Graphical User Interfaces in Java

CS314

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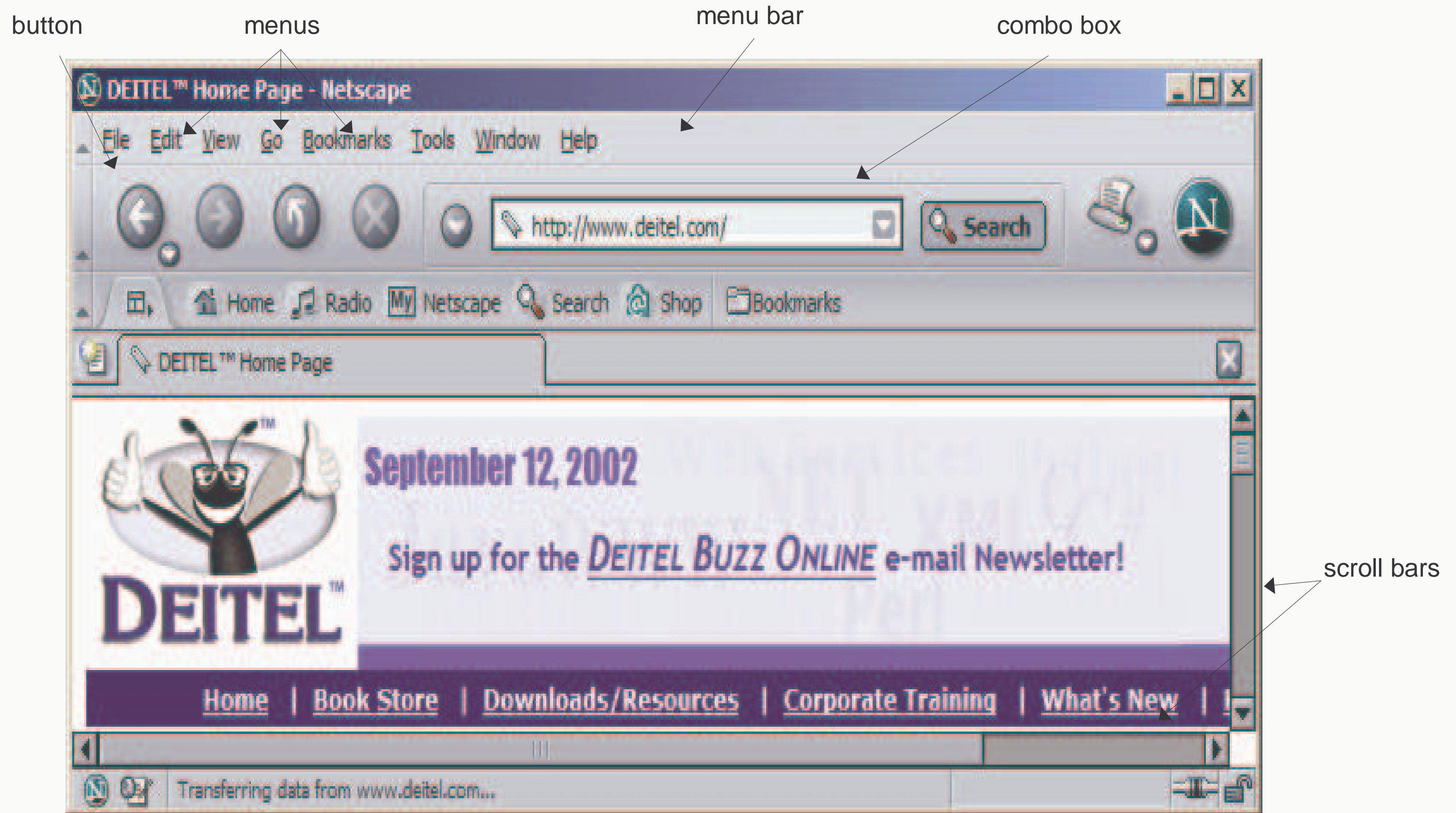
GUI Components



A Brief History

- Original AWT was suitable for Java applets but not for full-fledged application development.
- AWT 1.1 (JDK 1.1) had better event handling but did not have enough GUI components and was too dependent on (nonportable) native code.
- In 1997 Netscape and Sun developed a set of GUI classes written entirely in Java. The *Java Foundation Classes (JFC)*, including the Swing component set, were released with JDK 2.0.
- A Swing program can have the same look and feel on a Mac, Windows, or Unix platform.

Some basic GUI components

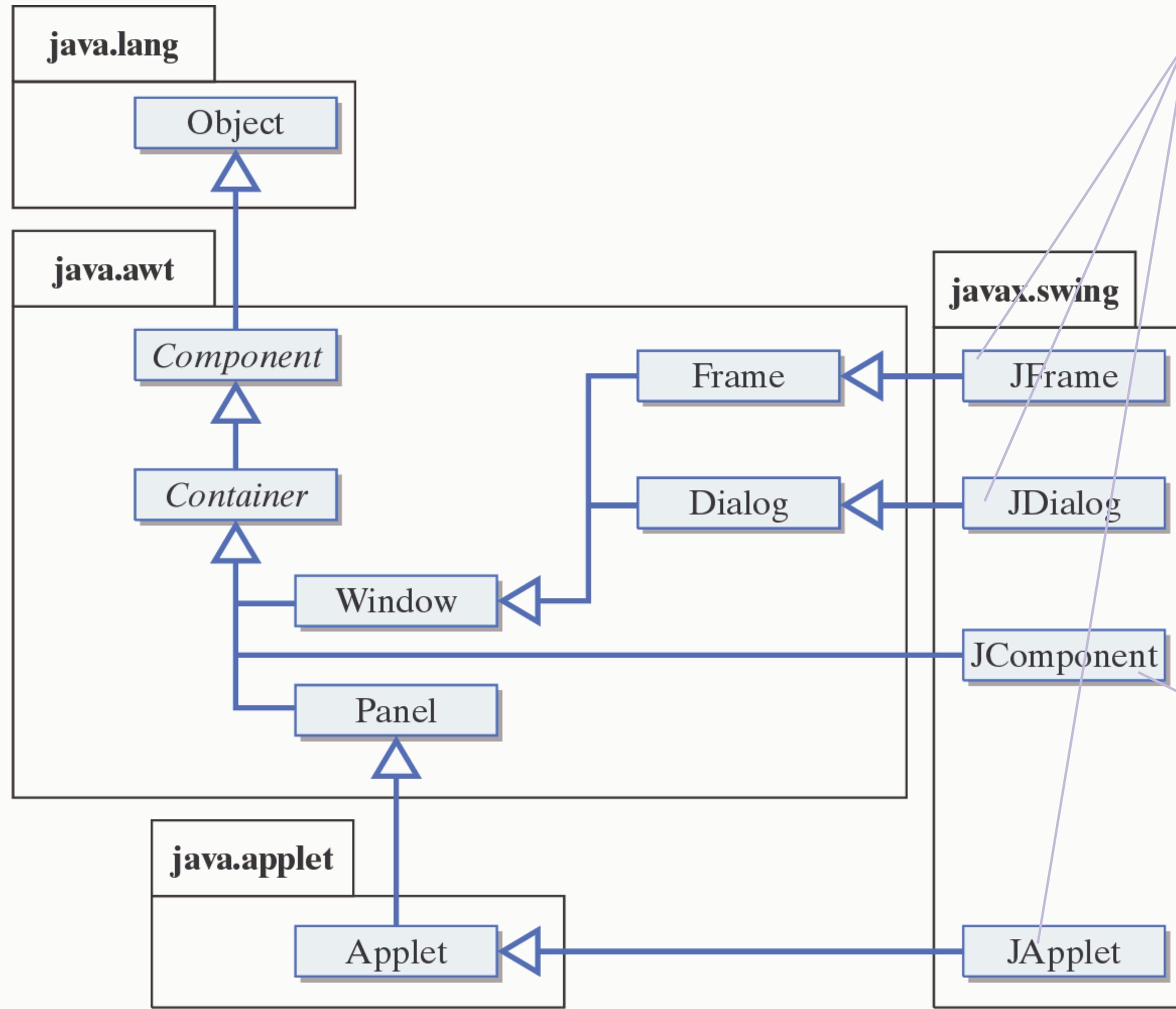
Component	Description
JLabel	An area where uneditable text or icons can be displayed.
JTextField	An area in which the user inputs data from the keyboard. The area can also display information.
JButton	An area that triggers an event when clicked with the mouse.
JCheckBox	A GUI component that is either selected or not selected.
JComboBox	A drop-down list of items from which the user can make a selection by clicking an item in the list or possibly by typing into the box.
JList	An area containing a list of items from which the user can make a selection by clicking on any element in the list. Multiple elements can be selected.
JPanel	A container in which components can be placed and organized.

Heavyweight versus Lightweight Components

- ***Heavyweight components:*** AWT components (java.awt.Button) use native code.
- ***Lightweight components:*** written in pure Java (more portable).
- Most Swing components are lightweight
  - Exceptions: JApplet, JDialog, JFrame, and JWindow are lightweight.
- Developing lightweight (pure Java) components: extend java.awt.Component and override paint():

```
public class LightWeightButton extends Component {
    public void paint(Graphics g) {
        /* Java code goes here */
    }
}
```

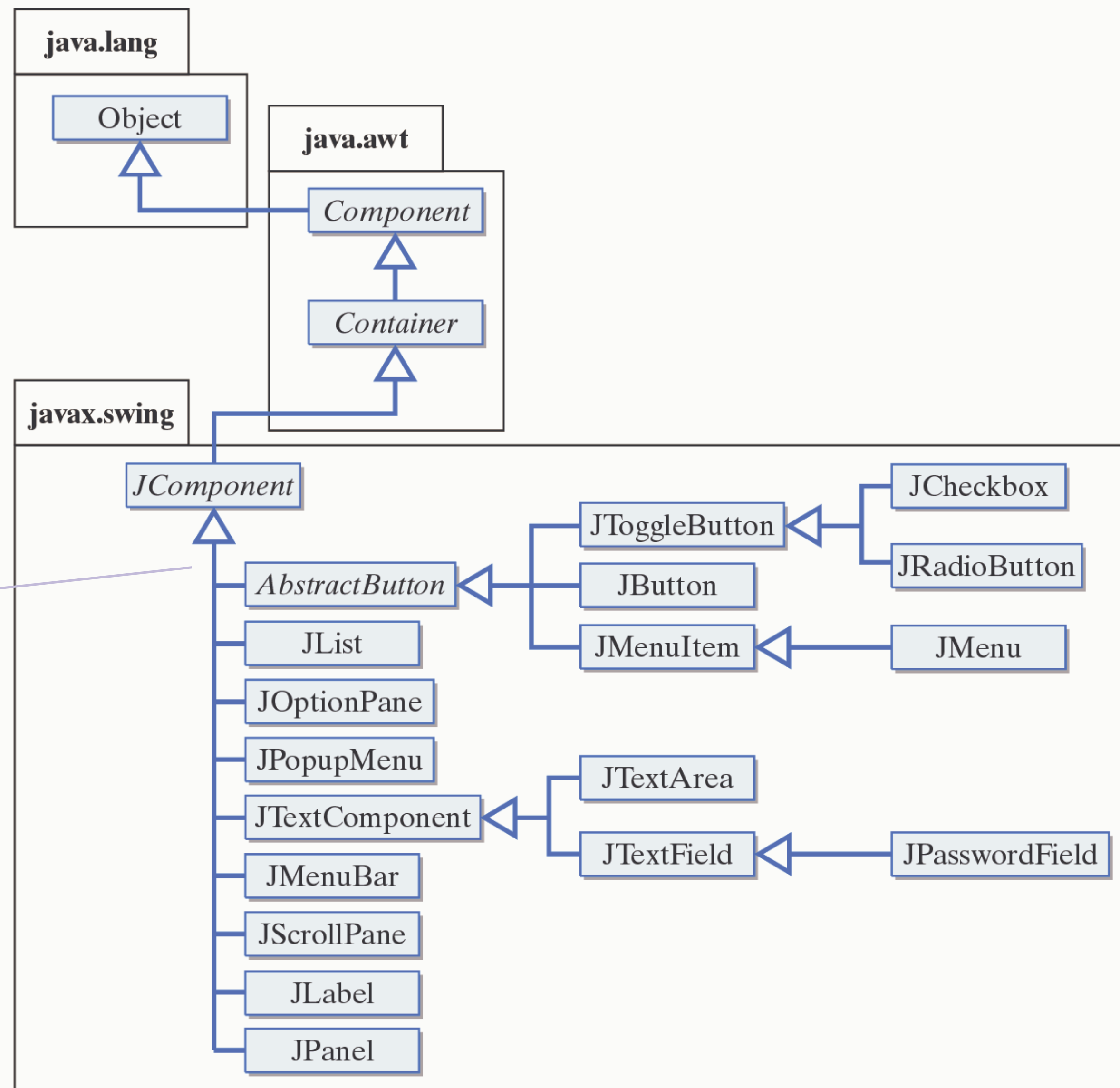
Swing Hierarchy



The top-level Swing windows are heavyweight. They depend on the native system.

