CS193J: Programming in Java
Summer Quarter 2003

Lecture 5
Java Swing, Layout Managers, Inner Classes, Listeners

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HW#1: Pencil Me In Status!?

- Assigned Work Reminder:
  - HW #1: Pencil Me In
    - Due before midnight Wednesday, July 9th, 2003
    - You do have three floating late days, but use wisely!
- Reminder: Use office hours!
  - Questions on theory from class
  - Questions or clarifications on HW requirements
  - Development environment issues
  - Design issues

Random tips and pointers

- "Deprecated"
  - java.util.Date has lots of methods which are deprecated
  - Instead it references the "Calendar" class
- "Abstract"
  - java.util.Calendar is abstract!
  - The "concrete implementation" is actually in java.util.GregorianCalendar
- You do no need to do too much date arithmetic
  - But you do need to figure out how to use the API
  - The Java API is your friend. Use it well.

Summary

- Last Time
  - OOP/Inheritance
    - Pop-down rule
    - Constructors
    - instanceOf
    - Grad example
  - Abstract superclasses
    - Account example
  - Java Interfaces
    - Moodable example
  - Drawing in Java started
    - FirstFrame example
- Lots of Stuff!
  - Warning/Remider: *The summer quarter courses move fast!*

Handouts

- 2 Handout for today!
  - #12: Inner Classes
  - #13: Listeners

Today

- Continue with Drawing in Java
- Java Swing classes
  - JComponent
    - Paintcomponent
  - Graphics Object
  - My Component Example
- Layout Managers
  - Flow, Box and Border
  - Nesting
  - Layout Example
- Inner Classes
- Anonymous Inner Classes (maybe)
- Listener model (maybe)
  - Button Listener Example

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Drawing in Java (Handout #11)

- Last time
  - FirstFrame example
    - Subclass JFrame
    - Get content pane
    - Set layout manager
    - Add components
      - Instantiate JLabel
      - Instantiate JButton
    - Pack
    - Set close behavior
    - Set visible

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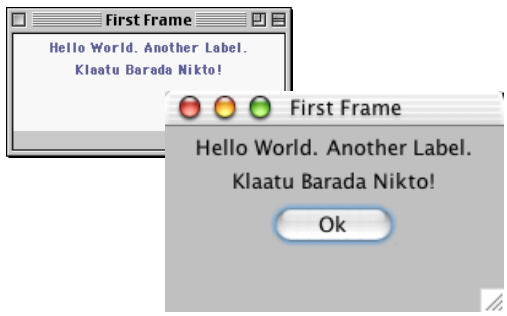
FirstFrame example



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FirstFrame Code: getting started

```
// FirstFrame.java
/*
 Demonstrates bringing up a frame with some labels.
*/
import java.awt.*;
import javax.swing.*;
import java.util.*;
import java.awt.event.*;
public class FirstFrame extends JFrame {
    public FirstFrame(String title) {
        super(title);     // superclass ctor takes frame title

        // Get content pane -- contents of the window
        JComponent content = (JComponent) getContentPane();
```


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FirstFrame Code: adding components

```
// Set to use the "flow" layout
// (controls the arrangement of the components in the content)
content.setLayout(new FlowLayout());

// Background color is a property of all components --
// set it to white
content.setBackground(Color.lightGray);

// Use add() to install components
content.add(new JLabel("Hello World."));
content.add(new JLabel("Another Label."));
content.add(new JLabel("Klaatu Barada Nikto!"));
content.add(new JButton("Ok"));
```


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FirstFrame example: finishing touch

```
    // Force the frame to size/layout its components
    pack();

    setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE)
    ;
    // Java 1.3 or later
    setVisible(true);   // make it show up on screen
}

    public static void main(String[] args) {
        new FirstFrame("First Frame");
    }
}
```


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JComponent

- JComponent Basics
  - Superclass of all things that can be drawn on the screen
  - Size and position on screen
    - bounds rectangle
  - Draws itself
    - Anthropomorphic nature of objects
- 227 public methods
  - Check out the API docs!
- Class Hierarchy
  - java.awt.Component
    - java.awt.Container
      - javax.swing.JComponent

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Component Location/Size

- Each JComponent has its own coordinate system
  - (0,0) is in the top left corner
  - x grows to the right
  - Y grows to the left
- Bounds
  - Upper left corner (0,0)
  - component.getWidth()
  - component.getHeight()
- Local coordinate system
  - Does not change as the component is moved

