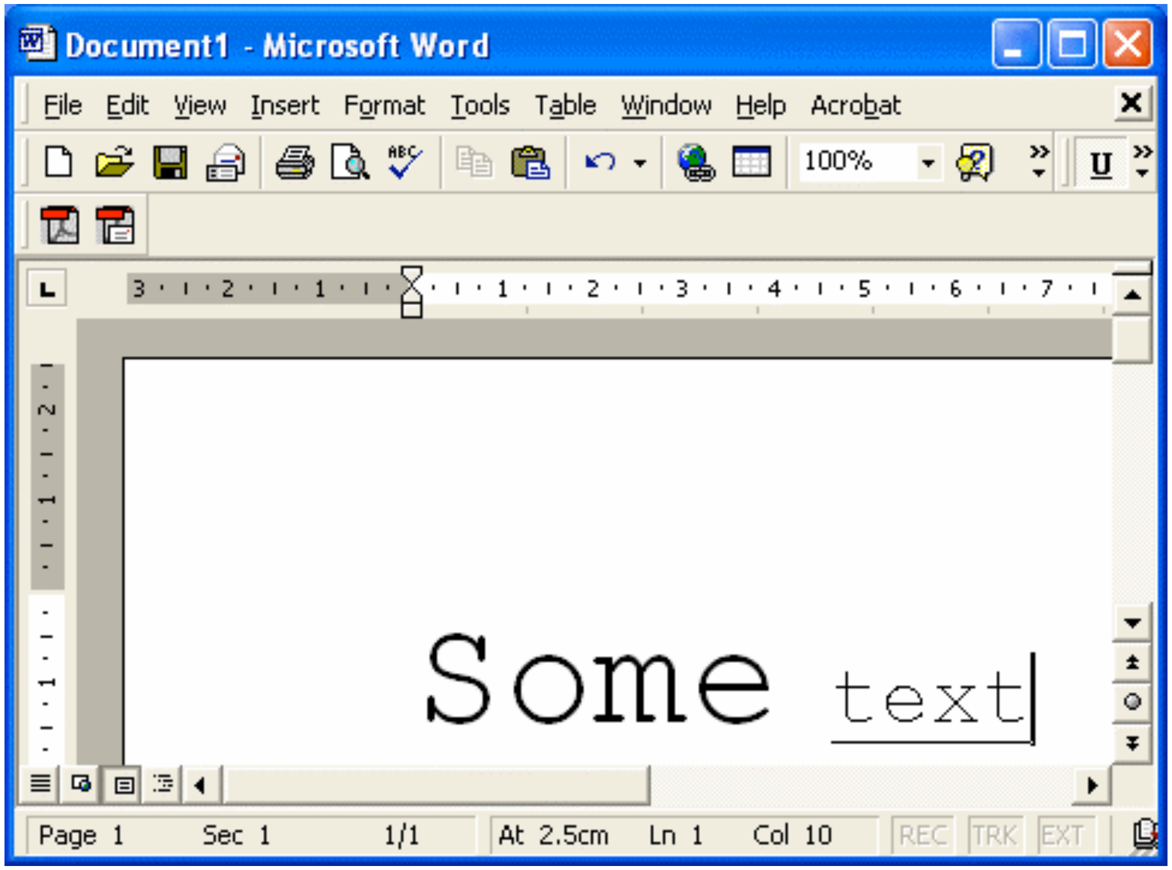
Some

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

Default... | OK | Cancel

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

A GUI test case


Document1 - Microsoft Word
File Edit View Insert Format Tools Table Window Help Acrobat
100%
Some text
Page 1 Sec 1 1/1 At 2.5cm Ln 1 Col 10 REC TRK EXT

