An Introduction To Graphical User Interfaces

You will learn about the event-driven model and how to create simple graphical user interfaces (GUI's) in Java

James Tam

Note: GUI Code Cannot Be Run Through A Text-Only Connection: SSH

```
[csb exampleTwo 45 ]> ls
Driver.class*    Driver.java      MyListener.class*  MyListener.java

[csb exampleTwo 46 ]> java Driver
Exception in thread "main" java.lang.InternalError: Can't connect to X11 window server using
  ':0.0' as the value of the DISPLAY variable.
      at sun.awt.X11GraphicsEnvironment.initDisplay(Native Method)
      at sun.awt.X11GraphicsEnvironment.<clinit>(X11GraphicsEnvironment.java:125)
      at java.lang.Class.forName0(Native Method)
      at java.lang.Class.forName(Class.java:140)
      at
  java.awt.GraphicsEnvironment.getLocalGraphicsEnvironment(GraphicsEnvironment.java:62)
      at java.awt.Window.init(Window.java:223)
      at java.awt.Window.<init>(Window.java:267)
      at java.awt.Frame.<init>(Frame.java:398)
      at java.awt.Frame.<init>(Frame.java:363)
      at Driver.main(Driver.java:7)
```

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Components

- They are many types of graphical controls and displays available:
  - JButton, JFrame, JLabel, JTextArea, JWindow, JList
- A graphical component is also known as “widgets”
- For Sun’s online documentation refer to the url:
  - *http://download.oracle.com/javase/7/docs/api/* (especially java.awt.event, javax.swing.event, and javax.swing).

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Containers

- A special type of component that is used to hold/contain the components (subclass of the basic component class).
- Can be used to group components on the screen (i.e., one container holds another container which in turn groups a number of controls).
- You must have at least one container object for your GUI:
  - JPanel, JWindow, JDialog, JFrame
- Components which have been added to a container will appear/disappear and be garbage collected along with the container.

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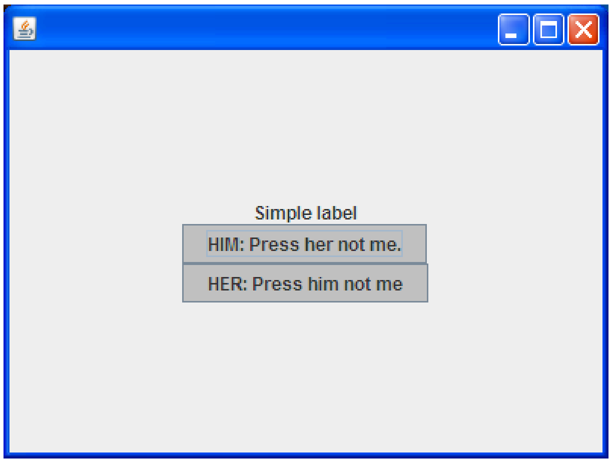
Containers

- You must have at least one container object for your GUI:
  - JPanel, JWindow, JDialog, J**Frame**



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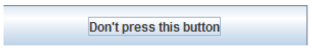
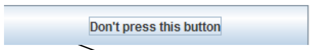
Some Relevant Java GUI libraries

1. Java classes for the components and containers
   - e.g., JButton class
   - javax.swing (import javax.swing.* or import javax.swing.<*class name*>)



2. Java classes with the code to react to user-initiated events
   - e.g., code that executes when a button is pressed
   - java.awt.event (import java.awt.event.*, import javax.swing.event.*)



```
class ButtonListener implements ActionListener
{
    public void actionPerformed(ActionEvent e)
    {
            :          :          :
    }
}
```

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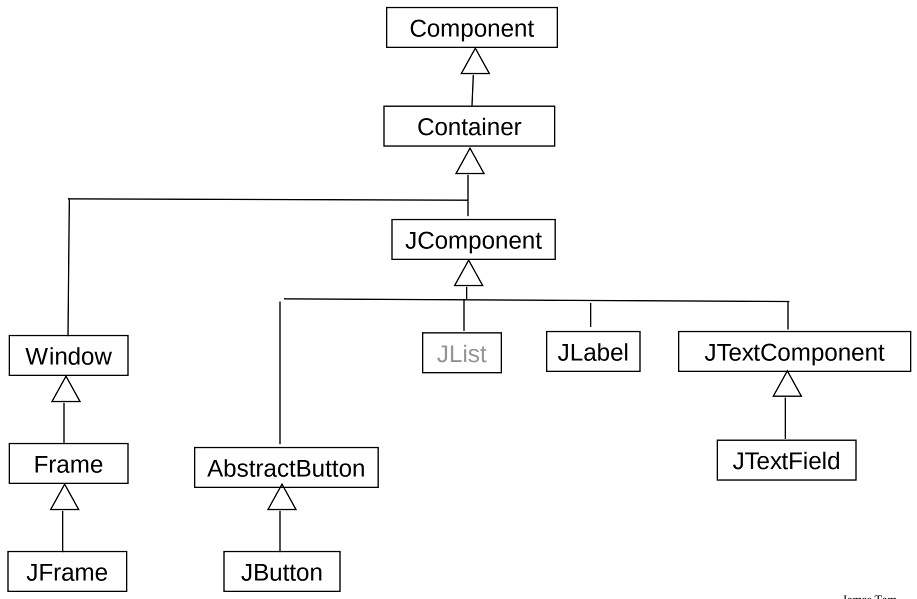
Hierarchy: Important Widget Classes



