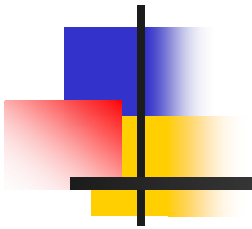
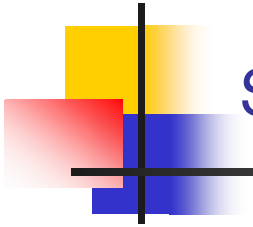


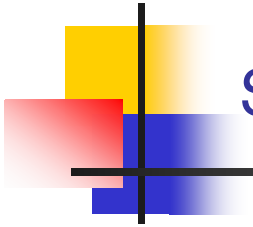
Automated GUI Testing

How to test an interactive application automatically



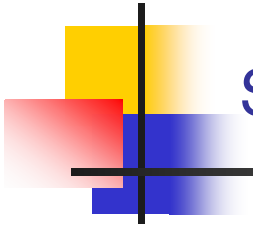
Some GUI facts

- Software testing accounts for 50-60% of total software development costs



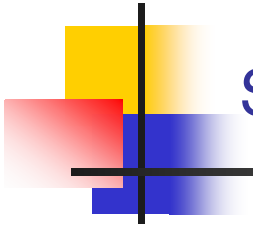
Some GUI facts – 2

- Software testing accounts for 50-60% of total software development costs
- GUIs can constitute as much as 60% of the code of an application



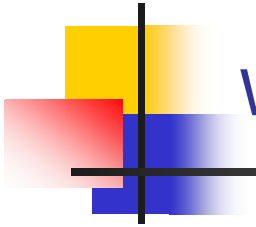
Some GUI facts – 3

- 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



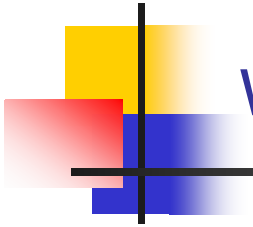
Some GUI facts – 4

- 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



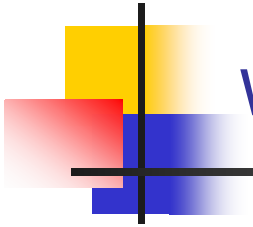
Why is GUI testing difficult?

- **Why is GUI testing so difficult?**



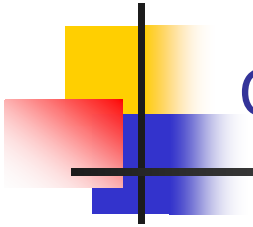
Why is GUI testing difficult? – 2

- **Why is GUI testing so difficult?**
  - **Event-driven architecture**
    - **User actions create events**
    - **An automatic test suite has to simulate these events somehow**



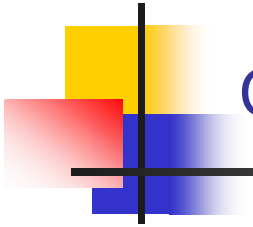
Why is GUI testing difficult? – 3

- **Why is GUI testing so difficult?**
  - **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**



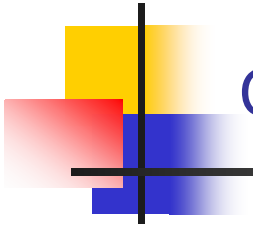
Challenges of GUI testing

- **Test case generation**
  - **What combinations of user actions to try?**



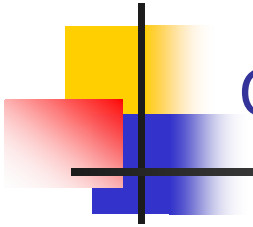
Challenges of GUI testing – 2

- **Test case generation**
  - **What combinations of user actions to try?**
- **Oracles**
  - **What is the expected GUI behaviour?**



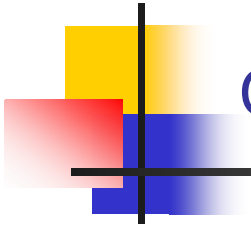
Challenges of GUI testing – 3

- **Test case generation**
  - **What combinations of user actions to try?**
- **Oracles**
  - **What is the expected GUI behaviour?**
- **Coverage**
  - **How much testing is enough?**