Swing classes derived from JComponent will be lightweight, written entirely in Java.

Swing Hierarchy
(Part II)



Swing components names start with 'J'.

AWT and Swing

- Swing's top-level elements -- JApplet, JDialog, JFrame, and JWindow – inherit from their AWT counterparts.
- The base Swing class (JComponent) is derived from java.awt.Container.
  - Swing components are fundamentally based on the AWT.
- All GUI programs use classes defined in the AWT:
  - layout managers (java.awt.FlowLayout),
  - fonts (java.awt.Font),
  - colors (java.awt.Color).

The Swing Component Set

- Swing packages
  - javax.swing.event.*: contains Swing events and listeners; similar to java.awt.event.*
  - javax.swing.text.*: contains the classes for JTextField and JTextComponent, the Swing classes that replace the AWT's TextField and TextArea classes.

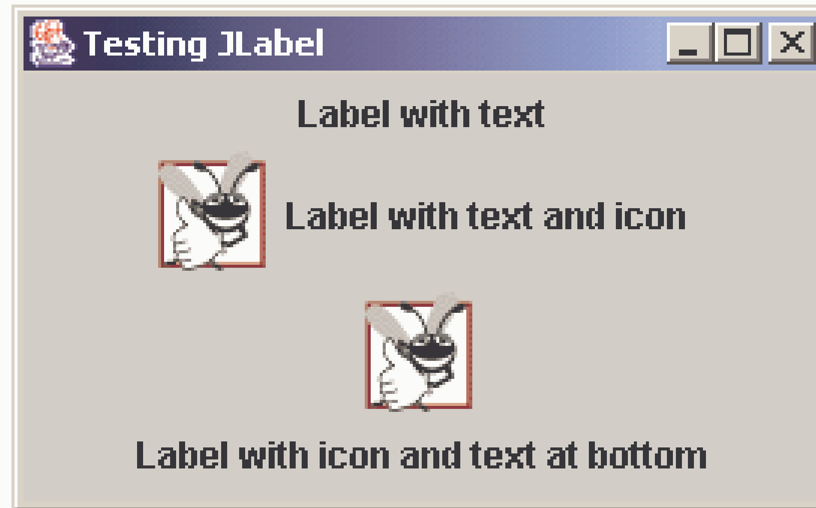
`JLabel`

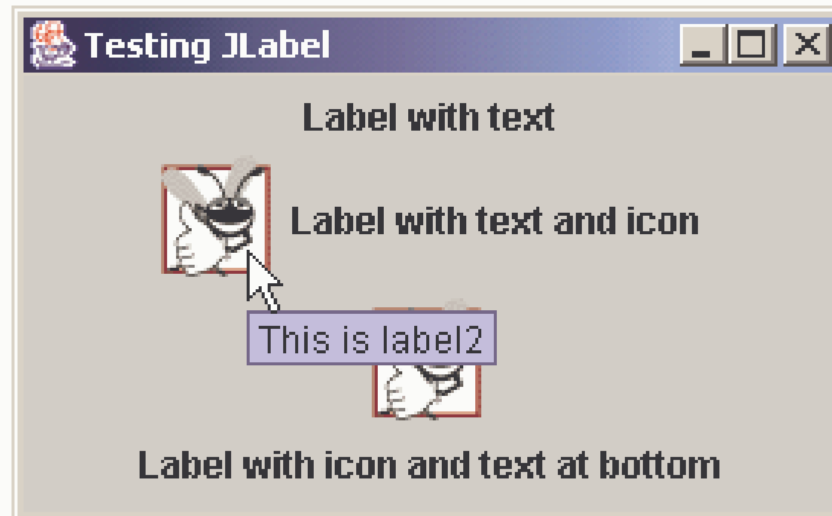
- Label
  - Provide text on GUI
  - Defined with class `JLabel`
  - Can display:
    - Single line of read-only text
    - Image
    - Text and image

```
3    import java.awt.*;
4    import java.awt.event.*;
5    import javax.swing.*;
6
7    public class LabelTest extends JFrame {
8       private JLabel label1, label2, label3;
9
10      // set up GUI
11      public LabelTest()
12      {
13         super( "Testing JLabel" );
14
15         // get content pane and set its layout
17         setLayout( new FlowLayout() );
18
19         // JLabel constructor with a string argument
20         label1 = new JLabel( "Label with text" );
21         label1.setToolTipText( "This is label1" );
22         add( label1 );
23
```

```
24        // JLabel constructor with string, Icon and alignment arguments
25        Icon bug = new ImageIcon(getClass().getResource( "bug1.gif“) );
26        label2 = new JLabel( "Label with text and icon", bug,
27           SwingConstants.LEFT );
28        label2.setToolTipText( "This is label2" );
29        add( label2 );
31        // JLabel constructor no arguments
32        label3 = new JLabel();
33        label3.setText( "Label with icon and text at bottom" );
34        label3.setIcon( bug );
35        label3.setHorizontalTextPosition( SwingConstants.CENTER );
36        label3.setVerticalTextPosition( SwingConstants.BOTTOM );
37        label3.setToolTipText( "This is label3" );
38        add( label3 );
43       } // end constructor

45     public static void main( String args[] )
46     {
47        LabelTest application = new LabelTest();
48       application.setDefaultCloseOperation( JFrame.EXIT_ON_CLOSE );
49       application.setSize(275,170);
50       application.setVisible(true);
49     }
```

```
50
51 } // end class LabelTest
```





TextFields

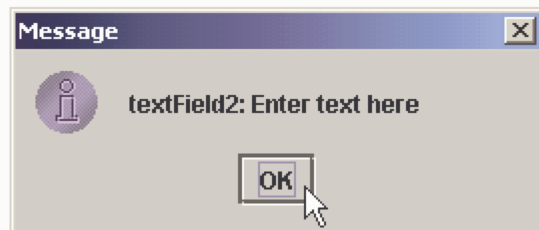
- `JTextField`
  - Single-line area in which user can enter text
- `JPasswordField`
  - Extends `JTextField`
  - Hides characters that user enters

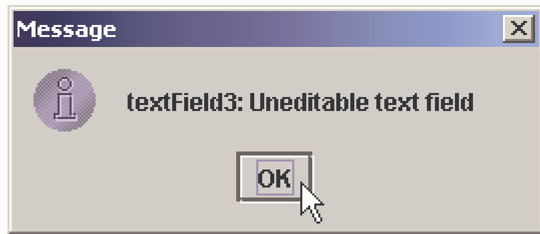
```java
// Demonstrating the JTextField class.
import java.awt.*;
import java.awt.event.*;
import javax.swing.*;

public class TextFieldTest extends JFrame {
   private JTextField textField1, textField2, textField3;
   private JPasswordField passwordField;

   // set up GUI
   public TextFieldTest()
   {
      super( "Testing JTextField and JPasswordField" );
      setLayout( new FlowLayout() );

      // construct textfield with default sizing
      textField1 = new JTextField( 10 );
      add( textField1 );

      // construct textfield with default text
      textField2 = new JTextField( "Enter text here" );
      add( textField2 );
```

```
      // construct textfield with default text,
      // 20 visible elements and no event handler
      textField3 = new JTextField( "Uneditable text field", 20 );
      textField3.setEditable( false );
      add( textField3 );

      // construct passwordfield with default text
      passwordField = new JPasswordField( "Hidden text" );
      add( passwordField );

      // register event handlers
      TextFieldHandler handler = new TextFieldHandler();
      textField1.addActionListener( handler );
      textField2.addActionListener( handler );
      textField3.addActionListener( handler );
      passwordField.addActionListener( handler );

      setSize( 325, 100 );
      setVisible( true );

   } // end constructor TextFieldTest

   public static void main( String args[] )
   {
      TextFieldTest application = new TextFieldTest();
      application.setDefaultCloseOperation( JFrame.EXIT_ON_CLOSE );
   }
```

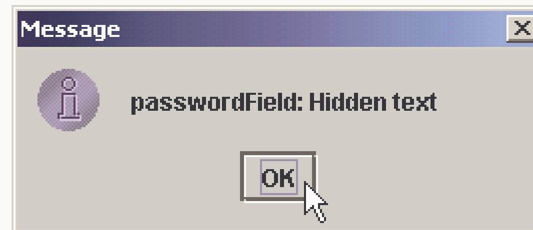
```
  // private inner class for event handling
private class TextFieldHandler implements ActionListener {

  // process textfield events
  public void actionPerformed( ActionEvent event )
  {
    String string = "";

    // user pressed Enter in JTextField textField1
    if ( event.getSource() == textField1 )
      string = "textField1: " + event.getActionCommand();

    // user pressed Enter in JTextField textField2
    else if ( event.getSource() == textField2 )
      string = "textField2: " + event.getActionCommand();

    // user pressed Enter in JTextField textField3
    else if ( event.getSource() == textField3 )
      string = "textField3: " + event.getActionCommand();

    // user pressed Enter in JTextField passwordField
    else if ( event.getSource() == passwordField ) {
      string = "passwordField: " +
        new String( passwordField.getPassword() );
    }
```

```
        JOptionPane.showMessageDialog( null, string );

      } // end method actionPerformed

   } // end private inner class TextFieldHandler

} // end class TextFieldTest
```




Message
textField3: Uneditable text field
OK

Testing JTextField and JPasswordField
hello
Enter text here
Uneditable text field
****