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

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**

Two approaches to GUI testing

- Black Box
- Glass Box

Black box GUI testing

- 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**

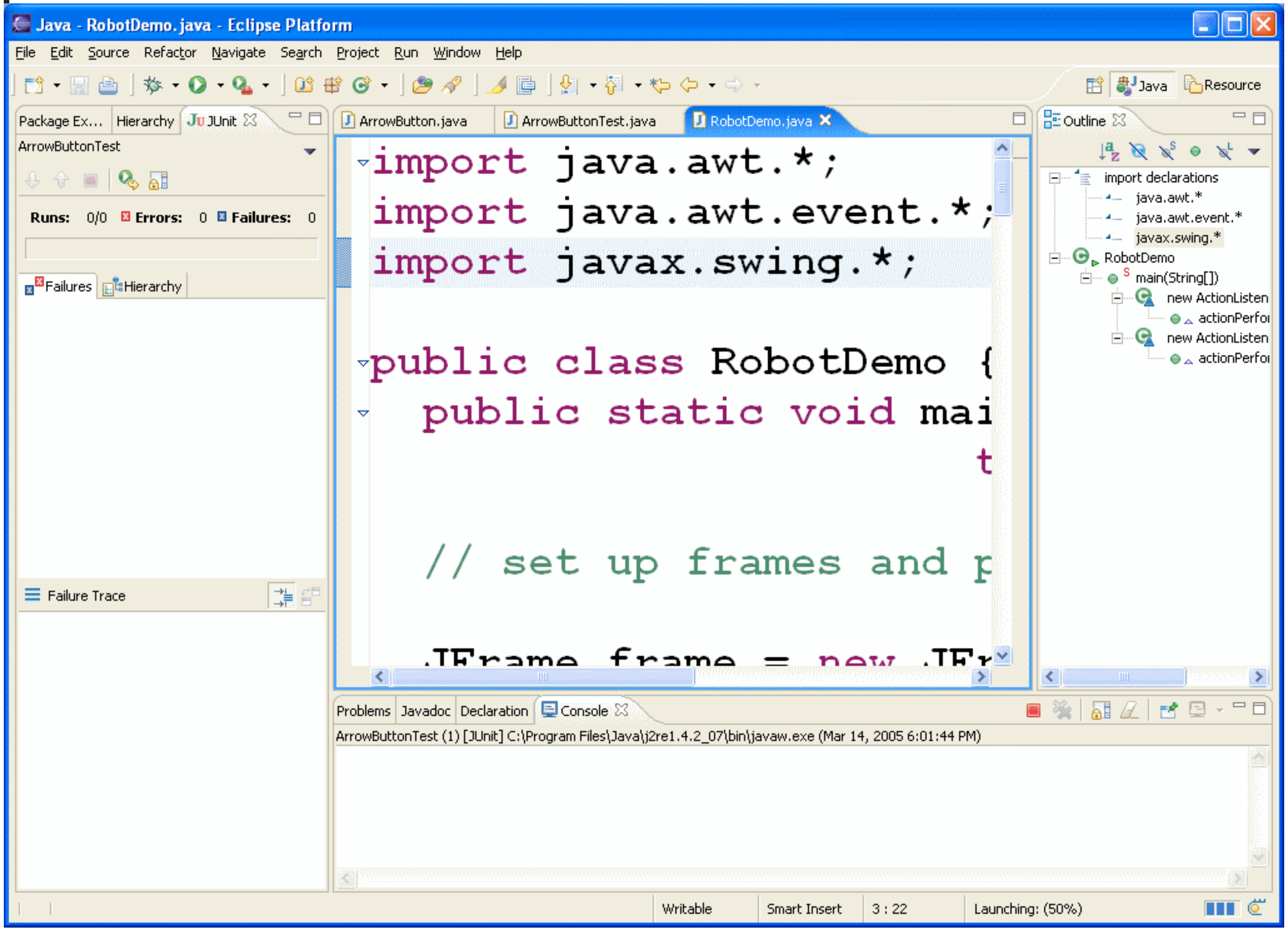
Glass box GUI testing

- 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 more difficult to break**
  - **Business model can be tested**
  - **Framework dependent**