Challenges of GUI testing – 4

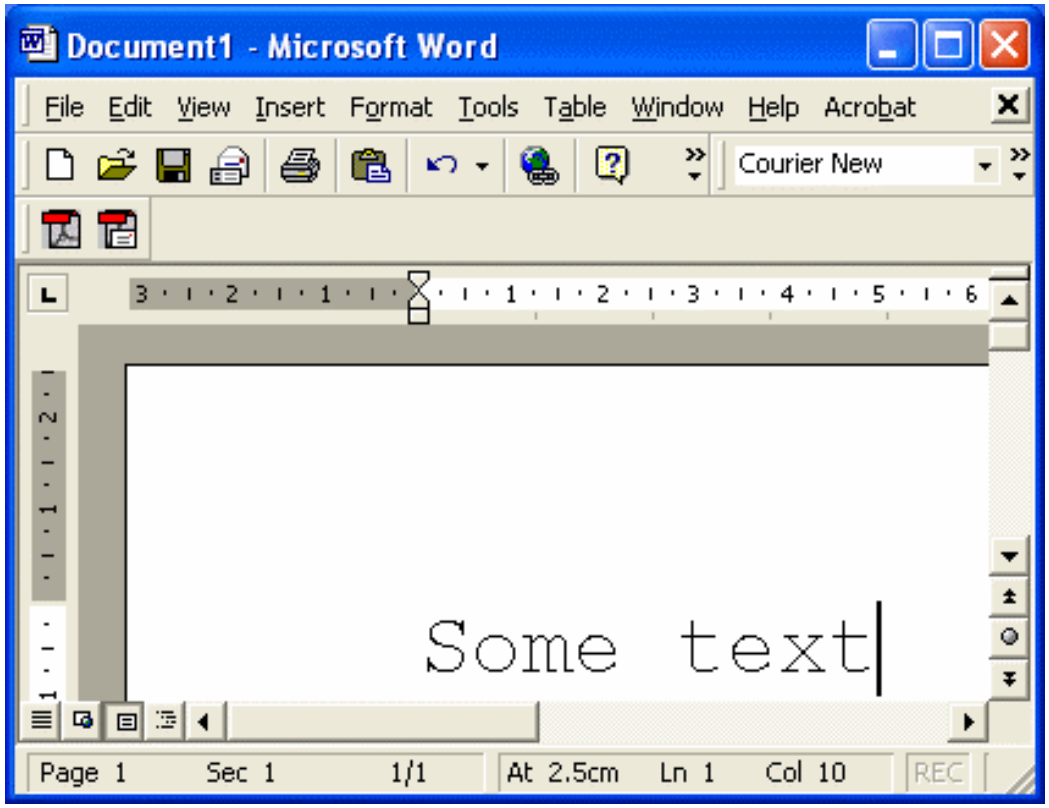
- **Test case generation**
  - **What combinations of user actions to try?**
- **Oracles**
  - **What is the expected GUI behaviour?**
- **Coverage**
  - **How much testing is enough?**
- **Regression testing**
  - **Can test cases from an earlier version be re-used?**



