

GUI Dynamics

Lecture 11
CS2110 – Fall 2008

GUI Statics and GUI Dynamics

- Statics: what's drawn on the screen
 - Components
 - ♦ buttons, labels, lists, sliders, menus, ...
 - Containers: components that contain other components
 - ♦ frames, panels, dialog boxes, ...
 - Layout managers: control placement and sizing of components
- Dynamics: user interactions
 - Events
 - ♦ button-press, mouse-click, key-press, ...
 - Listeners: an object that responds to an event
 - Helper classes
 - ♦ Graphics, Color, Font, FontMetrics, Dimension, ...

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Dynamics Overview

- Dynamics = causing and responding to actions
 - What actions?
 - ♦ Called *events*: mouse clicks, mouse motion, dragging, keystrokes
 - ♦ We would like to write code (a *handler*) that is invoked when an event occurs so that the program can respond appropriately
 - ♦ In Java, you can intercept events by providing an *object* that "hears" the event – a *listener*
 - What objects do we need to know about?
 - Events
 - Event listeners

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Brief Example Revisited

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

public class Intro extends JFrame {

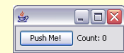
    private int count = 0;
    private JButton myButton = new JButton("Push Me!");
    private JLabel label = new JLabel("Count: " + count);

    public Intro() {
        setDefaultCloseOperation(EXIT_ON_CLOSE);
        setLayout(new FlowLayout(FlowLayout.LEFT)); //set layout manager
        add(myButton); //add components
        add(label);
        label.setPreferredSize(new Dimension(60, 10));

        myButton.addActionListener(new ActionListener() {
            public void actionPerformed(ActionEvent e) {
                count++;
                label.setText("Count: " + count);
            }
        });

        pack();
        setVisible(true);
    }

    public static void main(String[] args) {
        new Intro();
    }
}
```



Brief Example Revisited

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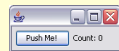
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        myButton.addActionListener(new ActionListener() {
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                count++;
                label.setText("Count: " + count);
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        });

        pack();
        setVisible(true);
    }

    public static void main(String[] args) {
        new Intro();
    }
}
```



The Java Event Model

- Timeline
 - User or program does something to a component
 - ♦ clicks on a button, resizes a window, ...
 - Java issues an *event object* describing the event
 - A special type of object (a listener) "hears" the event
 - ♦ The listener has a method that "handles" the event
 - ♦ The handler does whatever the programmer programmed
- What you need to understand
 - Events: How components issue events
 - Listeners: How to make an object that listens for events
 - Handlers: How to write a method that responds to an event

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Events

- An Event is a Java object
- Events are normally created by the Java runtime system
 - You can create your own, but this is unusual
- Normally events are associated with a component
- Most events are in `java.awt.event` and `javax.swing.event`
- All events are subclasses of `AWTEvent`

ActionEvent
AdjustmentEvent
ComponentEvent
ContainerEvent
FocusEvent
HierarchyEvent
InputEvent
InputMethodEvent
InvocationEvent
ItemEvent
KeyEvent
MouseEvent
MouseWheelEvent
PaintEvent
TextEvent
WindowEvent

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Types of Events

- Each Swing Component can generate one or more types of events
 - The type of event depends on the component
 - ♦ Clicking a `JButton` creates an `ActionEvent`
 - ♦ Clicking a `JCheckbox` creates an `ItemEvent`
 - The different kinds of events include different information about what has occurred
 - ♦ All events have method `getSource()` which returns the object (e.g., the button or checkbox) on which the Event initially occurred
 - ♦ An `ItemEvent` has a method `getStateChange()` that returns an integer indicating whether the item (e.g., the checkbox) was *selected* or *deselected*

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Event Listeners

- `ActionListener`, `MouseListener`, `WindowListener`, ...
- Listeners are Java interfaces
 - Any class that implements that interface can be used as a listener
- To be a listener, a class must implement the interface
 - Example: an `ActionListener` must contain a method `public void actionPerformed(ActionEvent e)`

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Implementing Listeners

- Which class should be a listener?
 - Java has no restrictions on this, so any class that implements the listener will work
- Typical choices
 - Top-level container that contains whole GUI
 - `public class GUI implements ActionListener`
 - Inner classes to create specific listeners for reuse
 - `private class LabelMaker implements ActionListener`
 - Anonymous classes created on the spot
 - `b.addActionListener(new ActionListener() {...});`

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Listeners and Listener Methods

- When you implement an interface, you must implement all the interface's methods
 - Interface `ActionListener` has one method:
`void actionPerformed(ActionEvent e)`
 - Interface `MouseListener` has five methods:
`void mouseClicked(MouseEvent e)`
`void mouseEntered(MouseEvent e)`
`void mouseExited(MouseEvent e)`
`void mousePressed(MouseEvent e)`
`void mouseReleased(MouseEvent e)`
 - Interface `MouseMotionListener` has two methods:
`void mouseDragged(MouseEvent e)`
`void mouseMoved(MouseEvent e)`