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Component Location/Size

- Parent container
  - "parent" is the container the component is in
  - Parent is itself a component
- "Location" of a component
  - The position of its upper left corner in the coordinate system of its parent
- PreferredSize
  - Used by Layout Manager to determine the size of the component
  - setPreferredSize()
  - Can also use set minimum and maximum size to be considered by the layout manager

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Component Location/Size

- Layout Manager
  - Looks at the preferred size of all components and tries to do the best possible layout
  - Assigns final size and location
    - Use setPreferredSize *before* calling pack()
    - Hardly ever call setsize()
- Size and Location messages
  - getWidth(), getHeight(), getSize(), getLocation(), getBounds()

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Geometry methods

- Mostly inherited from java.awt.Component
- Constructor
  - Constructs a component with initial size zero
- Methods
  - int getWidth(), getHeight()
  - Dimension getSize()
  - int getX(), getY()
  - Point getLocation()
  - get/setPreferredSize()
  - Rectangle getBounds()
  - boolean contains(x,y), boolean contains(Point p)
  - setBounds(x,y,width, height), setBounds(Rectangle)
  - getParent()

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OOP GUI Drawing Theory

- Subclass JComponent
- Override paintComponent()
  - Draw within the bound of the component
  - Install your components in a window/container
- Remember:
  - Objects are anthropomorphic (like a person)
    - So we tell them *how* to do something (draw themselves)
    - Then send a message asking them to do the action (draw itself)

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paintComponent(Graphics g)

- Notification that is sent to a JComponent when it should draw itself
- Override to provide custom drawing code
- Call getWidth() etc to get geometry information
  - Do not hardcode!
- Do no need to erase
  - Erased before paintComponent is called
- Call super.paintComponent() for more complex cases
  - Often subclass JPanel instead

paintComponent example

```
public void paintComponent(Graphics g) {
    // not necessary for simple cases
    // super.paintComponent(g);

    int width = getWidth();
    int height = getHeight();

    // draw a rect around the bounds of the component
    // -1 since drawRect overhangs by one
    g.drawRect(0, 0, width-1, height-1);

    // draw a line from upper-left, to lower-right
    g.drawLine(0, 0, width-1, height-1);
}
```


"Respond To" Draw Style

- Again:
  - Objects are told *how* to draw themselves
  - Send a message to the object telling it to draw
- But
  - The message telling the object to draw is *not* sent by the user
  - The System determines the right time
    - When to redraw can be complex
- Drawing is therefore
  - Passive – works well in a windowing system
  - Different from C approach!
- No need to erase first

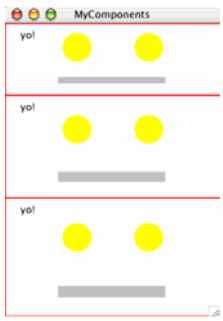
Graphics Object

- Passed in to paintComponent
  - Pointer to a drawing context
  - Passed in in default state
    - no state from earlier paints
- AWT Graphics
  - Simple. More complex: Java2D.
  - (0,0) is upper left, x extends right, y extends down
  - g.drawRect(x, y, width, height)
    - Extends past width and height by 1 pixel, therefore used with -1
  - g.fillRect(x, y, width, height)
    - Does not extend past!

Graphics Object

- Methods
  - drawLine(x1, y1, x2, y2)
  - drawString(String, x, y)
    - Use Font class to change the font of the string
  - g.setColor(Color)
    - Use constants in the Color class
  - Component.getGraphics()
    - Usually never want to call this
    - Use the object that is passed to paintComponent instead

MyComponent Example



MyComponent Example Code

```
// MyComponent.java
import java.awt.*;
import javax.swing.*;
import java.util.*;
import java.awt.event.*;

/*
 Demonstrates a component that draws itself
*/
class MyComponent extends JComponent {

    MyComponent(int width, int height) {
        super(); // reminder that we have a super ctor
        // Set the preferred size -- used by the layout mgr
        setPreferredSize(new Dimension(width, height));
    }
```