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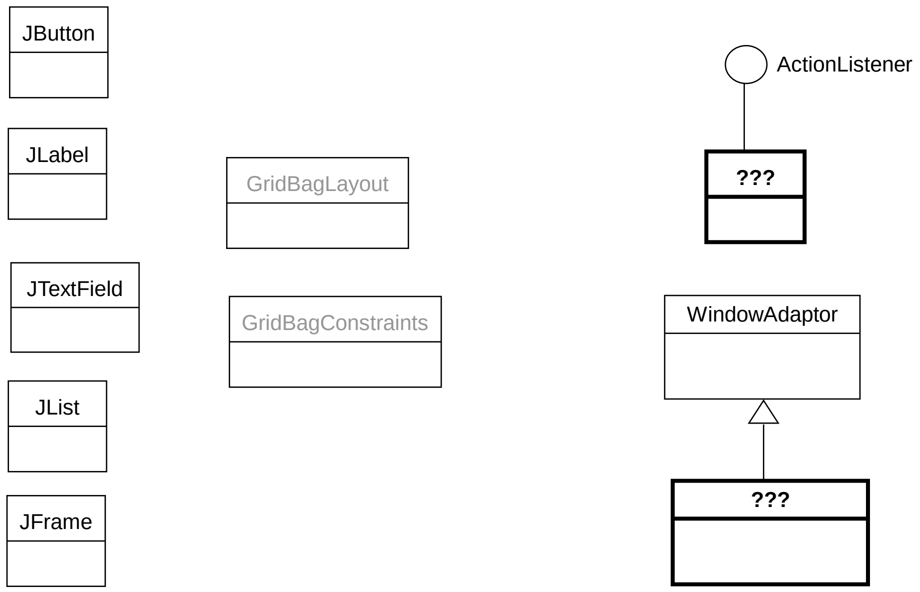
Some Relevant Java GUI Classes For This Section



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Traditional Software

•Program control is largely determined by the program through a series of sequential statements.

Example

```
    :
    if (num >= 0)
    {
        // Statements for the body of the if
    }
    else
    {
        // Statements for the body of the else
    }
```

When num is non-negative

Num is negative

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Traditional Software

•The user can only interact with the program at places that are specified by the program (e.g., when an input statement is encountered).

Example

```
Scanner aScanner = new Scanner (System.in);
System.out.print(“Enter student ID number: “);
id = aScanner.nextInt ();
```

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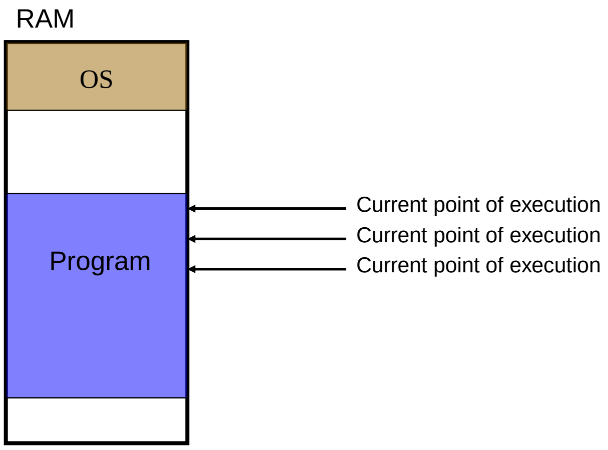
Event-Driven Software

•Program control can also be sequential


RAM
OS
Program
Current point of execution
Current point of execution
Current point of execution

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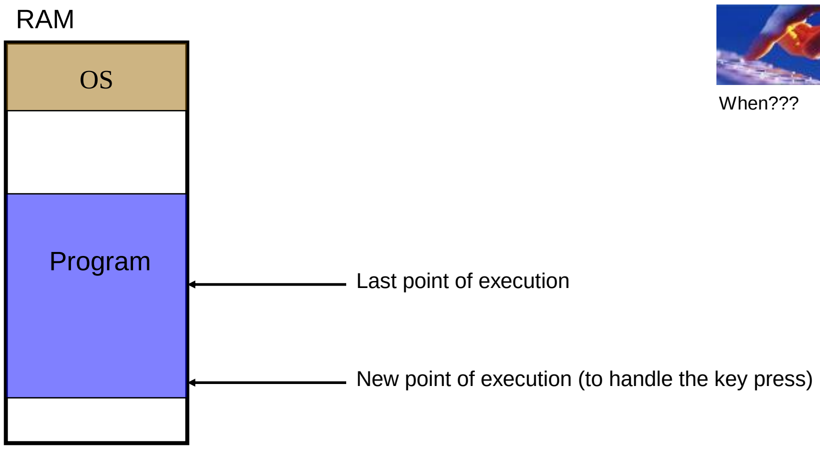
Event-Driven Software

- In addition program control *can also* be determined by events



When???