Message
passwordField: Hidden text
OK

How Event Handling Works

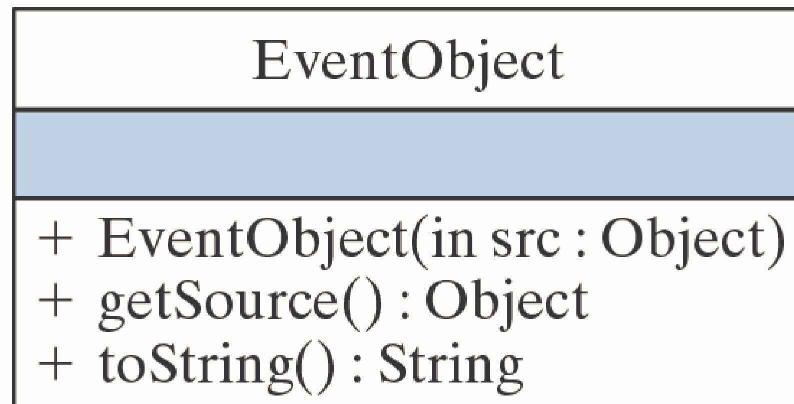
- Two open questions
  - How did event handler get registered?
    - Answer:
      - Through component's method `addActionListener`
      - Lines 39-42 of `TextFieldTest.java`
  - How does component know to call `actionPerformed`?
    - Answer:
      - Event is dispatched only to listeners of appropriate type
      - Each event type has corresponding event-listener interface
        - » Event ID specifies event type that occurred

Event Handling

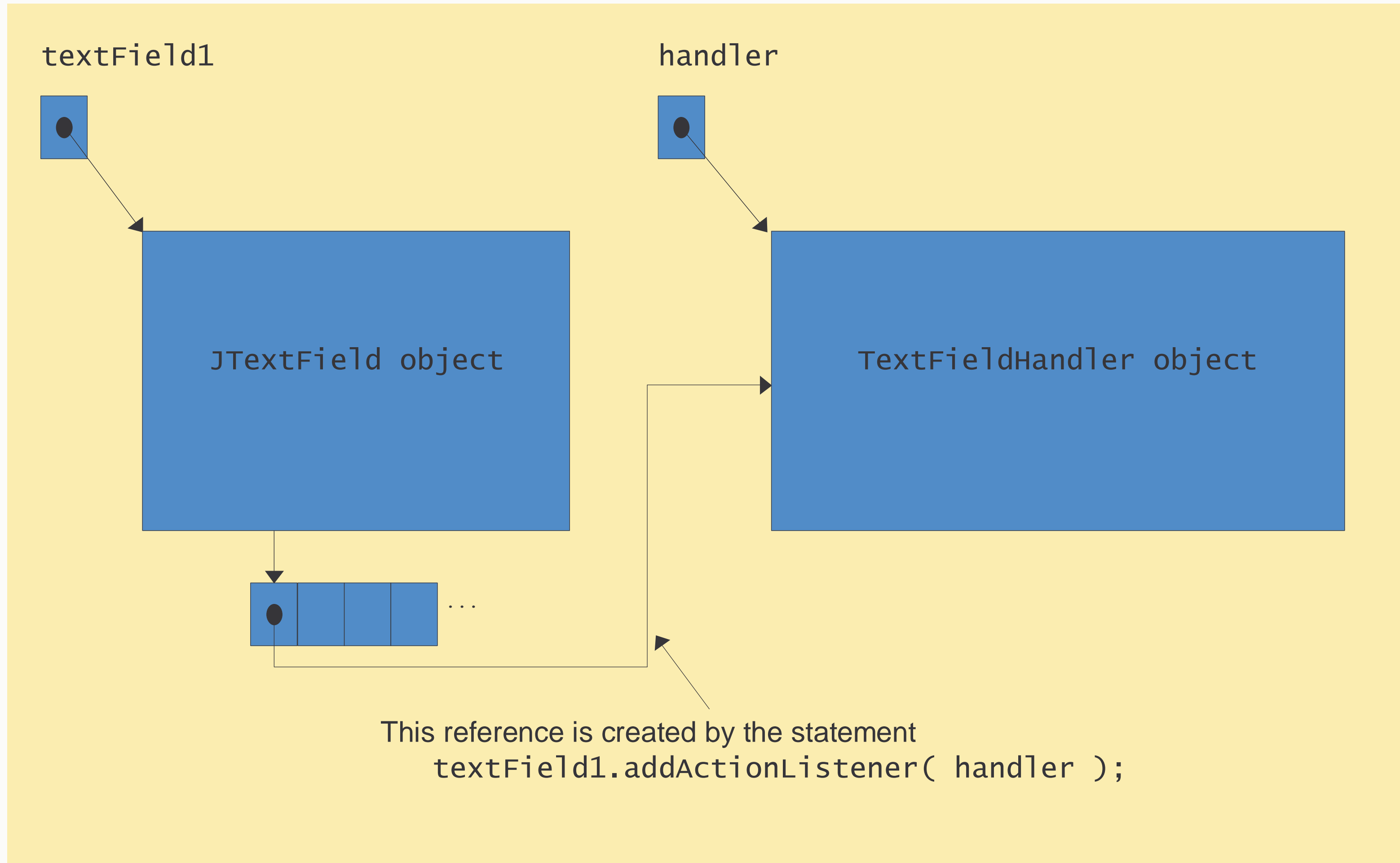
- Event-handling model
  - Three parts
    - Event source
      - GUI component with which user interacts
    - Event object
      - Encapsulates information about event that occurred
    - Event listener
      - Receives event object when notified, then responds
  - Programmer must perform two tasks
    - Register event listener for event source
    - Implement event-handling method (event handler)

The EventObject Class

- The getSource() method is used to get the Object that caused the event.