MyComponent Example Code

```
/**
 Draws a sort of face -- a rect at the bounds, two eyes,
 and a rect mouth. Draws a string "yo" string near the bottom.

 Typical paint component:
 -see how big you are
 -draw within your bounds
 -don't need to erase first -- canvas already erased
*/
public void paintComponent(Graphics g) {
        //super.paintComponent(g); // not necessary for simple cases

        // Could use this to get a sense of when drawing happens
        // Toolkit.getDefaultToolkit().beep();

        // see how big we are
        int width = getWidth();
        int height = getHeight();
```


My Component Example Code

```
// Draw a red rect at our bounds
g.setColor(Color.red);
g.drawRect(0, 0, width-1, height-1);          // -1 for drawRect


// eyes 1/3 from top, 1/3 from each side
int eyeY = height/3;
int left = width/3;
int right = 2*width/3;
int radius = width/15;

// Draw two eyes
g.setColor(Color.yellow);
// fillOval(x, y, width, height) -- draws oval inside given rect
g.fillOval(left-radius, eyeY-radius, radius*2, radius*2);
g.fillOval(right-radius, eyeY-radius, radius*2, radius*2);
```


MyComponent Example Code

```
        // Draw a little mouth from 1/4 to 3/4
        g.setColor(Color.lightGray);
        // fillRect(x, y, width, height)
        g.fillRect(width/4, 3*height/4, width/2, height/10);

        // Draw a string at 20, 20
        g.setColor(Color.black);
        g.drawString("yo!", 20, 20);
    }

    /*
     Creates a frame with a few MyComponents in it.
    */
    public static void main(String[] args) {
        FirstFrame.main(null);

        JFrame frame = new JFrame("MyComponents");
```


MyComponent Example Code

```
/*
 Note: earlier examples subclassed off JFrame,
 and set things up in its ctor. In this case,
 we are just a client of JFrame, and send it
 messages like getContentPane() and pack().
 Both of these approaches are reasonable.
*/

// Get the content area of the frame
JComponent content = (JComponent) frame.getContentPane();
content.setBackground(Color.white);

// The Box layout makes a vertical arrangement.
// Its components grow and shrink with the window
content.setLayout(new BoxLayout(content, BoxLayout.Y_AXIS));
```


MyComponent Example Code

```
        // add a few components
        content.add(new MyComponent(120, 80));
        content.add(new MyComponent(120, 120));
        content.add(new MyComponent(120, 140));

        // Layout manager packs things to fit into the minimum window
        frame.pack();

        // frame.setSize(300, 200); // alternative to pack()

        frame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
        frame.setVisible(true);

    }
}
```


Layout Managers

- Theory
  - Similar to HTML – policy, not position
    - Do not set explicit pixel sizes or positions of things
    - Layout Managers know the intent (policy)
    - Layout Managers apply the intent to figure out the correct size on the fly
- Advantages
  - Platform independence
    - Different platforms have different size fonts
  - Resizing of windows
  - Internationalization
    - Adjust based on changing language
- Disadvantage
  - Can sometimes be frustrating if it doesn't do what you want!

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Visual Hierarchy

- Visual Hierarchy
  - Components are placed inside other components
    - Resulting "hierarchy"
  - Frames/Windows usually outermost components
  - Constructed at run-time
    - JPanel which contains a JButton and several JLabels
- Visual Hierarchy vs. Class Hierarchy
  - Class hierarchy is a compile time hiaerarchy enforced by the compiler
  - Visual Hiwerarchy is how components are nested inside each other

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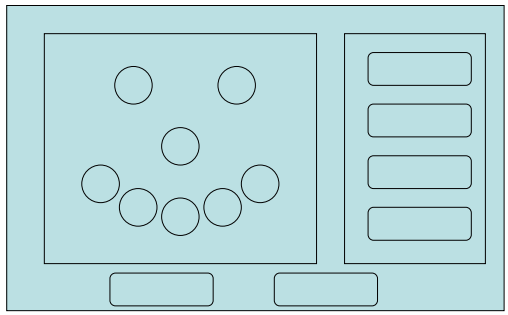
Visual Hierarchy example



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Visual Hierarchy Example

- JFrame
  - JPanel (Smiley)
    - 8 Ovals
  - JPanel (ButtonPad)
    - 4 JButtons
  - JButton
  - JButton

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FlowLayout

- Simplest
- Arranges components
  - Left to right
  - Top to Bottom
- Alignment options
  - RIGHT
  - LEFT
  - CENTER
  - LEADING
  - TRAILING

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BoxLayout

- Aligns components in a line
  - Horizontally or vertically
- Can install a box layout into a JComponent
  - comp.setLayout(new BoxLayout(comp, BoxLayout.Y_AXIS)
- Or, create a "Box" Component
  - Box.createVerticalBox()
  - Box.createHorizontalBox()
  - Box.createVerticalStruts to create spacers between boxes
- See API documentation!