Challenges of GUI testing – 5

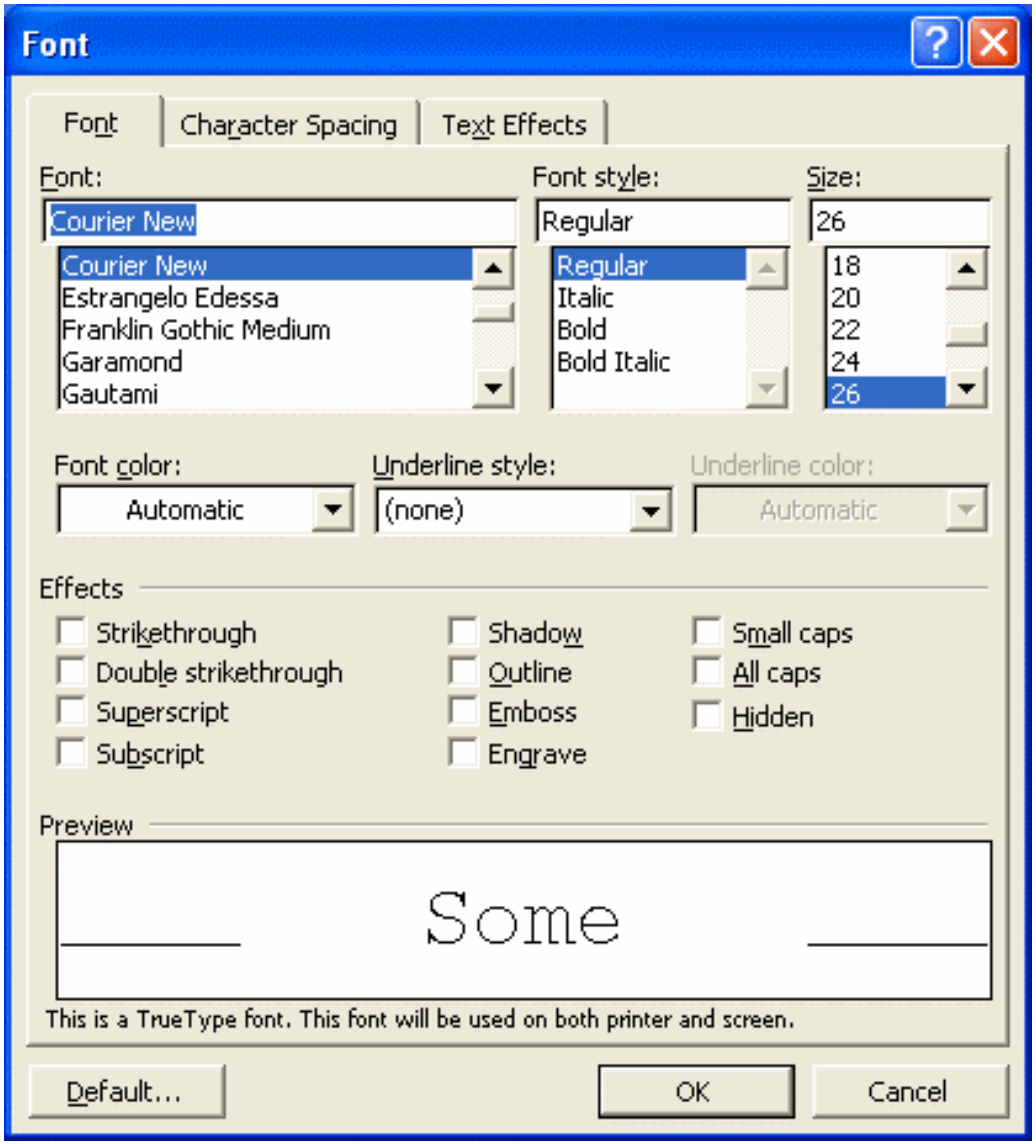
- **Test case generation**
  - **What combinations of user actions to try?**
- **Oracles**
  - **What is the expected GUI behaviour?**
- **Coverage**
  - **How much testing is enough?**
- **Regression testing**
  - **Can test cases from an earlier version be re-used?**
- **Representation**
  - **How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