Event registration for `JTextField textField1`



Creating an ActionListener

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

public class MyApplet extends JApplet implements ActionListener {
    private JButton clickme = new JButton("ClickMe");
    public void init() {
        getContentPane().add(clickme);    // Add clickme to the applet
        clickme.addActionListener(this);  // Register with a listener
    } // init()
    public void actionPerformed(ActionEvent e) {
        if (e.getSource() == clickme) {
            showStatus("clickme was clicked");
            System.out.println( e.toString() );
        }
    } // actionPerformed()
} // MyApplet
```

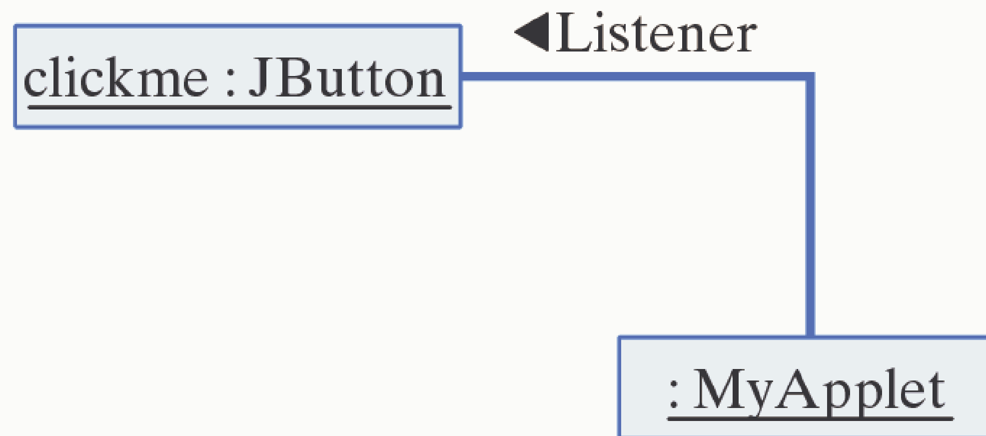
Button click events are handled by ActionListeners

The applet is the listener.

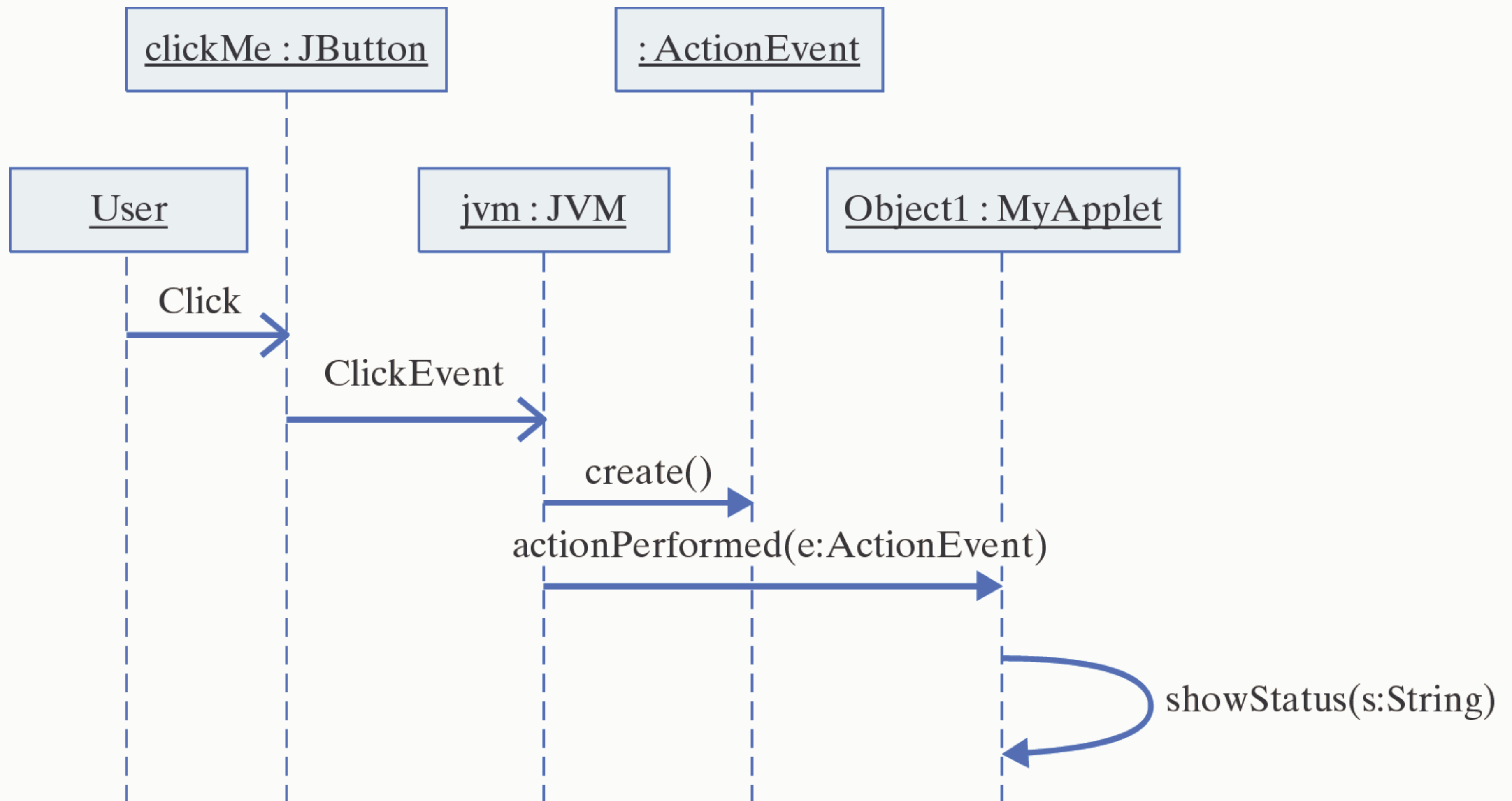
The actionPerformed() method contains code that handles the button click.

The Java Event Model

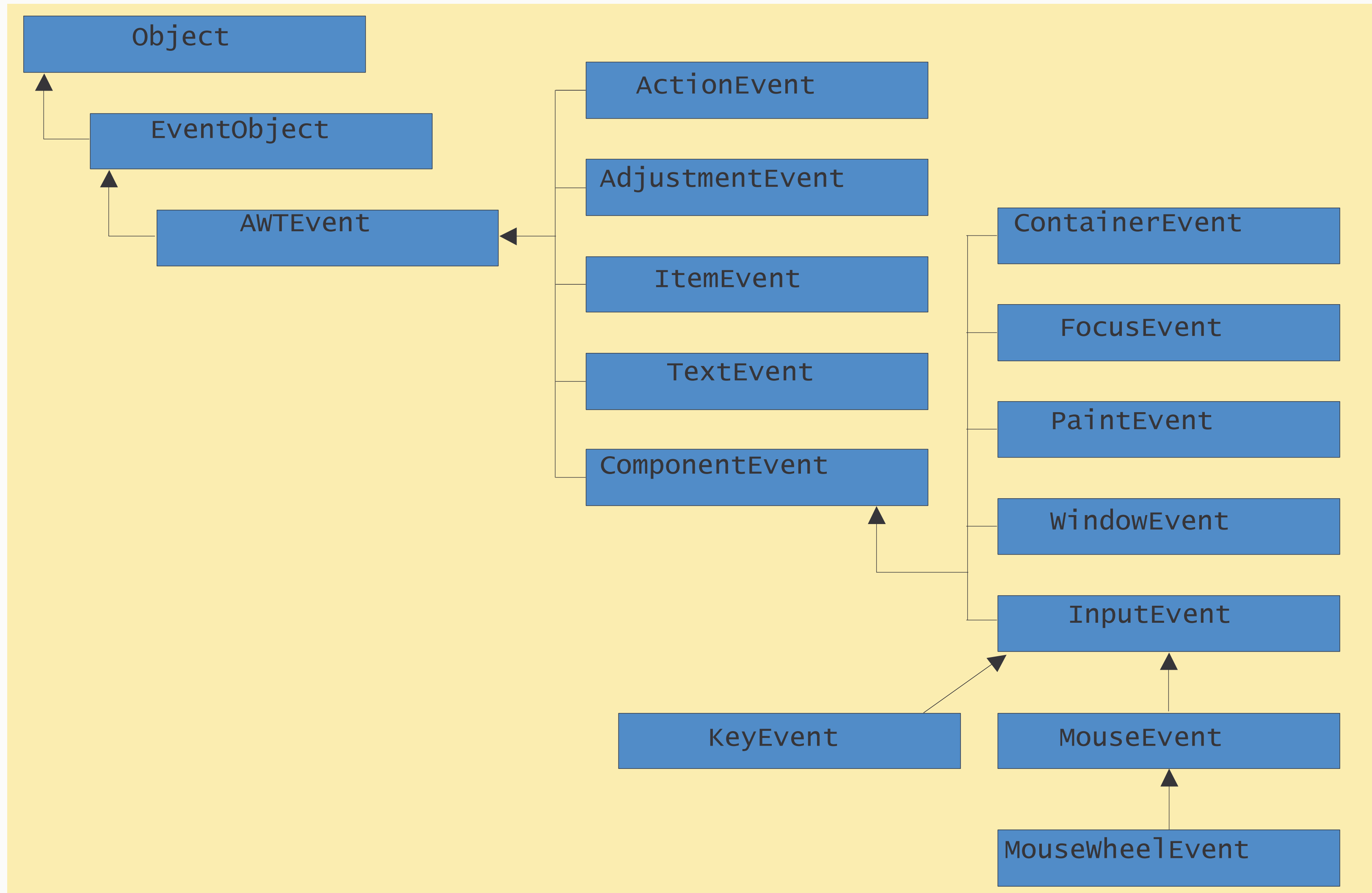
- All events are handled by objects called ***listeners***.



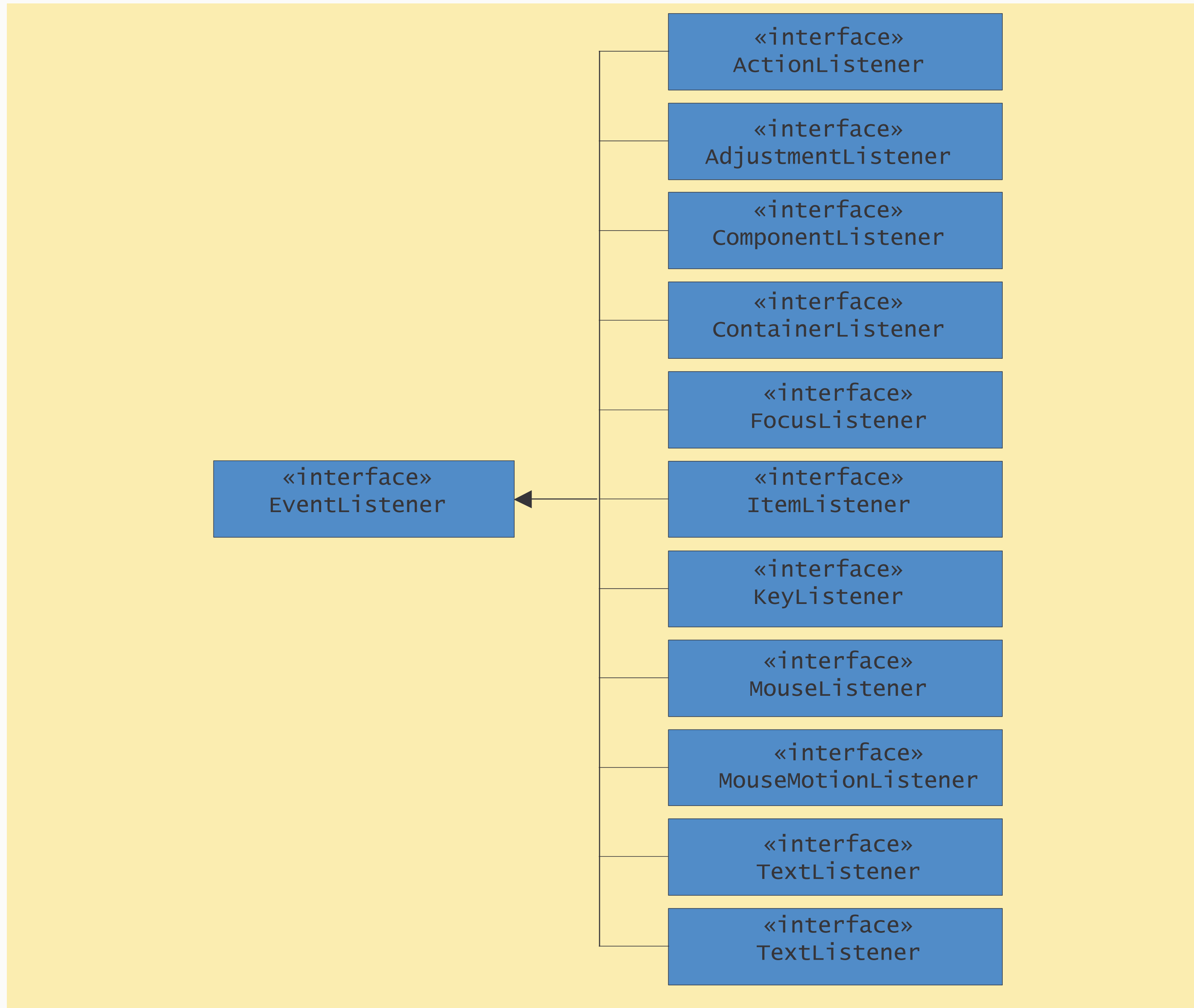
Handling an ActionEvent



Some event classes of package `java.awt.event`



Event-listener interfaces of package java.awt.event



Event Classes

- AWT events for each type of component.

Components	Events	Description
Button, JButton	ActionEvent	User clicked button
CheckBox, JCheckBox	ItemEvent	User toggled a checkbox
CheckboxMenuItem, JCheckboxMenuItem	ItemEvent	User toggled a checkbox
Choice, JPopupMenu	ItemEvent	User selected a choice
Component, JComponent	ComponentEvent	Component was moved or resized
	FocusEvent	Component acquired or lost focus
	KeyEvent	User typed a key
	MouseEvent	User manipulated the mouse
Container, JContainer	ContainerEvent	Component added/removed from container
List, JList	ActionEvent	User double-clicked a list item
	ItemEvent	User clicked a list item
Menu, JMenu	ActionEvent	User selected menu item
Scrollbar, JScrollbar	AdjustmentEvent	User moved scrollbar
TextComponent, JTextComponent	TextEvent	User edited text
TextField, JTextField	ActionEvent	User typed Enter key
Window, JWindow	WindowEvent	User manipulated window

New Swing Event Classes

- Newly defined Swing events.

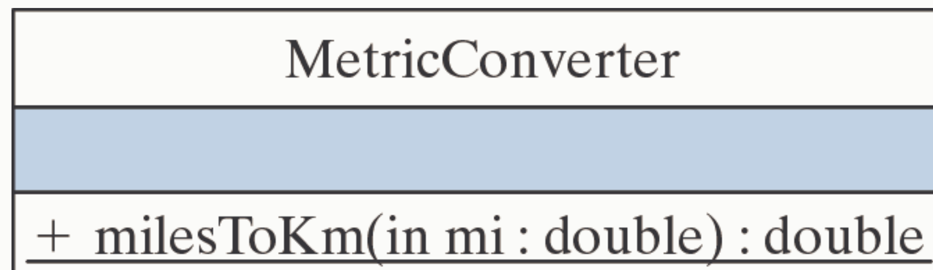
Component	Events	Description
JPopupMenu	PopupMenuEvent	User selected a choice
JComponent	AncestorEvent	An event occurred in an ancestor
JList	ListSelectionEvent	User double-clicked a list item
	ListDataEvent	List's contents were changed
JMenu	MenuEvent	User selected menu item
JTextComponent	CaretEvent	Mouse clicked in text
	UndoableEditEvent	An undoable edit has occurred
JTable	TableModelEvent	Items added/removed from table
	TableColumnModelEvent	A table column was moved
JTree	TreeModelEvent	Items added/removed from tree
	TreeSelectionEvent	User selected a tree node
	TreeExpansionEvent	User changed tree node
JWindow	WindowEvent	User manipulated window

Case Study: Designing a Basic GUI

- Basic User Interface Tasks:
  - Provide help/guidance to the user.
  - Allow input of information.
  - Allow output of information.
  - Control interaction between the user and device.

The MetricConverter Class

- Problem Description: Design a GUI for a Java application that converts miles to kilometers. The class that performs the conversions is defined as:




```
public class MetricConverter {

    public static double milesToKm(double miles) {
        return miles / 0.62;
    }
}
```

GUI Design: Choosing Components

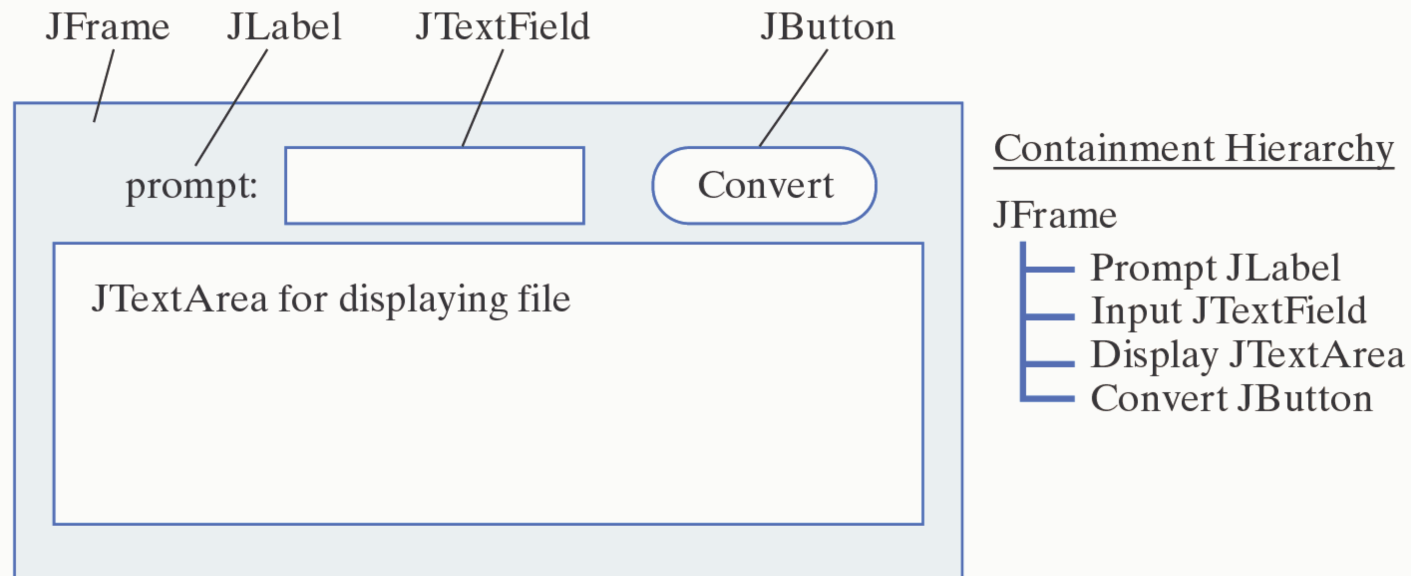
- Swing objects for input, output, control, guidance:
  - **Guidance**: A JLabel displays a short string of text or an image. It can serve as a prompt.
  - **Input**: A JTextField allows editing of a single line of text. It can get the user's input.
  - **Output**: A JTextArea allows editing of multiple lines of text. We'll use it to display results.
  - **Control**: A JButton is an action control. By implementing the ActionListener interface we will handle the user's action events.

GUI Design: The Top-Level Window

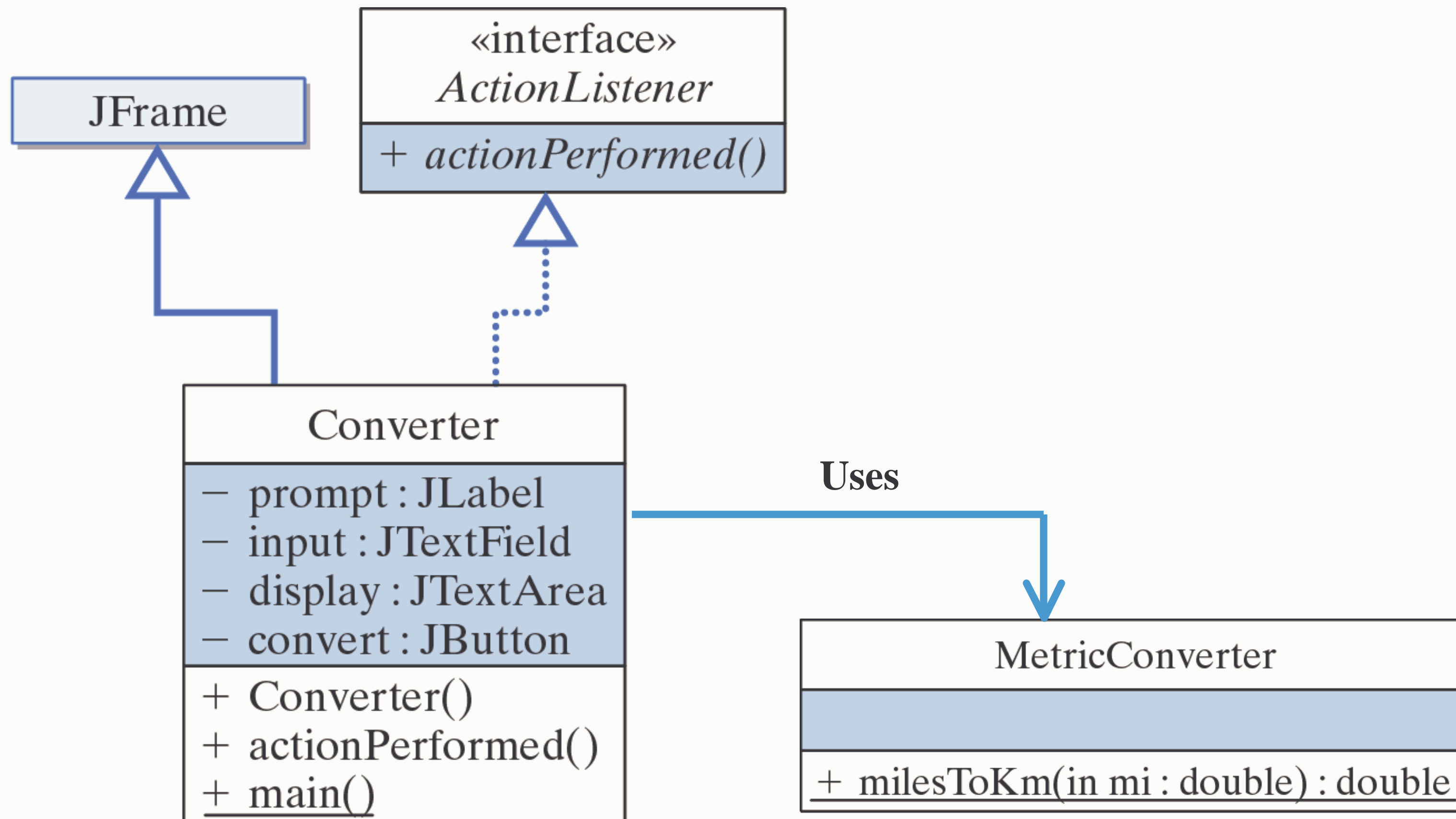
- For applets, top-level window is JApplet.
- For applications, a JFrame is used.
- Both JApplet and JFrame are subclasses of Container and are suitable for holding the interface components.
- Both JApplet and JFrame are *heavyweight* components.

GUI Design: Layout

- In a FlowLayout components are arranged left to right in rows within the container.



Class Design



Implementing the Converter Class

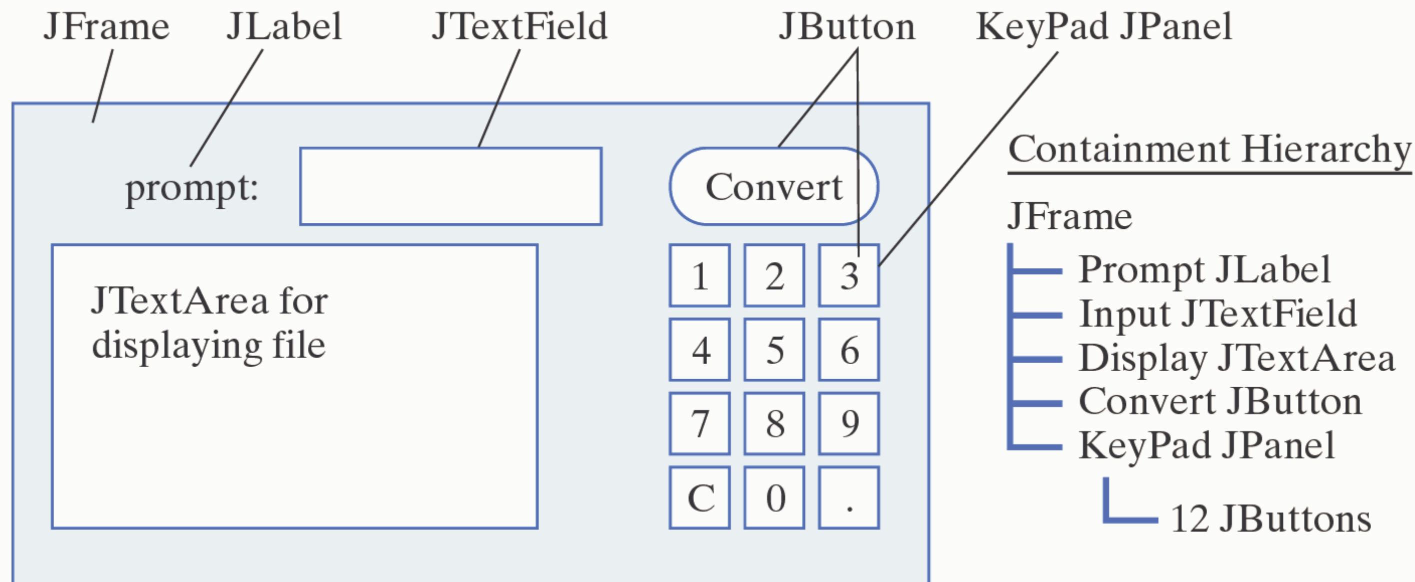
```
import javax.swing.*;                    // Packages used
import java.awt.*;
import java.awt.event.*;
public class Converter extends JFrame implements ActionListener{
    private JLabel prompt = new JLabel("Distance in miles: ");
    private JTextField input = new JTextField(6);
    private JTextArea display = new JTextArea(10,20);
    private JButton convert = new JButton("Convert!");
    public Converter() {
        setLayout(new FlowLayout());
        add(prompt);
        add(input);
        add(convert);
        add(display);
        display.setLineWrap(true);
        display.setEditable(false);
        convert.addActionListener(this);
    } // Converter()
    public void actionPerformed( ActionEvent e ) {
        double miles =
               Double.valueOf(input.getText()).doubleValue();
        double km = MetricConverter.milesToKm(miles);
        display.append(miles + " miles equals " + km +
                " kilometers\n");
    } // actionPerformed()
} // Converter
```

Instantiating the Top-Level JFrame