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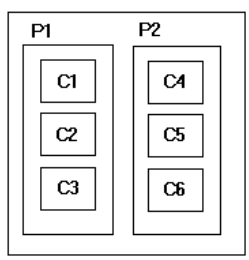
BoxLayout Example



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BorderLayout

- Versatile layout
  - Can build very complex layouts by nesting BorderLayouts
- Main content in the “center”
  - Resize space allocated primarily to center
- Decorate borders on either side
  - North, South, East, West
- Takes second paramter to determine location
  - border.add(comp, BorderLayout.CENTER);

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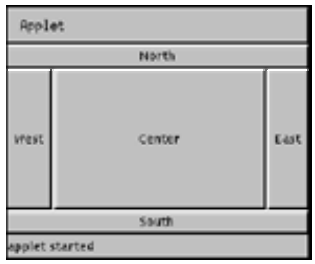
BorderLayout



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Nested JPanel

- JPanel is a simple component
  - Used to aggregate other components
    - Put multiple components in a JPanel using a given layout
    - Can then position the JPanel within another layout as if it were a *complex component*
  - To control the size of the elements in a panel we can use setPreferredSize
- Examples
  - Group label with a control
  - Set the layout of a vertical box and put lots of buttons in it and put it in the EAST of a BorderLayout

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Layout Example

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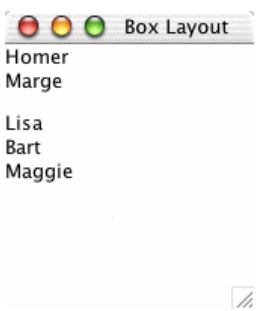
Layout Example



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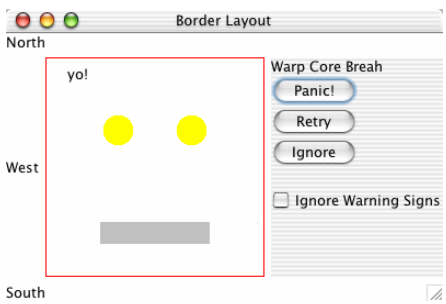
Layout Example



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Layout Example

- Code walkthrough…

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Inner Classes (Handout #12)

- Inner Class
  - A class definition inside a class
  - Generally used as a private utility class which does not need to be seen by others classes
  - Operates as a sub-part of the outer class
  - It can have constructors, instance variables and methods, just like a regular class

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Inner Class access

- Outer and inner classes can access each other state!
  - Even if private!
  - Stylistically, acceptable as they are both from a common code base
- Inner class always created inside a containing class (outer class)
  - It always has a pointer to the outer object
    - (Classname.this, example: Outer.this)
  - Can access instance variables automatically
- Use inner class when there is a natural need to access the variables of the outer class
  - Otherwise use a nested class (coming up!)

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Inner Class example

```
public class Outer {
    private int ivar;

    // inner class definition
    private class Inner {
        void foo() {
                // we can "see" our outer class automatically
                ivar = 13;
        }
    }

    public void test() {
        ivar = 10;
        Inner in = new Inner();
        in.foo();
        ...
    }
}
```


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Nested Class

- Like an inner class
  - But does not have a pointer to the outer object
  - Does not have automatic access to the ivars of the outer object
- Users the *static* keyword

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Nested Class example

```
public class Outer {
    private int ivar;

    // a class known only to Outer
    private static class Nested {
        void foo() {
                // no automatic access to outer ivars
        }
    }

    public void test() {
        Nested nested = new Nested();
        nested.foo();
        ...
    }
}
```


Inner/Nested Example

- Each inner object is created in the context of a single, "owning", outer object
  - At runtime, the inner object has a pointer to its outer object which allows access to the outer object.
- Each inner object can access the ivars/methods of its outer object
  - Can refer to the outer object using its classname as "Outer.this".
- The inner/outer classes can access each other's ivars and methods, even if they are "private"
  - Stylistically, the inner/outer classes operate as a single class that is superficially divided into two.