A GUI test case

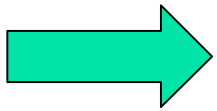


1. Select text “Some”
2. Menu “Format”
3. Option “Font”

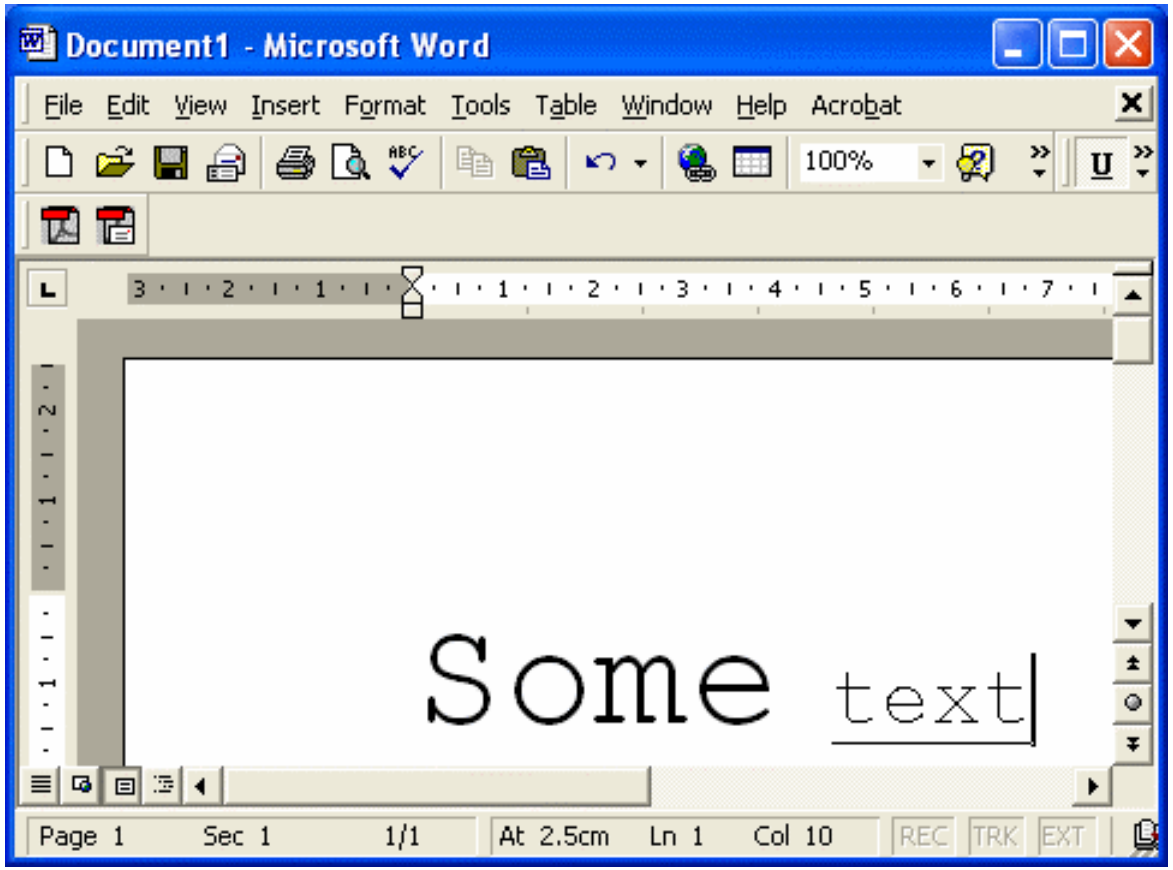
A GUI test case



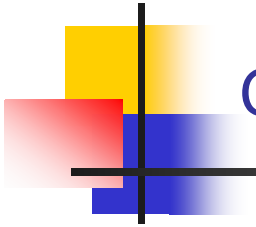
4. Combobox "Size"
5. Click on 26
6. Click OK



A GUI test case

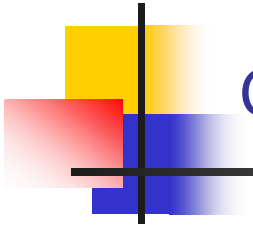


7. Select "text"
8. Click **U**
9. Verify that the output looks like this



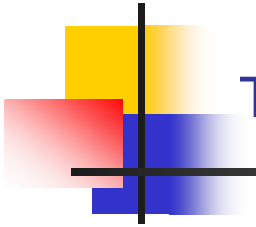
GUI vs. business model testing

- 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**



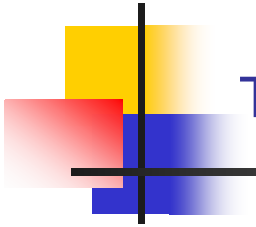
GUI vs. business model testing – 2

- Business model testing
  - **Word's internal model reflects the text formatting we performed**