```
public static void main(String args[]) {
      Converter f = new Converter();
      f.setSize(400, 300);
      f.setVisible(true);
                        // Quit the application
      f.addWindowListener(new WindowAdapter() {
          public void windowClosing(WindowEvent e) {
              System.exit(0);
          }
      });
} // main()
```

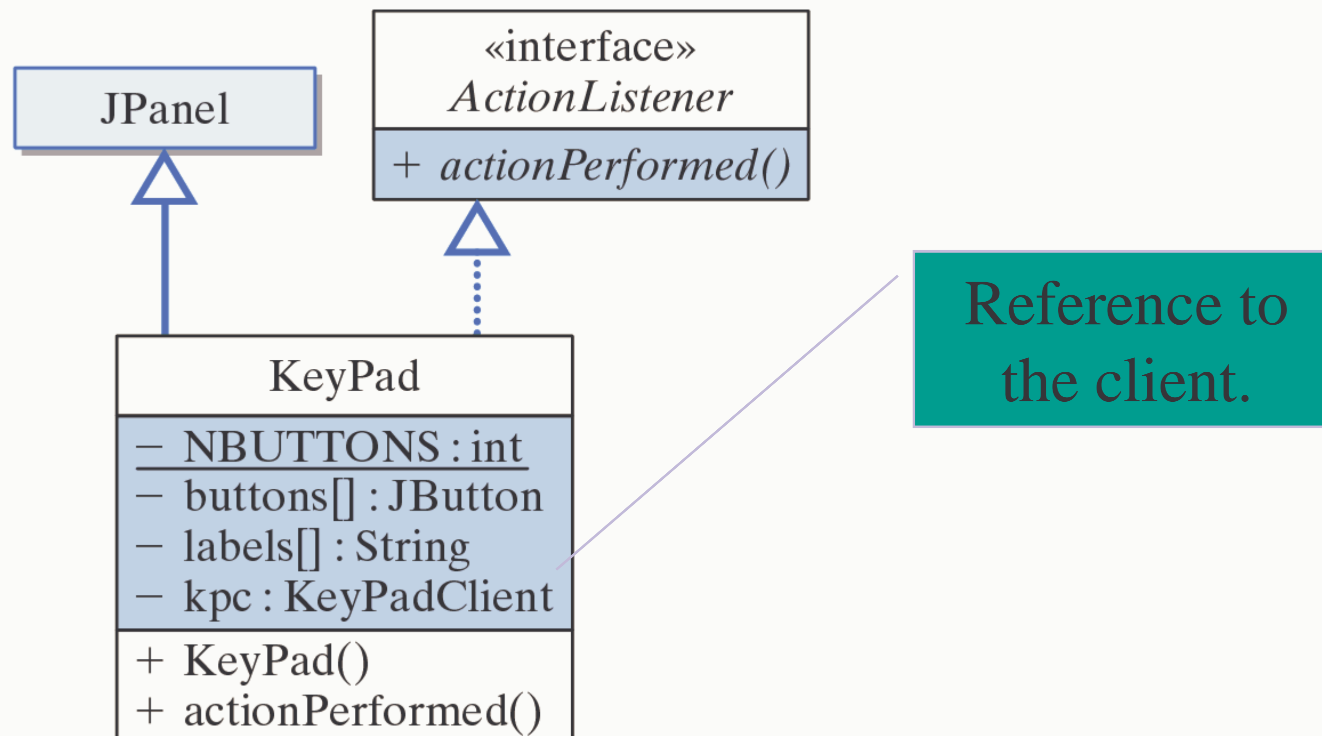
Extending the GUI: Button Array

- Make the JTextField a control so the user doesn't have to use the mouse to perform conversions.
- Implement a 10-key pad so a conversion can be done with just the mouse control.
- **Effective Design:** Redundant controls.

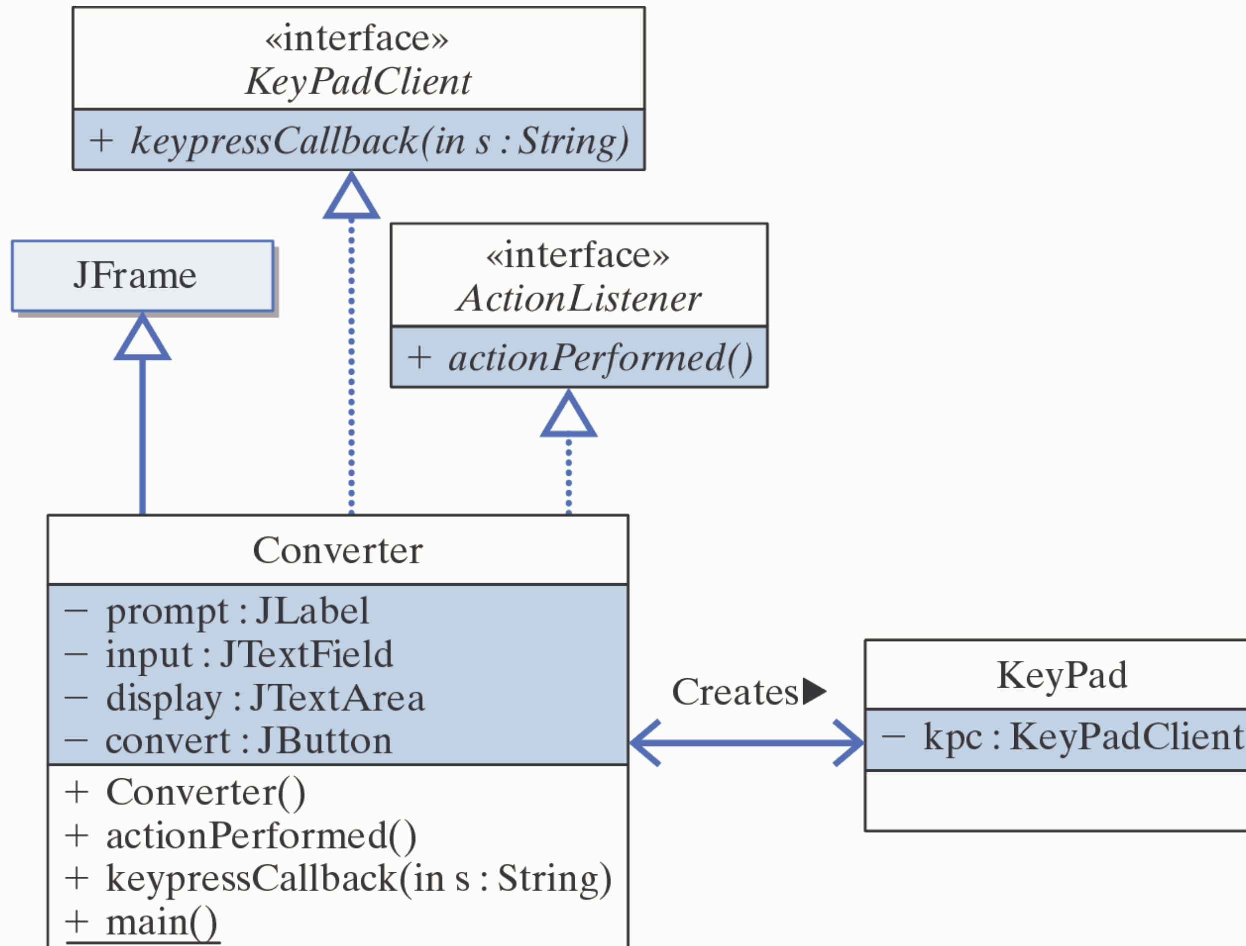


The KeyPad JPanel

- The KeyPad JPanel handles its own actions.



The Callback Method Design



Implementation: The KeyPad

```
public class KeyPad extends Jpanel implements ActionListener {
    private final static int NBUTTONS = 12;
    private KeyPadClient kpc;    // Owner of the KeyPad
    private JButton buttons[];   // An array of buttons
    private String labels[] =    // And their labels
              { "1","2","3",
                "4","5","6",
                "7","8","9",
                "C","0","." };
    public KeyPad(KeyPadClient kpc) {
        this.kpc = kpc;
        buttons = new JButton[NBUTTONS];      // Create the array
        for(int k = 0; k < keyPad.length; k++) { // For each button
           buttons[k] = new JButton(labels[k]);  // Create it w/label
           buttons[k].addActionListener(this);   // and a listener
           add(buttons[k]);                      // and add to panel
        } // for
    }
    public void actionPerformed(ActionEvent e) {
        String keylabel = ((Jbutton)e.getSource()).getText();
        kpc.keypressCallback(keylabel);
    }
}
```

Callback.

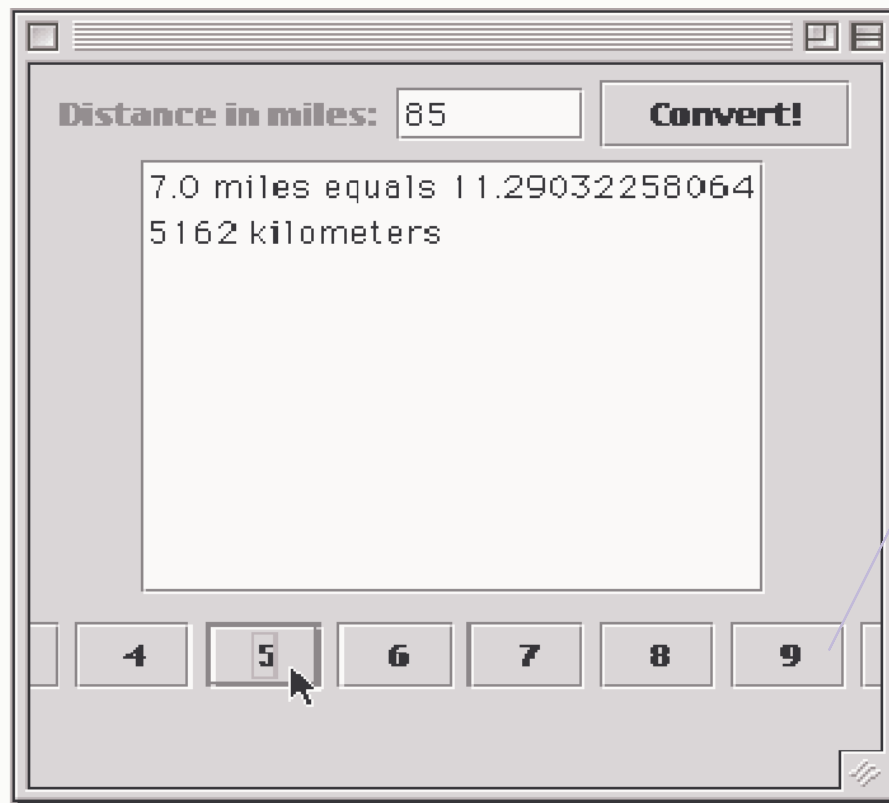
Implemention: The Callback Method

- KeyPad's actionPerformed() calls the client's keypressCallback() method, passing it the key's label.

```
public void keypressCallback(String s) {
     if (s.equals("C"))
         input.setText("");  // Clear the input
     else
         input.setText(input.getText() + s); // Type the key
}
```

GUI Design Critique

- Problem: The default layout for a JPanel is FlowLayout but we need GridLayout.



We got the keypad layout wrong!

Containers

- A *container* is a component that contains other components -- e.g., JPanel, JFrame, JApplet.
- Container methods:

Container
+ add(in c : Component) : Component + remove(in index : int) + remove(in c : Component) + removeAll()

Layout Managers

- A *layout manager* is an object that manages the layout and organization of a container, including:
  - Size of container.
  - Size of each element in the container.
  - Position and spacing between elements.

Types of Layout Managers

Manager	Description
java.awt.BorderLayout	Arranges elements along the north, south, east, west, and in the center of the container.
java.swing.BoxLayout	Arranges elements in a single row or single column.
java.awt.CardLayout	Arranges elements like a stack of cards, with one visible at a time.
java.awt.FlowLayout	Arranges elements left to right across the container.
java.awt.GridBagLayout	Arranges elements in a grid of variable sized cells (complicated).
java.awt.GridLayout	Arranges elements into a two-dimensional grid of equally sized cells.
java.swing.OverlayLayout	Arranges elements on top of each other.

Default Layout Managers

Container	Layout Manager
JApplet	BorderLayout (on its content pane)
JBox	BoxLayout
JDialog	BorderLayout (on its content pane)
JFrame	BorderLayout (on its content pane)
JPanel	FlowLayout
JWindow	BorderLayout (on its content pane)

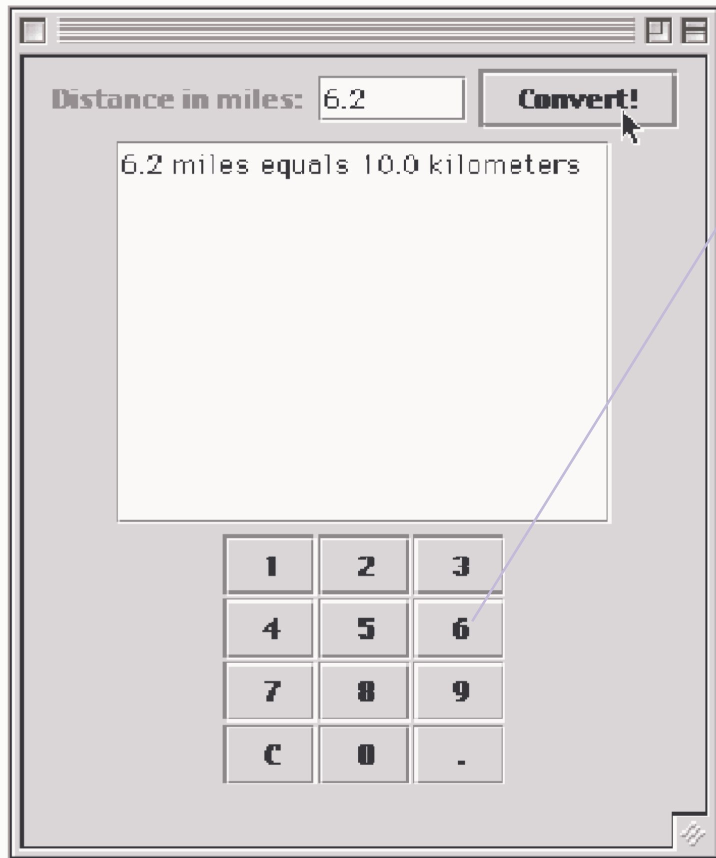
The GridLayout Manager

- A GridLayout arranges components in a two-dimensional grid.