Inner/Nested Example Code

```
// Outer.java

public class Outer {
    private int a;

    private void increment() {
        a++;
    }

    private class Inner extends Object {
        private int b;

        private Inner(int initB)  {
            b = initB;
        }
```


Inner/Nested Example Code

```
        private void demo() {
            // access our own ivar
            System.out.println("b: " + b);

            // access the ivar of our outer object
            System.out.println("a: " + a);

            // message send can also go to the outer object
            increment();

            /*
             Outer.this refers to the outer object, so could say
             Outer.this.a or Outer.this.increment()
             */
        }
    }
```


Inner/Nested Example Code

```
    // Nested class is like an inner class, but
    // without a pointer to the outer object.
    // (uses the keyword "static")
    private static class Nested {
        private int c;

        void demo() {
            c = 11;   // this works
            // b = 13;          // no does not compile --
            // nested object does not have pointer
            // to outer object
        }
    }
```


Inner/Nested Example Code

```
    public void test() {
        a = 10;
        Inner i1 = new Inner(1);
        Inner i2 = new Inner(2);

        i1.demo();
        i2.demo();

        Nested n = new Nested();
        n.demo();

    }

    public static void main(String[] args) {
        Outer outer = new Outer();
        outer.test();
    }
}
```


Inner/Nested Example Output

Output:

b: 1
a: 10
b: 2
a: 11

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Listeners (Handout #13)

- Anonymous Inner Classes
  - An inner class created on the fly using a quick and dirty syntax (no name!)
  - Convenient for creating small inner classes which play the role of callback function pointers (will see an example soon)
  - When compiled they look like Outer$1, Outer$2
- Stylistic notes
  - Useful for small sections of code
  - If it requires non-trivial ivars or methods, then a true inner class is better

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Anonymous Inner Classes

- Do not have a name
- Does not have a constructor
  - Relies on the default constructor of the super class
- Does not have access to local stack variables (parameters to a method)
  - Unless they are declared final
- Example
  - Class Outer. Anonymous Inner class subclassed off of a class called Superclass

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Anonymous Inner Class Example

```
public class Outer {
    int ivar;

    public Superclass method() {
        int sum;                    // ordinary stack var
        sum = ivar + 1;
        final int temp = ivar + 1;  // stack var, but declared final (constant)
        // Create new anonymous inner class, subclassed off Superclass
        Superclass s = new Superclass() {
            private int x = 0;
            public void foo() {
                x++;                // x of inner class
                ivar++;             // ivar of outer class
                bar();              // inherited from Superclass
                // x = sum;         // no, cannot see sum
                x = temp;           // this works, since temp is final
            }
        };
        return(s);                  // later on, someone can send s.foo()
    }
...
```


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final var trick

- Inner classes can see ivars of outer objects
- Inner classes **cannot** see stack variables (parameters)
- However
  - Inner classes can see “final” stack variables
- Why
  - Inlining of finals by the compiler
- *Declare stack variables as final to communicate their value to an anonymous inner class*
- Outer.this os the pointer to the outer object

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Controls and Listeners

- Theory
  - Source
    - Buttons, controls etc.
  - Listener
    - An Object that wants to know when the control is operated
  - Notification Message
    - A message sent from the source to the listener as a notification that the event has occured
- Essentially: registering callbacks

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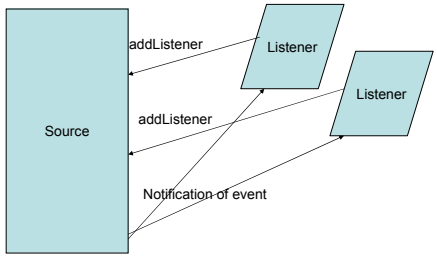
Listeners and Interface

- An Object may be interested in multiple events
  - It can implement multiple listener interfaces
- Once an object implements a listener interface, it can then be added to the source buy using
  - source.addListener(Listener l)
- Interfaces are key in the ability to implement the Listener model

Source-Listener Interaction



Listener Interface

- ActionListener Interface
  - Objects that would like to listen to a JButton must implement ActionListener

```
public interface ActionListener extends EventListener {
   /**
    * Invoked when an action occurs.
    */
   public void actionPerformed(ActionEvent e);
}
```