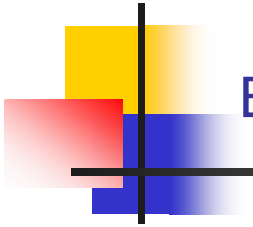
Two approaches to GUI testing

- **Why is GUI testing so difficult?**



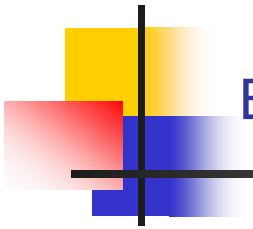
Two approaches to GUI testing – 2

- **Why is GUI testing so difficult?**
  - **Black Box**
  - **Glass Box**



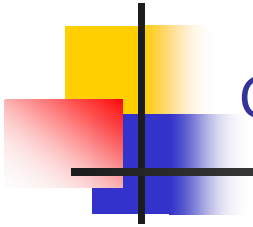
Black box GUI testing

- **How do we do black box testing?**



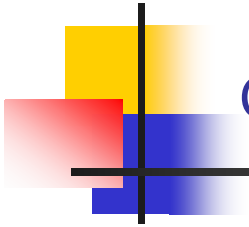
Black box GUI testing – 2

- How do we do black box 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



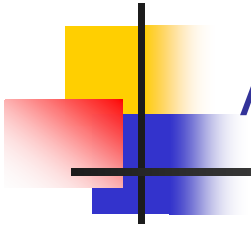
Glass box GUI testing

- **How do we do glass box testing?**



Glass box GUI testing – 2

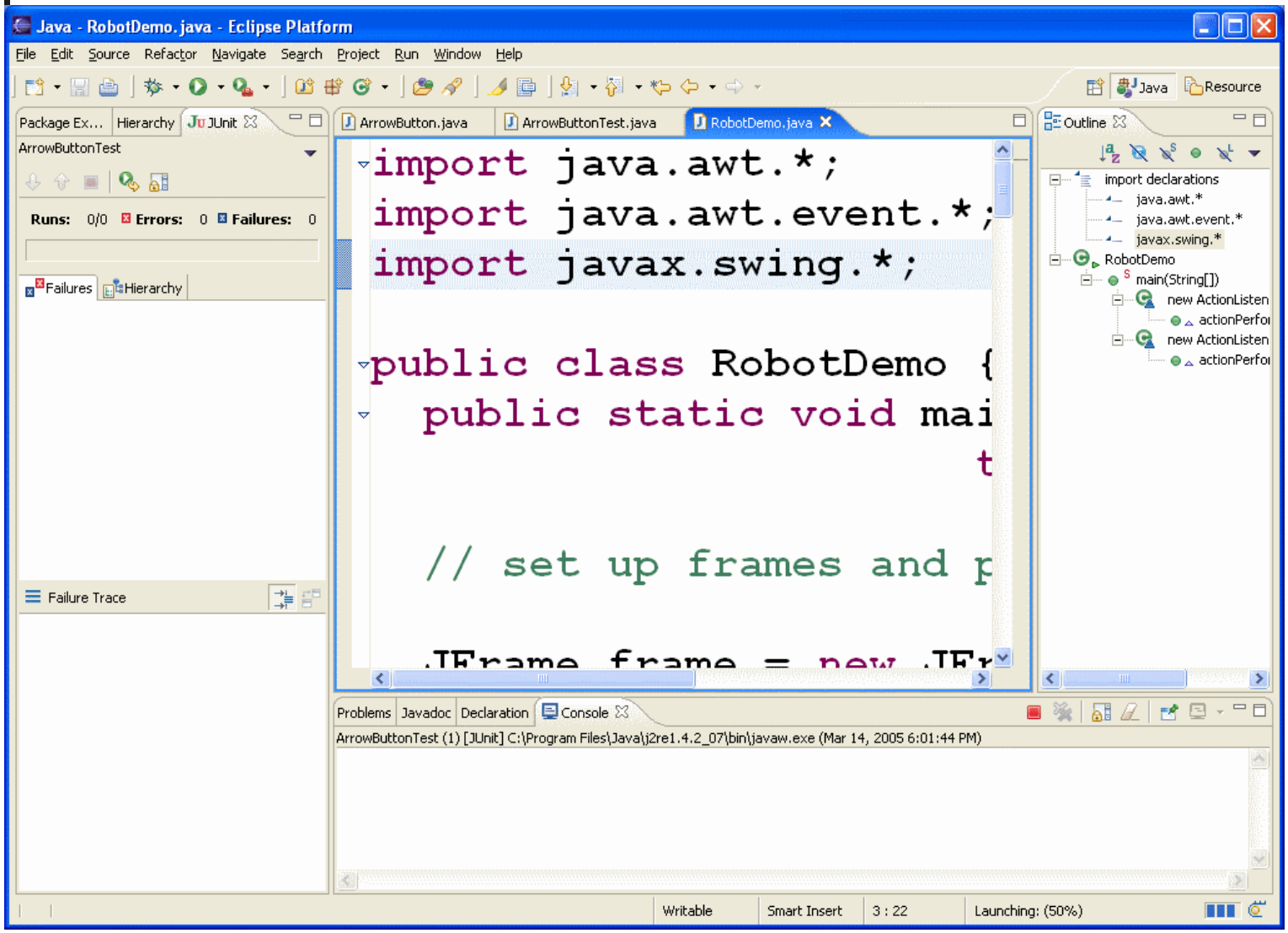
- How do we do glass box testing?
  - Launch application in the testing code
  - Obtain references to the various components and send events to them
  - Assert the state of components directly
    - Test cases more difficult to break
    - Business model can be tested
    - Framework dependent