```
keypadPanel.setLayout(
   new GridLayout(4,3,1,1));
```

4 rows and 3 columns

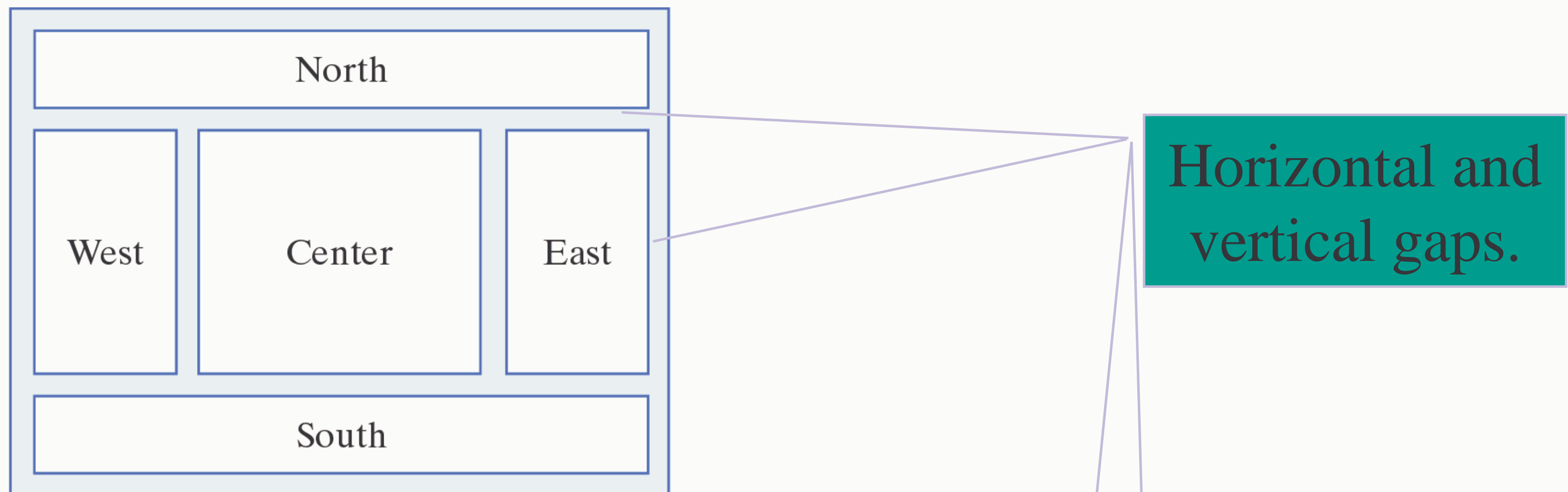
1 space between each row and column



- **Design Critique:** We should use BorderLayout for top-level window.

The BorderLayout Manager

- A BorderLayout divides the container into five areas: north, south, east, west, and center.

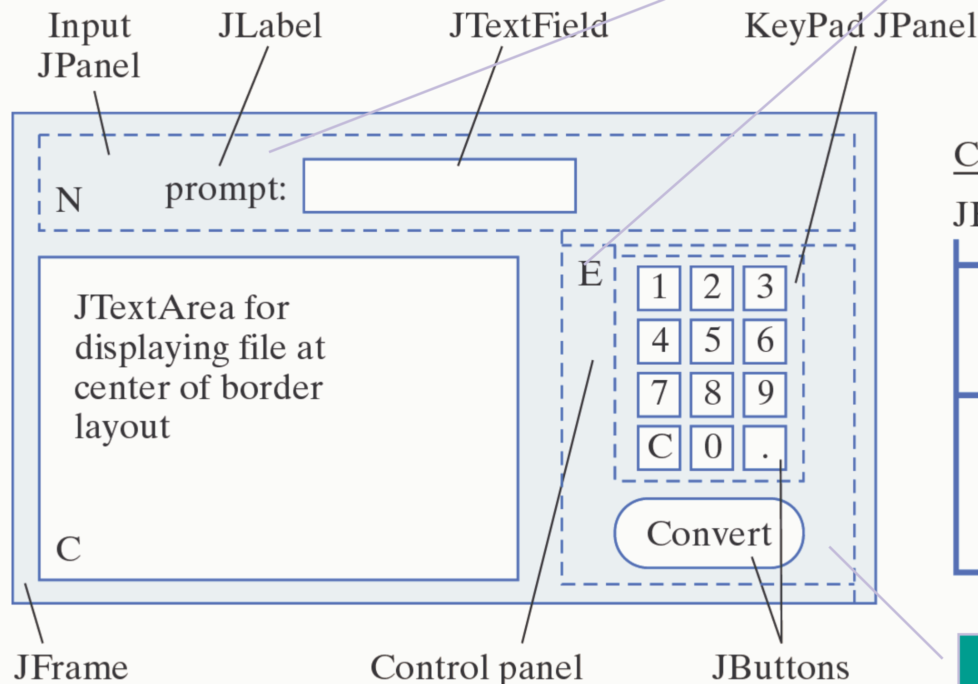


- Use add(Component, String) method to add components to a border layout :

```
getContentPane().setLayout(new BorderLayout(2, 2));
getContentPane().add(keypadPanel, "East");
```

Converter: BorderLayout Design

Panels are used to group components by function.



Containment Hierarchy

JFrame(Border)
- Input JPanel(Flow)
  - Prompt JLabel
  - Input JTextField
- Control JPanel(Border)
  - KeyPad JPanel(Grid)
    - 12 Button
  - Convert JButton
- Display JTextArea

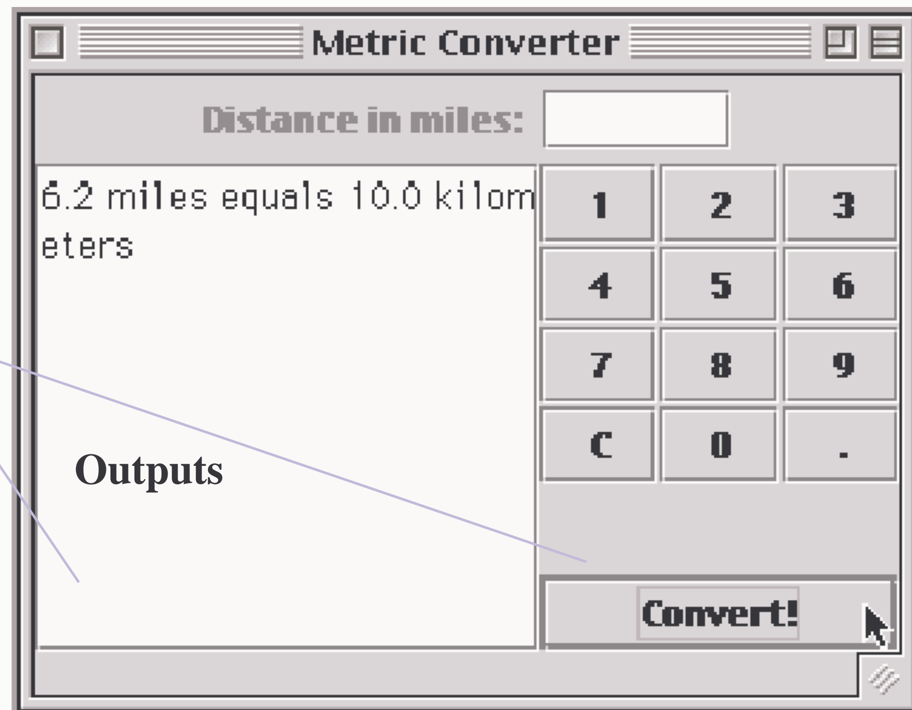
All the controls are grouped together.

Converter: BorderLayout Implementation

```
public Converter() {
    setLayout(new BorderLayout());
    initKeyPad();
    JPanel inputPanel = new JPanel();         // Input panel
    inputPanel.add(prompt);
    inputPanel.add(input);
    add(inputPanel,"North");
    JPanel controlPanel = new JPanel(new BorderLayout(0, 0));// Controls
    controlPanel.add(keypadPanel, "Center");
    controlPanel.add(convert, "South");
    add(controlPanel, "East");
    add(display,"Center");  // Output display
    display.setLineWrap(true);
    display.setEditable(false);
    convert.addActionListener(this);
    input.addActionListener(this);
} // Converter()
```

Converter: Final Version

- In BorderLayout, when one or more areas is not used, then one or more of the other areas fills its space, except for the center, which would be left blank if unused.



The unused south area is filled by center and east.

Checkboxes

- A JCheckBox is a button which always displays its current state (selected or not).
- Used to select one or more options from a set.

```
private JCheckBox titles[] = new JCheckBox[NTITLES];
private String titleLabels[] =
    {"Chess Master - $59.95", "Checkers Pro - $39.95",
         "Crossword Maker - $19.95"};