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.**

RobotDemo



```
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)

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**

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)

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
  - **Principle of reciprocity**
- Component behaviour should be separated from event handling code
- For example, class JButton contains the doClick() method

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()

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/**

Goals of the Abbot framework

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

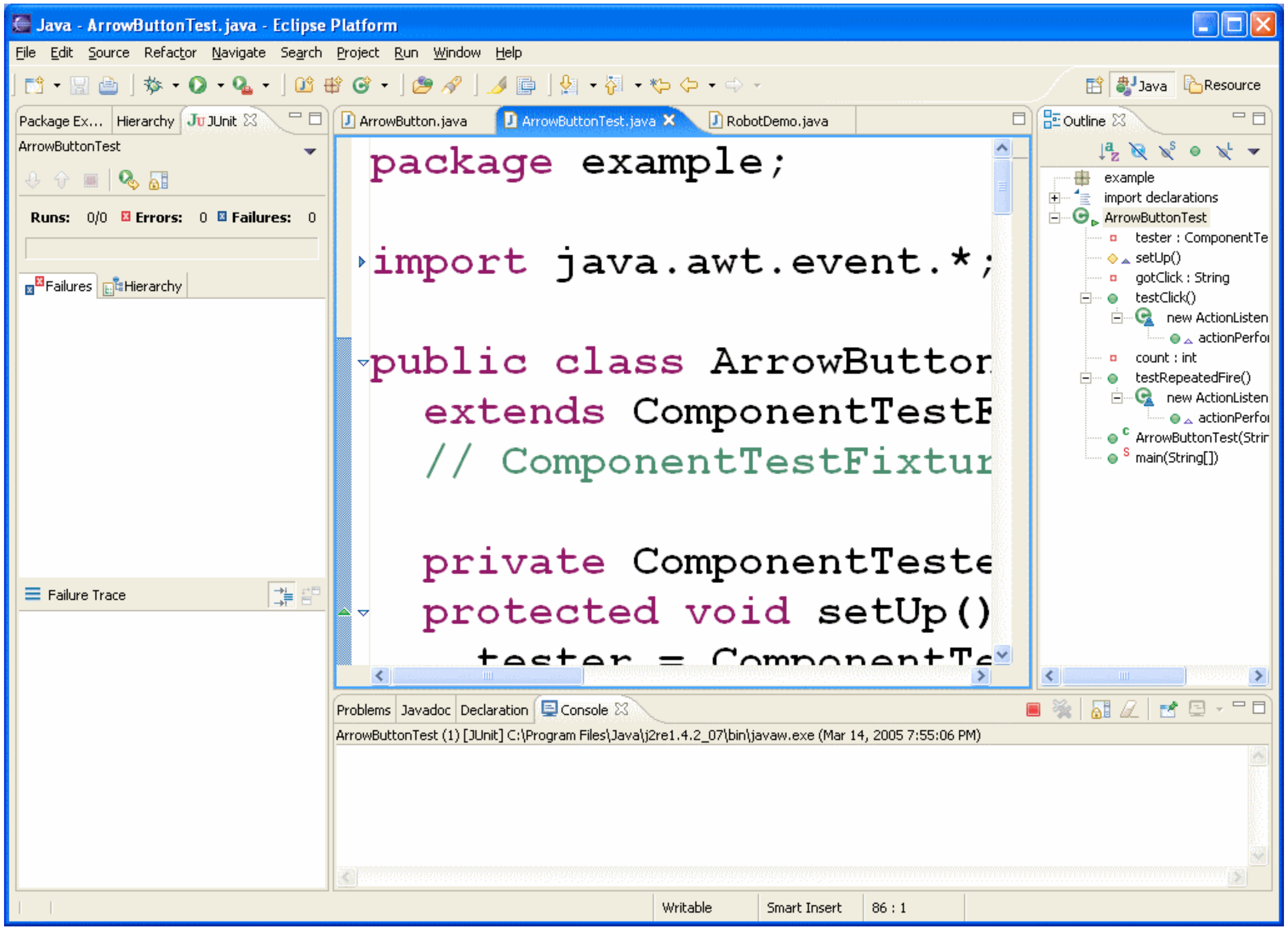
Abbot overview

- 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**

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());
```

Testing with Abbot demo


Java - ArrowButtonTest.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
example
import declarations
ArrowButtonTest
tester : ComponentTe
setUp()
gotClick : String
testClick()
new ActionListen
actionPerfo
count : int
testRepeatedFire()
new ActionListen
actionPerfo
ArrowButtonTest(Strir
main(String[])
Problems Javadoc Declaration Console
Writable Smart Insert 86 : 1

```
package example;

import java.awt.event.*;

public class ArrowButtor
    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)
```

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

Extending TestCase

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

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

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

Test suite creation

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

Test suite creation template

```
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;
  }
}
```