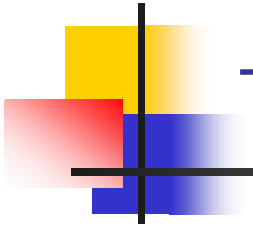


A first approach

- 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.**

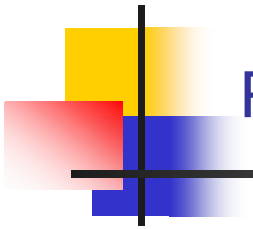
RobotDemo


Java - RobotDemo.java - Eclipse Platform
File Edit Source Refactor Navigate Search Project Run Window Help
Java Resource
Package Ex... Hierarchy JUnit
ArrowButtonTest
Runs: 0/0 Errors: 0 Failures: 0
Failures Hierarchy
Failure Trace
ArrowButton.java ArrowButtonTest.java RobotDemo.java
import java.awt.*;
import java.awt.event.*;
import javax.swing.*;
public class RobotDemo {
public static void mai
t
// set up frames and p
Outline
import declarations
java.awt.*
java.awt.event.*
javax.swing.*
RobotDemo
main(String[])
new ActionListen
actionPerfo
new ActionListen
actionPerfo
Problems Javadoc Declaration Console
ArrowButtonTest (1) [JUnit] C:\Program Files\Java\j2re1.4.2_07\bin\javaw.exe (Mar 14, 2005 6:01:44 PM)
Writable Smart Insert 3 : 22 Launching: (50%)



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**

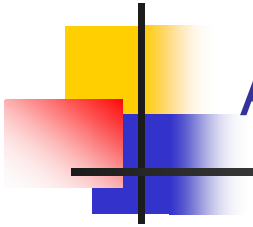


Problems with this approach

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

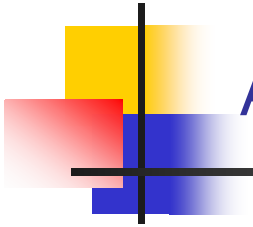
```
Move to the colour list co-ordinates
Click
Press ↓ 5 times
Click
```

- Brittle test cases (regression impossible)



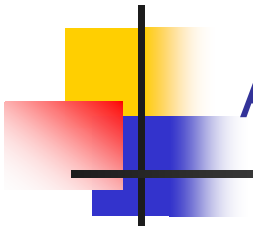
A better approach

- 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**



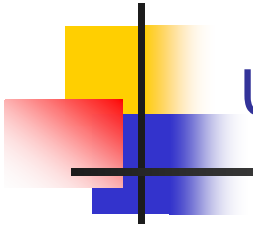
A better approach – 2

- 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



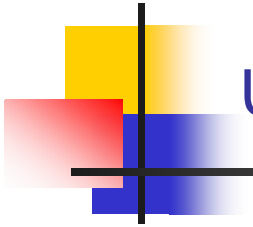
A better approach – 3

- 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



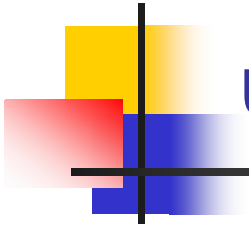
Unfortunately…

- Most GUI development frameworks are not designed in this fashion



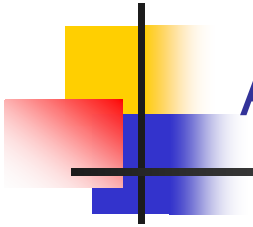
Unfortunately… – 2

- 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



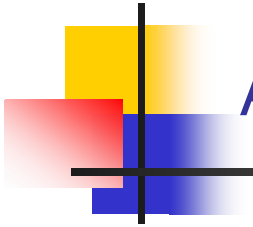
Unfortunately… – 3

- 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()