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Characteristics Of Event Driven Software

- Program control can be determined by events as well as standard program control statements.
- A typical source of these events is the user.
- These events can occur at any time.

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Most Components Can Trigger Events

- Graphical objects can be manipulated by the user to trigger events.
- Each graphical object can have 0, 1 or many events that can be triggered.

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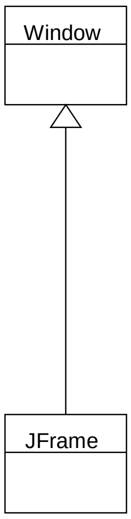
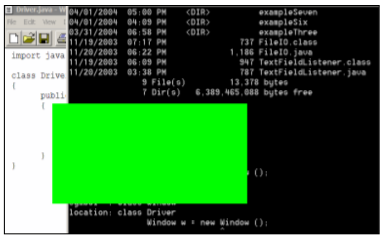
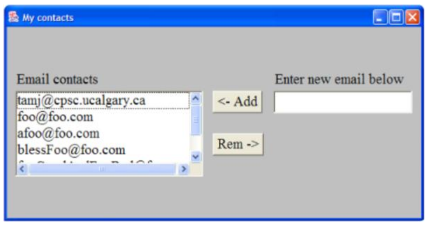
Window Classes





```
import java

class Drive
{
        publi
        {

        }
}
```

```
04/01/2004  05:00 PM    <DIR>          exampleSeven
04/01/2004  04:09 PM    <DIR>          exampleSix
03/31/2004  06:58 PM    <DIR>          exampleThree
11/19/2003  07:17 PM               737 FileIO.class
11/20/2003  06:22 PM             1,186 FileIO.java
11/19/2003  06:09 PM               947 TextFieldListener.class
11/20/2003  03:38 PM               787 TextFieldListener.java
               9 File(s)         13,378 bytes
               7 Dir(s)   6,389,465,088 bytes free

                                     ();

location: class Driver
                Window w = new Window ();
                               ^
```



tamj@cpsc.ucalgary.ca
foo@foo.com
afoo@foo.com
blessFoo@foo.com

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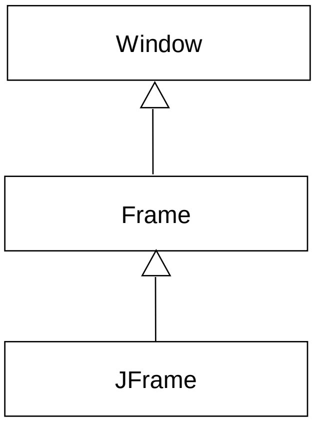
The Window Class Hierarchy



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Class JFrame

- For full details look at the online API:
  - http://download.oracle.com/javase/7/docs/api/javax/swing/JFrame.html
- Some of the more pertinent methods:
  - JFrame ("<*Text on the title bar*>")
  - setSize (<*pixel width*>, <*pixel height*>)
  - setVisible (<*true/false*>)
  - setDefaultCloseOperation (<*class constants*>[1])

1 DISPOSE_ON_CLOSE, HIDE_ON_CLOSE, DO_NOTHING_ON_CLOSE

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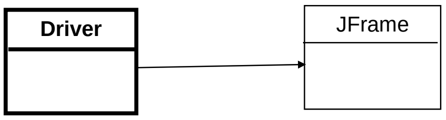
Example: Creating A Frame That Can Close (And Cleanup Memory After Itself)

- Location of the example:

/home/233/examples/gui/first_frame

OR

www.cpsc.ucalgary.ca/~tamj/233/examples/gui



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Example: Creating A Frame That Can Close (And Cleanup Memory After Itself)

```
import javax.swing.*;
public class Driver
{
    public static void main (String [] args)
    {
        JFrame mf = new JFrame ("Insert title here");
        mf.setSize (300,200);
        mf.setDefaultCloseOperation(JFrame.DISPOSE_ON_CLOSE);
        mf.setVisible(true);
    }
}
```

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Pitfall 1: Showing Too Early

- When a container holds a number of components the components must be added to the container (later examples).
- To be on the safe side the call to the "setVisible()" method should be done after the contents of the container have already been created and added.

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Window Events

•The basic JFrame class provides basic capabilities for common windowing operations: minimize, maximize, resize, close.

•However if a program needs to perform other actions (i.e., your own custom code) when these events occur the built in approach won't be sufficient.

- E.g., the program is to automatically save your work to a file when you close the window.

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Steps In The Event Model For Handling A Frame Event: Window Closing

1) The frame must register all interested event listeners.
2) The user triggers the event by closing the window
3) The window sends a message to all listeners of that event.
4) The window event listener runs the code to handle the event (e.g., save information to a file).