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Registering Listeners

- How does a component know which listener to use?
- You must *register* the listeners
 - This connects listener objects with their source objects
 - Syntax: `component.addTypeListener(Listener)`
 - You can register as many listeners as you like
- Example:

```
b.addActionListener(new ActionListener() {  
    public void actionPerformed(ActionEvent e) {  
        count++;  
        label.setText(generateLabel());  
    }  
});
```

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Example 1: The Frame is the Listener

```
import javax.swing.*; import java.awt.*; import java.awt.event.*;
public class ListenerExample1 extends JFrame implements ActionListener {
    private int count;
    private JButton b = new JButton("Push Me!");
    private JLabel label = new JLabel("Count: " + count);
    public static void main(String[] args) {
        JFrame f = new ListenerExample1();
        f.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
        f.setSize(200,100);
        f.setVisible(true);
    }
    public ListenerExample1() {
        setLayout(new FlowLayout(FlowLayout.LEFT));
        add(b); add(label);
        b.addActionListener(this);
    }
    public void actionPerformed(ActionEvent e) {
        count++;
        label.setText("Count: " + count);
    }
}
```

Example 2: The Listener is an Inner Class

```
import javax.swing.*; import java.awt.*; import java.awt.event.*;
public class ListenerExample2 extends JFrame {
    private int count;
    private JButton b = new JButton("Push Me!");
    private JLabel label = new JLabel("Count: " + count);
    class Helper implements ActionListener {
        public void actionPerformed(ActionEvent e) {
            count++;
            label.setText("Count: " + count);
        }
    }
    public static void main(String[] args) {
        JFrame f = new ListenerExample2();
        f.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
        f.setSize(200,100); f.setVisible(true);
    }
    public ListenerExample2() {
        setLayout(new FlowLayout(FlowLayout.LEFT));
        add(b); add(label); b.addActionListener(new Helper());
    }
}
```

Example 3: The Listener is an Anonymous Class

```
import javax.swing.*; import java.awt.*; import java.awt.event.*;
public class ListenerExample3 extends JFrame {
    private int count;
    private JButton b = new JButton("Push Me!");
    private JLabel label = new JLabel("Count: " + count);
    public static void main (String[] args) {
        JFrame f = new ListenerExample3();
        f.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
        f.setSize(200,100); f.setVisible(true);
    }
    public ListenerExample3() {
        setLayout(new FlowLayout(FlowLayout.LEFT));
        add(b); add(label);
        b.addActionListener(new ActionListener() {
            public void actionPerformed (ActionEvent e) {
                count++;
                label.setText("Count: " + count);
            }
        });
    }
}
```

Adapters

- Some listeners (e.g., `MouseListener`) have lots of methods; you don't always need all of them
 - For instance, you may be interested only in mouse clicks
- For this situation, Java provides *adapters*
 - An *adapter* is a predefined class that implements all the methods of the corresponding Listener
 - ♦ Example: `MouseAdapter` is a class that implements all the methods of interfaces `MouseListener` and `MouseMotionListener`
 - The adapter methods *do nothing*
 - To easily create your own listener, you *extend* the adapter class, *overriding* just the methods that you actually need

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Using Adapters

```
import javax.swing.*; import javax.swing.event.*;
import java.awt.*; import java.awt.event.*;
public class AdapterExample extends JFrame {
    private int count; private JButton b = new JButton("Mouse Me!");
    private JLabel label = new JLabel("Count: " + count);
    class Helper extends MouseAdapter {
        public void mouseEntered(MouseEvent e) {
            count++;
            label.setText("Count: " + count);
        }
    }
    public static void main(String[] args) {
        JFrame f = new AdapterExample();
        f.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
        f.setSize(200,100); f.setVisible(true);
    }
    public AdapterExample() {
        setLayout(new FlowLayout(FlowLayout.LEFT));
        add(b); add(label); b.addMouseListener(new Helper());
    }
}
```

Notes on Events and Listeners

- A single component can have many listeners
- Multiple components can share the same listener
 - Can use `event.getSource()` to identify the component that generated the event
- For more information on designing listeners, see <http://java.sun.com/docs/books/tutorial/uiwing/events/>
- For more information on designing GUIs, see <http://java.sun.com/docs/books/tutorial/uiwing/>

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GUI Drawing and Painting

- For a drawing area, extend `JPanel` and override the method `public void paintComponent(Graphics g)`
- `paintComponent` contains the code to completely draw *everything* in your drawing panel
- Do not call `paintComponent` directly – instead, request that the system redraw the panel at the next convenient opportunity by calling `myPanel.repaint()`
- `repaint()` requests a call `paintComponent()` “soon”
 - `repaint(ms)` requests a call within `ms` milliseconds
 - Avoids unnecessary repainting
 - 16ms is a reasonable value

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Java Graphics

- The `Graphics` class has methods for colors, fonts, and various shapes and lines
 - `setColor(Color c)`
 - `drawOval(int x, int y, int width, int height)`
 - `fillOval(int x, int y, int width, int height)`
 - `drawLine(int x1, int y1, int x2, int y2)`
 - `drawString(String str, int x, int y)`
- Take a look at
 - `java.awt.Graphics` (for basic graphics)
 - `java.awt.Graphics2D` (for more sophisticated control)
 - The 2D Graphics Trail:
<http://java.sun.com/docs/books/tutorial/2d/>
 - examples on the web site

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