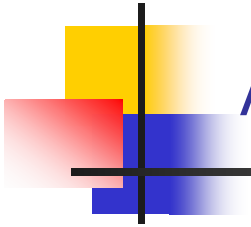
Abbot – A Better 'Bot

- A GUI testing framework for Swing



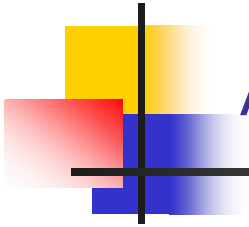
Abbot – A Better 'Bot – 2

- A GUI testing framework for Swing
- Works seamlessly with Junit
  - **Uses some Junit 3 features**



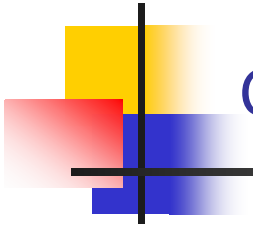
Abbot – A Better 'Bot – 3

- 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**



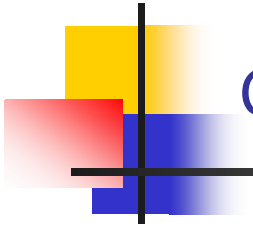
Abbot – A Better 'Bot – 4

- 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/**



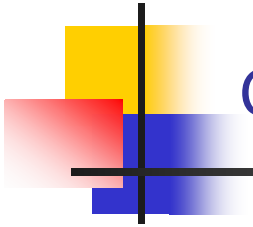
Goals of the Abbot framework

- Reliable reproduction of user input



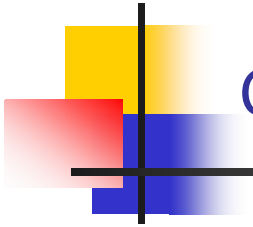
Goals of the Abbot framework – 2

- Reliable reproduction of user input
- High-level semantic actions



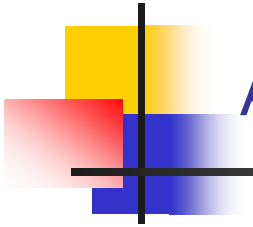
Goals of the Abbot framework – 3

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



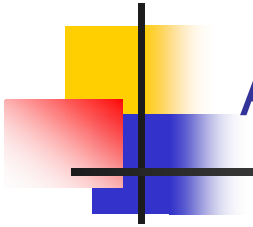
Goals of the Abbot framework – 4

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



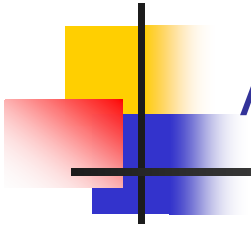
Abbot overview

- A better Robot class is provided
  - **abbot.tester.Robot includes events to click, drag, type on any component**