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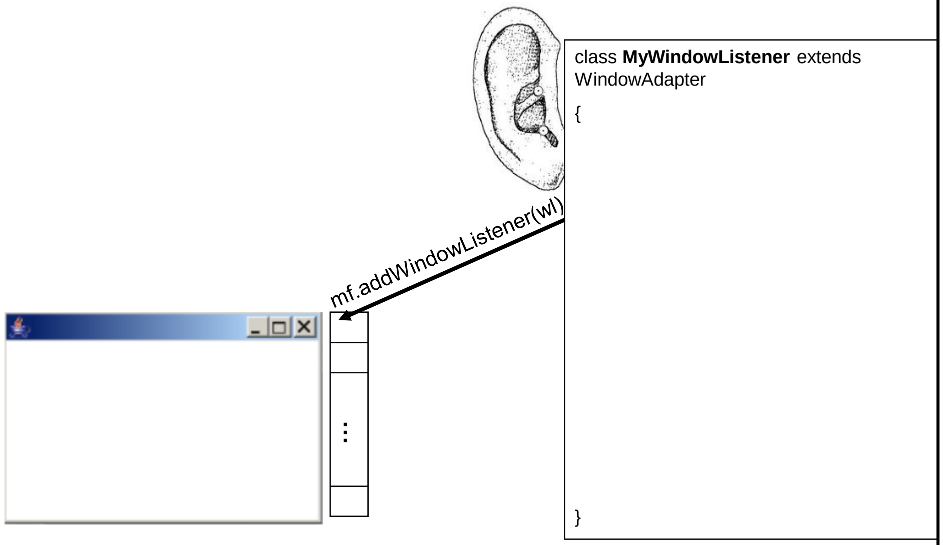
1. The Frame Must Register All Interested Event Listeners.



```
class MyWindowListener extends
WindowAdapter
{
}
```

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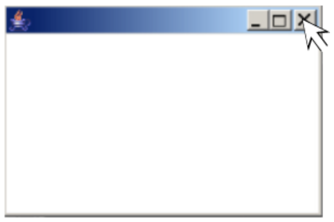
2. The User Triggers The Event By Closing The Window



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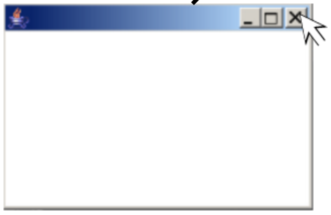
3. The Window Sends A Message To All Listeners Of That Event.



```
public class **MyWindowListener** extends
WindowAdapter
{
        public void windowClosing  (WindowEvent e)
        {



         }
}
```

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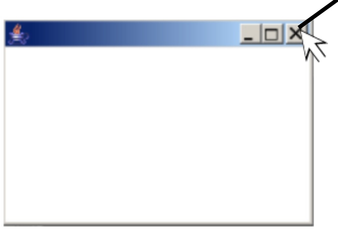
4. The Event Listener Runs The Code To Handle The Event.



```
public class MyWindowListener extends
WindowAdapter
{
        public void windowClosing (WindowEvent e)
        {
           /* Code to react to event * /
           JFrame aFrame = (JFrame) e.getWindow();
           aFrame.setTitle("Closing window...");
          // Pause program so user can see the message.
           aFrame.setVisible(false);
           aFrame.dispose();
        }
}
```

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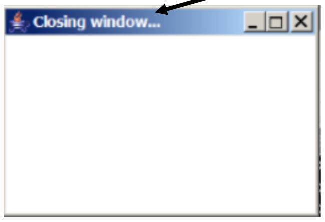
4. The Event Listener Runs The Code To Handle The Event.



```
public class MyWindowListener extends
WindowAdapter
{
        public void windowClosing (WindowEvent e)
        {
            /* Code to react to event * /
            JFrame aFrame = (JFrame) e.getWindow();
            aFrame.setTitle("Closing window...");
           // Pause program so user can see the message.
            aFrame.setVisible(false);
            aFrame.dispose();
        }
}
```

James Tam

An Example Of Handling A Frame Event

•Location of the example:

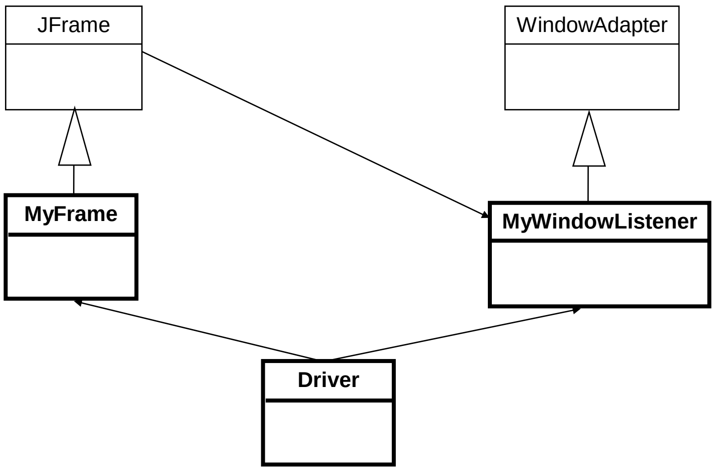
/home/233/examples/gui/second_window_events