Notification Prototype

- The message prototype defined in the ActionListener Interface
  - The message the button sends
- ActionEvent parameter includes extra info
  - A pointer to the source object (e.getSource())
  - When the event happened
  - Any modifier keys held down

```
public void actionPerformed(ActionEvent e);
```


source.addXXX(listener)

- To setup the listener relationship, the listener must register with the source
  - Example: button.addActionListener(listener)
- The listener must implement the ActionListener interface
  - It must respond to the message that the button will send

Event→Notification

- When the action happens
  - Button is clicked…
- The source iterates through its listeners
- Sends each listener the notification
  - JButton send the actionPerformed() message to each listener

Using a Button and a Listener #1

- Component implements ActionListener
  - The component could implement the ActionListener interface directly
  - Register “this” as the listener object

```
class MyComponent extends JComponent
   implements ActionListener {
   …
   // in the JComponent ctor
   button.addActionListener(this);
```


Using a Button and a Listener #2

- Create an inner class
  - Create a MyListener inner class which implements ActionListener
  - Create a new MyListener object
  - Add it via button.addXXX(listener)

```
// in the JComponent ctor
ActionListener listener = new MyActionListener();
button.addActionListener(listener);
```


Anonymous Inner class

- Most common method!
- Create an Anonymous Inner Class that implements the interface
  - Can be created on the fly inside the method!

```
button = new JButton("Beep");
panel.add(button);
button.addActionListener(
   new ActionListener() {
        public void actionPerformed(ActionEvent e) {
                Toolkit.getDefaultToolkit().beep();
        }
   }
);
```


Button Listener Example

ButtonListener Example Code

```
// ListenerFrame.java
import java.awt.*;
import javax.swing.*;
import javax.swing.event.*;
import java.awt.event.*;
/*
 Demonstrates bringing up a frame with a couple of buttons in it.
 Demonstrates using anonymous inner class listener.
*/
public class ListenerFrame extends JFrame {
    private JLabel label;
```


Button Listener Example

```
public ListenerFrame() {
        super("ListenerFrame");

        JComponent content = (JComponent) getContentPane();
        content.setLayout(new FlowLayout());

        JButton button = new JButton("Beep!");
        content.add(button);

        // ----
        // Creating an action listener in 2 steps...

        // 1. Create an inner class subclass of ActionListener
        ActionListener listener =
                new ActionListener() {
                        public void actionPerformed(ActionEvent e) {
                                Toolkit.getDefaultToolkit().beep();
                        }
                };
```


Button Listener Example

```
        // 2. Add the listener to the button
        button.addActionListener(listener);

        // ----
        // Creating a listener in 1 step...

        // Create a little panel to hold a button
        // and a label
        JPanel panel = new JPanel();
        content.add(panel);
        JButton button2 = new JButton("Yay!");
        label = new JLabel("Woo Hoo");
        panel.add(button2);
        panel.add(label);
```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Button Listener Example

```
// This listener adds a "!" to the label.
        button2.addActionListener(
                new ActionListener() {
                        public void actionPerformed(ActionEvent e) {
                                String text = label.getText();
                                label.setText(text + "!");
                                // note: we have access to "label" of
outer class
                                // we do not have access to local vars
like 'panel',
                                // unless they are declared final.
                        }
                }
        );

        pack();
        setVisible(true);
}
```


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Misc Listeners

- JCheckBox
  - Uses ActionListener, like JButton
  - Responds to boolean isSelected() to see if it is currently checked
- JSlider
  - Component with min/max/current values
  - Users StateChangedListener interface
    - Notification is stateChanged(ChangeEvent e)
    - e.getSource() to get a pointer to the source
  - Responds to int getValue() to get current value

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Event handling Strategies

- Listener strategy
  - Our approach so far
  - Event based
- Polling strategy
  - Do not listen to the control
  - Check the value when you choose
  - Often fraught with problems, but may have an appropriate use in some cases

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Summary

- Continued with Drawing in Java
- Java Swing classes
  - JComponent
    - paintComponent
  - Graphics Object
  - My Component Example
- Layout Managers
  - Flow, Box and Border
  - Nesting
  - Layout Example
- Inner Classes
- Anonymous Inner Classes (maybe)
- Listener model (maybe)
  - Button Listener Example
- Assigned Work Reminder:
  - HW #1: Pencil Me In
    - Due before midnight Wednesday, July 9th, 2003