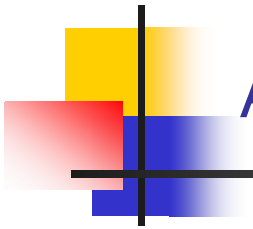
Abbot overview – 2

- 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()**



Abbot overview – 3

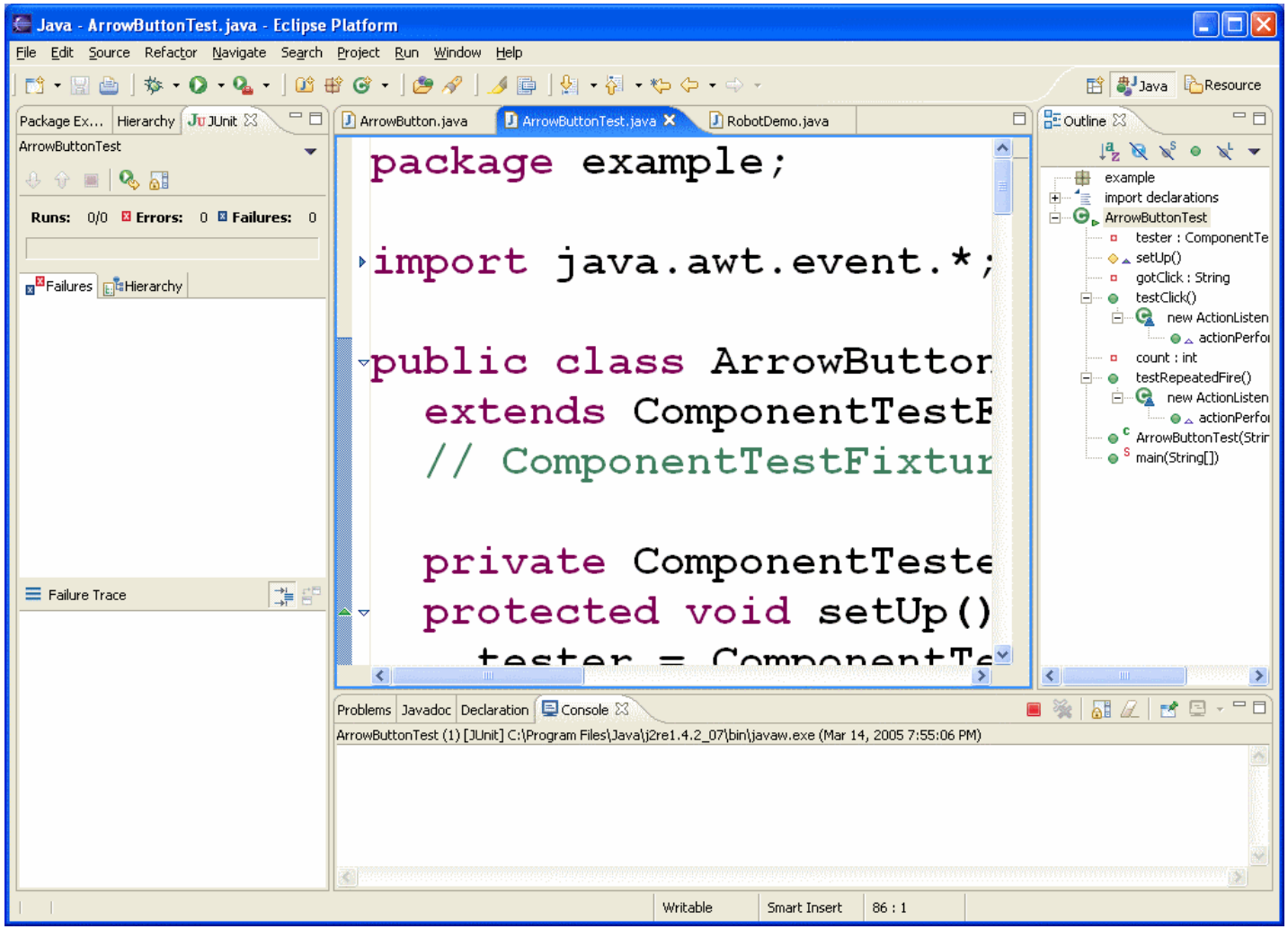
- A better Robot class is provided
  - **abbot.tester.Robot includes events to click, drag, type on any component**
- For each Swing widget a corresponding Tester class is provided
  - **E.g. JPopupMenuTester provides a method called getMenuLabels()**
- Components can be retrieved from the component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

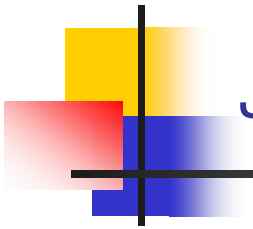


A typical test case

```
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());
```

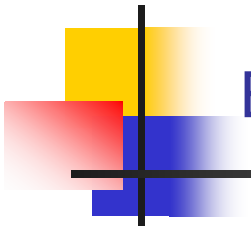
Testing with Abbot demo





JUnit 3 features

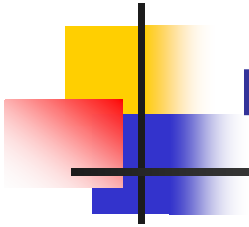
- Abbot requires JUnit 3
- Only the differences between JUnit 3 and JUnit 4 are presented in the next slides
- The JUnit 3 jar file is included in the abbot distribution



Extending TestCase

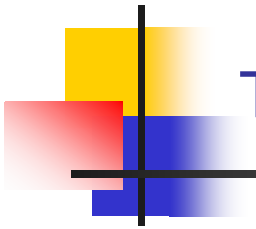
- Each test class needs to extend class junit.framework.TestCase

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



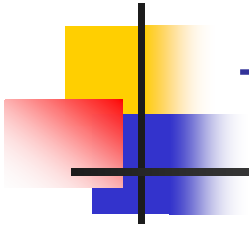
Naming vs. Annotations

- 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;
  }
}
```