OR

www.cpsc.ucalgary.ca/~tamj/233/examples/gui/second_window_events

James Tam

An Example Of Handling A Frame Event (2)



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The Driver Class

```
import javax.swing.JFrame;

public class Driver
{
    public static final int WIDTH = 300;
    public static final int HEIGHT = 200;
    public static void main (String [] args)
    {
        MyFrame aFrame = new MyFrame ();
        MyWindowListener aListener = new MyWindowListener() ;
        aFrame.addWindowListener(aListener);
        aFrame.setSize (WIDTH,HEIGHT);
        aFrame.setVisible(true);
    }
}
```

James Tam

Class MyFrame

```
import javax.swing.JFrame;

public class MyFrame extends JFrame
{
    // More code will be added in later examples.
}
```

James Tam

Class MyWindowListener

```
import java.awt.event.WindowAdapter;
import java.awt.event.WindowEvent;
import javax.swing.JFrame;

public class MyWindowListener extends WindowAdapter {
        public void windowClosing (WindowEvent e) {
        JFrame aFrame = (JFrame) e.getWindow();
        aFrame.setTitle("Closing window...");
        try
           Thread.sleep(3000);
        catch (InterruptedException ex)
           System.out.println("Pausing of program was interrupted");
        aFrame.setVisible(false);
        aFrame.dispose();
      }
}
```

James Tam

Callback

- The code that handles the event (the code that is called when a GUI event such as a window closing occurs) is commonly referred to as a "callback".
  - An old IBM IDE (VisualAge) used to refer to these as 'event to code'.
    - Evaluation copy: http://download.cnet.com/IBM-VisualAge-for-Java/3000-2247_4-18868.html
    - IBM page: http://www-142.ibm.com/software/products/us/en/atoz

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Callback (2)

- Example callbacks:

```
// Window event callback (you have already seen this example)
 public void windowClosing (WindowEvent e) {
     << Called when window event occurs >>
 }

// Button event callback (you haven't yet seen this example)
public void actionPerformed (ActionEvent e)  {
     << Called when button event occurs >>


}
```

James Tam

Steps In The Event Model For Handling A Button Event

1) The button must register all interested event listeners.
2) The user triggers an event by pressing a button.
3) The button sends a message to all listeners of the button press event.
4) The button listener runs the code to handle the button press event.

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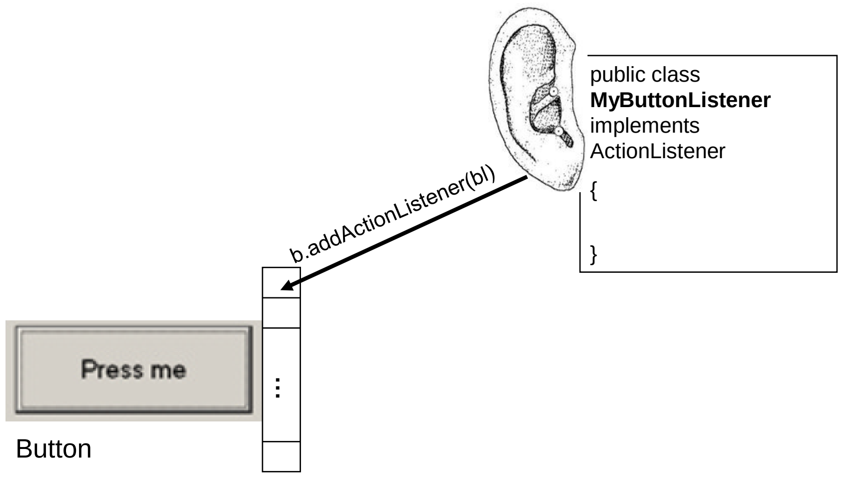
1. The Graphical Component Must Register All Interested Event Listeners.



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2. The User Triggers An Event By Pressing The Button

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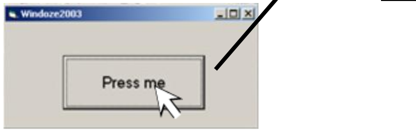
3. The Component Sends A Message To All Registered Listeners For That Event



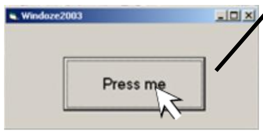
```
public class **MyButtonListener** implements ActionListener
{
     public void actionPerformed (ActionEvent e)
    {


    }
}
```

James Tam

3. The Component Sends A Message To All Registered Listeners For That Event

```
public class MyButtonListener implements ActionListener
{
    public void actionPerformed (ActionEvent e)
    {
        JButton b = (JButton) e.getSource();
        b.setLabel("Stop pressing me!");
    }
}
```