for(int k = 0; k < titles.length; k++) {
      titles[k] = new JCheckBox(titleLabels[k]);
      titles[k].addItemListener(this);
      choicePanel.add(titles[k]);
}
```

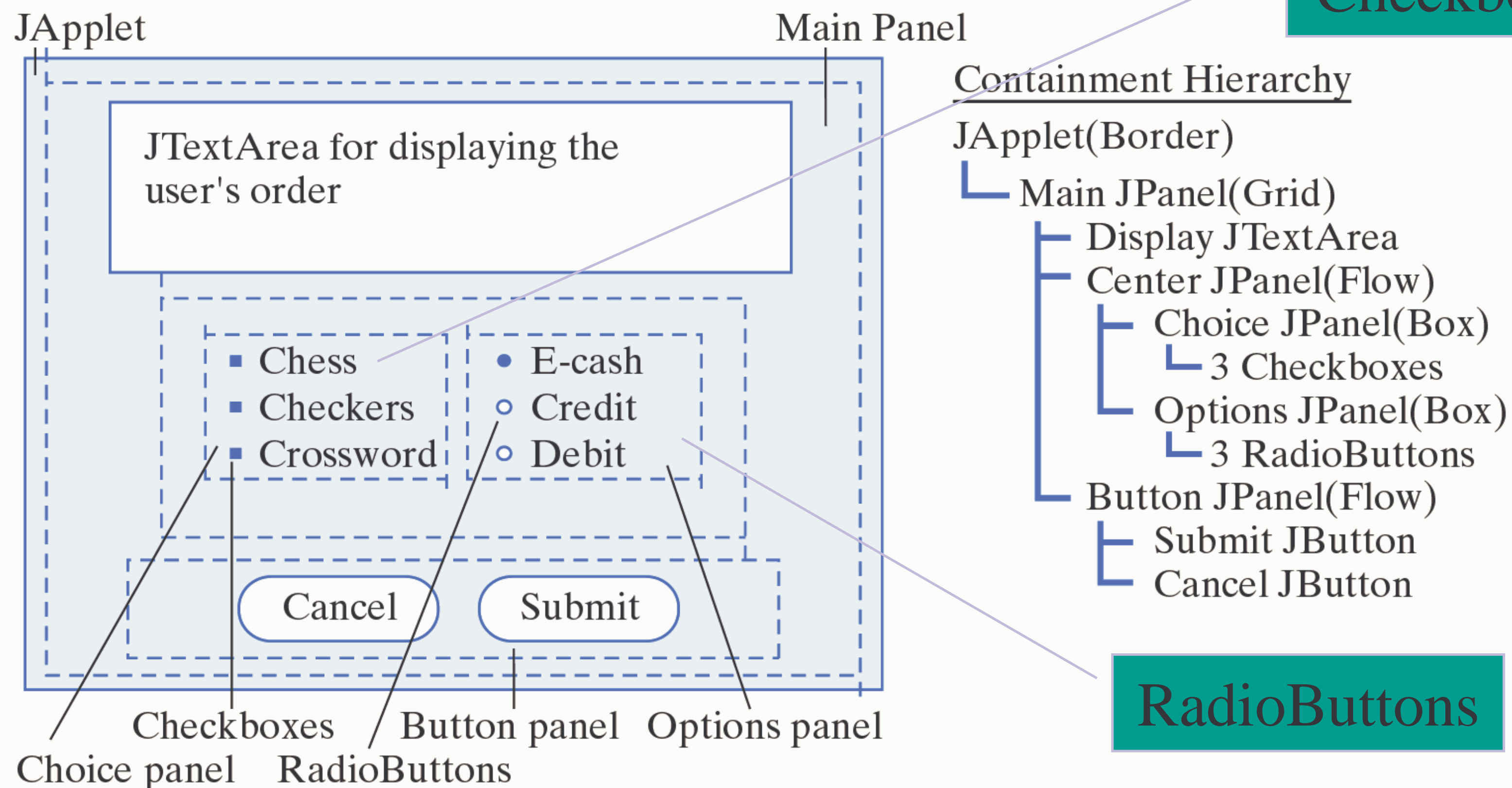
Radio Buttons

- A JRadioButton is a button that belongs to a ButtonGroup of mutually exclusive alternatives. Only one button from the group may be selected at a time.

```
private ButtonGroup optGroup = new ButtonGroup();
private JRadioButton options[] = new JRadioButton[NOPTIONS];
private String optionLabels[] = {"Credit Card", "Debit Card",
                                                "E-cash"};
for(int k = 0; k < options.length; k++) {
      options[k] = new JRadioButton(optionLabels[k]);
      options[k].addItemListener(this);
      optionPanel.add(options[k]);
      optGroup.add(options[k] );
}
options[0].setSelected(true);   // Set the first button on
```

Design: The Online Order Form

- Problem: Design an applet-based order form that can be used for ordering software over the Web.



The Order Form Applet

A Swing Titled Border

Applet Viewer: OrderApplet.class

Acme Software Titles

Your order so far (Payment by: E-cash)
Chess Master – $59.95
Thank you. Press 'Confirm' to submit your order!

Titles

- [x] Chess Master – $59.95
- [ ] Checkers Pro – $39.95
- [ ] Crossword Maker – $19.95

Payment By

- Credit Card
- Debit Card
- E-cash (selected)

Order Today

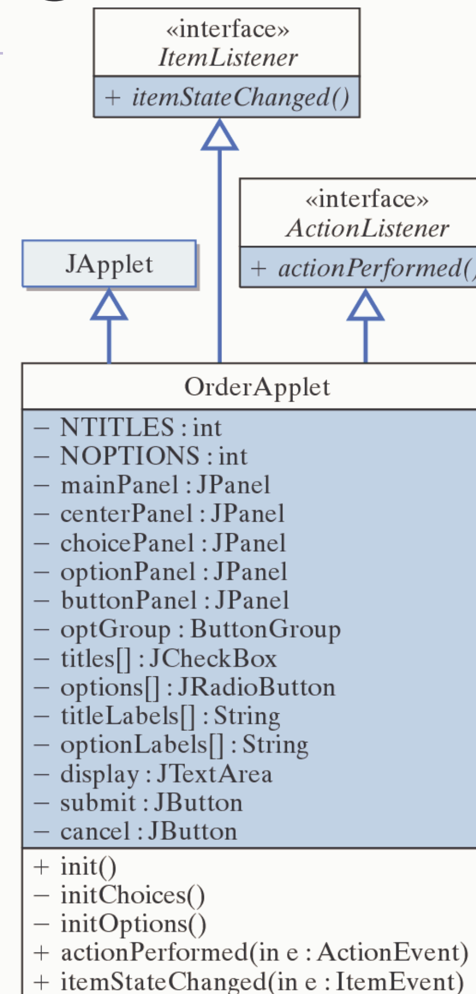
Cancel | Confirm Order

Applet started.

```
choicePanel.setBorder(
    BorderFactory.createTitledBorder("Titles"));
```

Class Design

- The OrderApplet makes extensive use of GUI components.



The ItemListener Interface

- ItemEvents are associated with items that make up menus, including JCheckBoxes and RadioButtons.
- They are handled by the ItemListener interface, which consists of the itemStateChanged() method.
- In the OrderApplet, each time the user selects a title or an option, the following method is executed.

```
public void itemStateChanged(ItemEvent e) {
    display.setText("Your order so far (Payment by: ");
    for (int k = 0; k < options.length; k++ )
        if (options[k].isSelected())
            display.append(options[k].getText() + ")\n");
    for (int k = 0; k < titles.length; k++ )
        if (titles[k].isSelected())
            display.append("\t" + titles[k].getText() + "\n");
} // itemStateChanged()
```

The OrderApplet Class: Initialization

```
public class OrderApplet extends JApplet implements ItemListener, ActionListener {
    private final int NTITLES = 3, NOPTIONS = 3;
    private JPanel mainPanel = new JPanel(),
                   centerPanel = new JPanel(),
                   choicePanel = new JPanel(),
                   optionPanel = new JPanel(),
                   buttonPanel = new JPanel();
    public void init() {
        mainPanel.setBorder(
            BorderFactory.createTitledBorder("Acme Software Titles"));
        mainPanel.setLayout(new GridLayout(3, 1, 1, 1));
        cancel.addActionListener(this);
        submit.addActionListener(this);
        initChoices();
        initOptions();
        buttonPanel.setBorder(
             BorderFactory.createTitledBorder("Order Today"));
        buttonPanel.add(cancel);
        buttonPanel.add(submit);
        centerPanel.add(choicePanel);
        centerPanel.add(optionPanel);
        mainPanel.add( display);
        mainPanel.add(centerPanel);
        mainPanel.add( buttonPanel);
        getContentPane().add(mainPanel);
        setSize(400,400);
    } // init()

} // OrderApplet
```

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

Panel hierarchy.

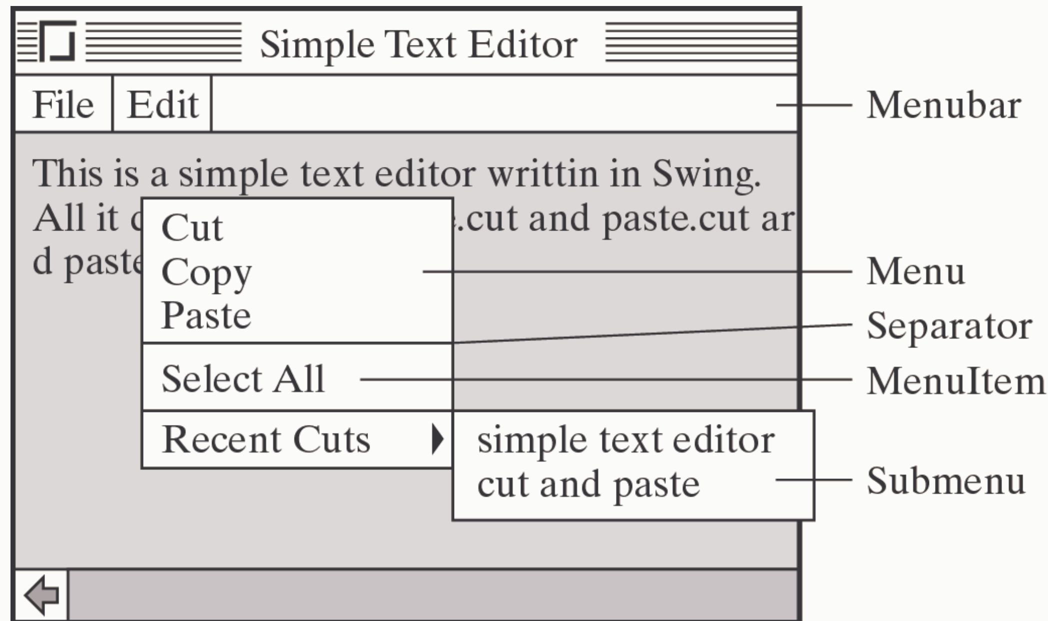
The init() method sets the layouts and adds components to panels.

OrderApplet Class: Handling Actions

The “Submit” button serves a dual purpose.

```
public void actionPerformed(ActionEvent e) {
    String label = submit.getText();
    if (e.getSource() == submit) {
        if (label.equals("Submit Order")) {
            display.append(
             "Thank you. Press 'Confirm' to submit for your order!\n");
            submit.setText("Confirm Order");
        } else {
            display.append(
             "Thank you. You will receive your order tomorrow!\n");
            submit.setText("Submit Order");
        }
    } else
        display.setText(
           "Thank you. Maybe we can serve you next time!\n");
} // actionPerformed()
```

Menus



- Menus allow a program to grow without cluttering the interface.

- A JMenuBar is a horizontal list of menus.
- A JMenu is a clickable area on the menu bar that is associated with a JPopupMenu, a small window that diplays JMenuItems.
- JSeparators are used to group menu items.

Menu Example

- Menus are hierarchical.

```
private void initFileMenu() {
     fileMenu = new JMenu("File");        // Create the file menu
     mBar.add(fileMenu);                  //  and add it to the menu
     openItem = new JMenuItem("Open");    // Open item
     openItem.addActionListener( this );
     openItem.setEnabled(false);
     fileMenu.add(openItem);
     saveItem = new JMenuItem("Save");    // Save
     saveItem.addActionListener(this);
     saveItem.setEnabled(false);
     fileMenu.add(saveItem);
     fileMenu.addSeparator();         // Separator
     quitItem = new JMenuItem("Quit");    // Quit i
     quitItem.addActionListener(this);
     fileMenu.add(quitItem);
} // initFileMenu()
```

Menus are added to the menu bar.

Menu items are added to the menu.

Action listeners are associated with menu items.

Handling Menu Actions

- Menu item selections generate ActionEvents.
- **Algorithm**: *Multiway selection*. Test for each menu item and take appropriate action.

```
public void actionPerformed(ActionEvent e) {
    JMenuItem m  = (JMenuItem)e.getSource();
    if ( m == quitItem ) {                          // Quit
         dispose();
    } else if (m == copyItem)                       // Copy
         scratchPad = display.getSelectedText();
    } else if (m == pasteItem) {                    // Paste
         display.insert(scratchPad, display.getCaretPosition());
    } else if ( m == selectItem ) {
         display.selectAll();          // Select entire document
    }
} // actionPerformed()
```

Need to cast source object.

A scratchpad (String) is used to store text.