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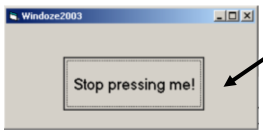
4. The Event Listener Runs The Code To Handle The Event

```
public class MyButtonListener implements ActionListener
{
    public void actionPerformed (ActionEvent e)
    {
        JButton b = (JButton) e.getSource();
        b.setLabel("Stop pressing me!");
    }
}
```



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An Example Of Handling A Button Event

•Location of the example:

/home/233/examples/gui/three_button_events

OR

www.cpsc.ucalgary.ca/~tamj/233/examples/gui/three_button_events

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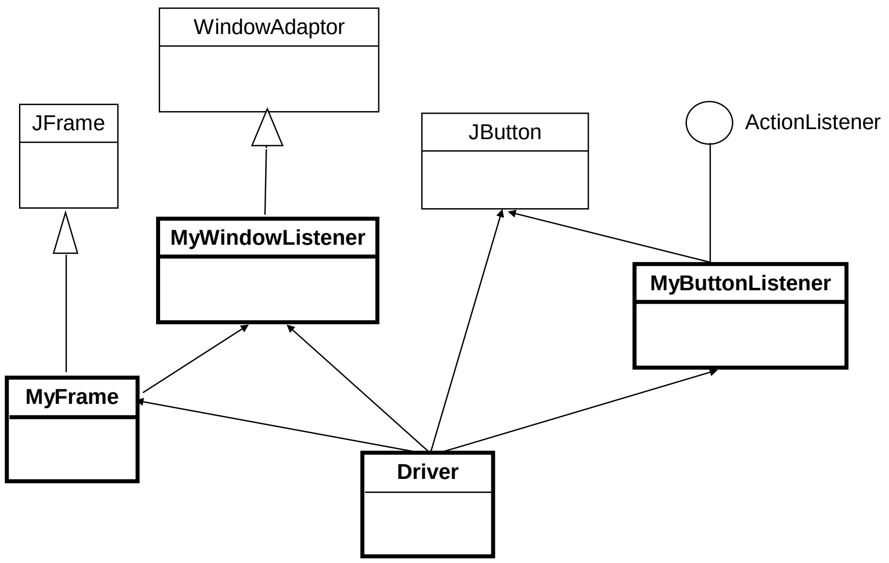
An Example Of Handling A Button Event (2)



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An Example Of Handling A Button Event: The Driver Class

```
import javax.swing.JButton;

public class Driver
{
    public static final int WIDTH = 300;
    public static final int HEIGHT = 200;
    public static void main (String [] args)
    {
        MyFrame aFrame = new MyFrame ();
        MyWindowListener aWindowListener = new MyWindowListener();
        aFrame.addWindowListener(aWindowListener);
        aFrame.setSize (WIDTH,HEIGHT);
```

James Tam

An Example Of Handling A Button Event: The Driver Class (2)

```
        JButton aButton = new JButton("Press me.");
        MyButtonListener aButtonListener = new
        MyButtonListener();
        aButton.addActionListener(aButtonListener);
        aFrame.add (aButton);
        aFrame.setVisible(true);
    }
}
```

James Tam

An Example Of Handling A Button Event: The ButtonListener Class

```
import javax.swing.JButton;
import java.awt.event.ActionEvent;
import java.awt.event.ActionListener;

public class MyButtonListener implements ActionListener
{
    public void actionPerformed (ActionEvent e)
    {
        JButton aButton = (JButton) e.getSource();
        aButton.setText("Stop pressing me!");
    }
}
```

James Tam

How To Handle The Layout Of Components

1. Manually set the coordinates yourself
2. Use one of Java’s built-in layout manager classes

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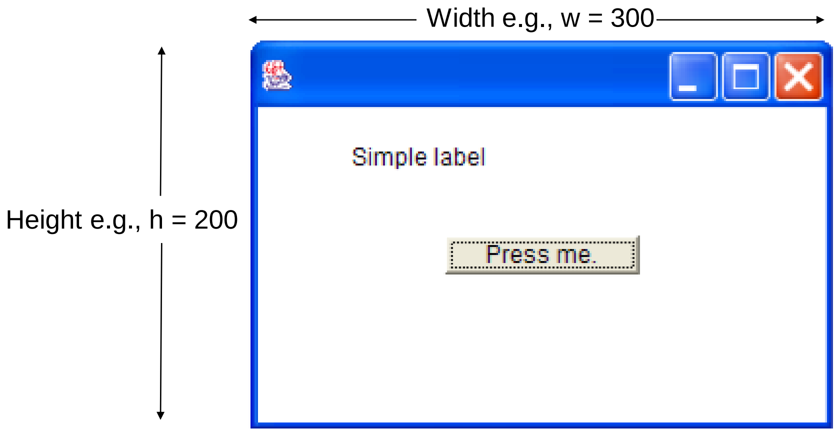
Layout Is Based On Spatial Coordinates

```
e.g. MyFrame my =new MyFrame ();
     my.setSize(300,200);
```



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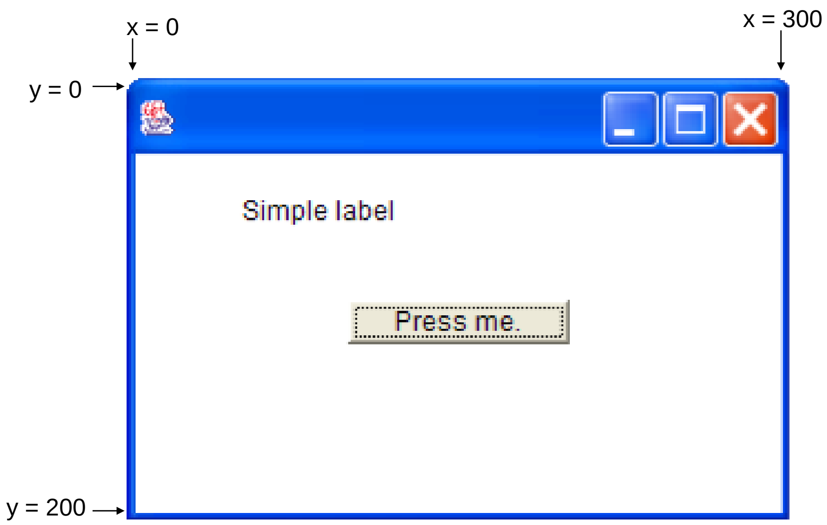
Layout Is Based On Spatial Coordinates



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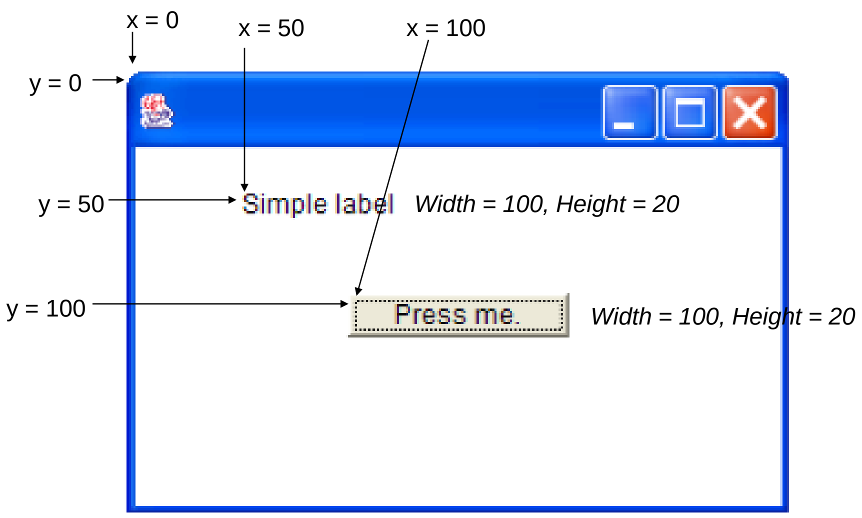
Coordinates Of Components: Relative To The Container



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Pitfall 2: Invisible Component

- Don’t forget that coordinates (0,0) are covered by the title bar of the frame.
- Components added at this location may be partially or totally hidden by the title bar.

James Tam

A Example Showing Manual Layout

•Location of the example:

/home/233/examples/gui/fourth_manual_layout

OR

www.cpsc.ucalgary.ca/~tamj/233/examples/gui/fourth_manual_layout

James Tam

An Example Showing Manual Layout: The Driver Class

```
import javax.swing.JButton;
import javax.swing.JLabel;
import javax.swing.JFrame;

public class Driver
{
    public static final int WIDTH_FRAME = 300;
    public static final int HEIGHT_FRAME = 300;
    public static final int X_COORD_BUTTON = 100;
    public static final int Y_COORD_BUTTON = 100;
    public static final int WIDTH_BUTTON = 100;
    public static final int HEIGHT_BUTTON = 20;
    public static final int X_COORD_LABEL = 50;
    public static final int Y_COORD_LABEL = 50;
    public static final int WIDTH_LABEL = 100;
    public static final int HEIGHT_LABEL = 20;
```

James Tam

An Example Showing Manual Layout: The Driver Class (2)

```
    public static void main (String [] args) {
        JFrame aFrame = new JFrame ();
        aFrame.setLayout(null);
        aFrame.setSize (WIDTH_FRAME,HEIGHT_FRAME);
        JButton aButton = new JButton("Press me.");
        aButton.setBounds(X_COORD_BUTTON,
                              Y_COORD_BUTTON,
                              WIDTH_BUTTON,
                              HEIGHT_BUTTON);
        JLabel aLabel = new JLabel ("Simple label");
        aLabel.setBounds(X_COORD_LABEL,
                            Y_COORD_LABEL,
                            WIDTH_LABEL,
                            HEIGHT_LABEL);
        aFrame.add(aButton);
        aFrame.add(aLabel);
        aFrame.setVisible(true);
    }
}
```

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Components Effecting The State Of Other Components

•Location of the example:

/home/233/examples/gui/sixth_controls_affect_controls

OR

www.cpsc.ucalgary.ca/~tamj/233/examples/gui/sixth_controls_affect_controls

James Tam

Components Effecting The State Of Other Components: The Driver Class

```
public class Driver
{
    public static final int WIDTH = 800;
    public static final int HEIGHT = 600;
    public static void main (String [] args)
    {
        MyFrame aFrame = new MyFrame ();
        aFrame.setSize(WIDTH,HEIGHT);
        aFrame.setVisible(true);
    }
}
```

James Tam

Components Effecting The State Of Other Components: Class MyFrame

```
public class MyFrame extends JFrame
{
   private JLabel aLabel1;
   private JButton aButton;
   private MyButtonListener aButtonListener;
```

James Tam

Components Effecting The State Of Other Components: Class MyFrame (2)

```
public MyFrame ()
{
    MyWindowListener aWindowListener = new MyWindowListener ();
    JLabel aLabel2;
    addWindowListener(aWindowListener);
    aLabel1 = new JLabel("Label 1");
    aLabel2 = new JLabel("Label 2");
    aLabel1.setBounds(100,100,100,30);
    aLabel2.setBounds(300,100,100,30);
```

James Tam

Components Effecting The State Of Other Components: Class MyFrame (3)

```
        aLabel = new JLabel("Simple label");
        aLayout = new GridBagLayout();
        setLayout(aLayout);     // Calling method of super class.
        addWidget(aLabel, 0, 0, 1, 1);
        addWidget(himButton, 0, 1, 1, 1);
        addWidget(herButton, 0, 2, 1, 1);
    }
```

James Tam

Components Effecting The State Of Other Components: Class MyFrame (4)

```
     aButtonListener = new MyButtonListener();
     aButton = new JButton("Press for multiple effects");
     aButton.addActionListener(aButtonListener);
     aButton.setBounds(150,300,200,50);
     add(aLabel1);
     add(aLabel2);
     add(aButton);
     setLayout(null);
   }

   public JButton getAButton () { return aButton; }
   public JLabel getLabel1 () { return aLabel1; }
   // JT: Note that label2 has no accessor – not the effect in Button listener
}
```

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Components Effecting The State Of Other Components: Class MyFrame (5)

```
   public class MyWindowListener extends WindowAdapter
   {
       public void windowClosing (WindowEvent e)
       {
          JFrame f = (JFrame) e.getWindow();
          f.setTitle("Closing window…");
           try {
                Thread.sleep(3000);
           }
           catch (InterruptedException ex) {
                System.out.println("Pausing of program was interrupted");
           }
          f.setVisible(false);
          f.dispose();
       }
}
```

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Components Effecting The State Of Other Components: Class ButtonListener

```
public class MyButtonListener implements ActionListener
{
   public void actionPerformed (ActionEvent e)
   {
              JButton aButton = (JButton) e.getSource();
              MyFrame aFrame = (MyFrame)
                   aButton.getRootPane().getParent();
              JLabel aLabel1 = aFrame.getLabel1();  // Has accessor
              aLabel1.setText("Effect1");

              JLabel aLabel2 = null;                  // No accessor
              Container aContainer = aFrame.getContentPane();
              Component aComponent = aContainer.getComponent(1)
              if (aComponent instanceof JLabel)
                     aLabel2 = (JLabel) aComponent;
```

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Components Effecting The State Of Other Components: Class ButtonListener

```
              JLabel aLabel2 = null;                  // No accessor
              Container aContainer = aFrame.getContentPane();
              Component aComponent = aContainer.getComponent(1)
              if (aComponent instanceof JLabel)
                     aLabel2 = (JLabel) aComponent;

              if (aLabel2 != null)
                     aLabel2.setText("Effect2");
   }
}
```

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Important Concepts And Terms

- GUI
- Event-based software
- Registering listeners
- Call back (event-to-code)

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References

- Books:
  - "*Java Swing*" by Robert Eckstein, Marc Loy and Dave Wood (O'Reilly)
  - "*Absolute Java*" (4th Edition) by Walter Savitch (Pearson)
  - "*Java: How to Program*" (6th Edition) by H.M. Deitel and P.J. Deitel (Pearson)
- Websites:
  - Java API specifications: http://download.oracle.com/javase/7/docs/api/
  - Java tutorials: http://download.oracle.com/javase/tutorial/uiswing/
  - Java tutorial (layout): http://docs.oracle.com/javase/tutorial/uiswing/layout/using.html

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You Should Now Know

- The difference between traditional and event driven software
- How event-driven software works (registering and notifying event listeners)
- How some basic Swing controls work
  - Example: Capturing common events for the controls such as a button press, Window events
- How to layout components manually using a coordinate system

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