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The Origins of Swing

Swing did not exist in the early days of Java. Rather, it was a response to deficiencies present in Java's original GUI subsystem: the Abstract Window Toolkit. The AWT defines a basic set of controls, windows, and dialog boxes that support a usable, but limited graphical interface. One reason for the limited nature of the AWT is that it translates its various visual components into their corresponding, platform-specific equivalents, or *peers*. This means that the look and feel of a component is defined by the platform, not by Java. Because the AWT components use native code resources, they are referred to as *heavyweight*.

The use of native peers led to several problems. First, because of variations between operating systems, a component might look, or even act, differently on different platforms. This potential variability threatened the overarching philosophy of Java: write once, run anywhere. Second, the look and feel of each component was fixed (because it is defined by the platform) and could not be (easily) changed. Third, the use of heavyweight components caused some frustrating restrictions. For example, a heavyweight component was always opaque.

Not long after Java's original release, it became apparent that the limitations and restrictions present in the AWT were sufficiently serious that a better approach was needed. The solution was Swing. Introduced in 1997, Swing was included as part of the Java Foundation Classes (JFC). Swing was initially available for use with Java 1.1 as a separate library. However, beginning with Java 1.2, Swing (and the rest of the JFC) was fully integrated into Java.

Swing Is Built on the AWT

Although Swingeliminates a number of the limitations inherent in the AWT, Swing *does not* replace it. Instead, Swing is built on the foundation of the AWT. This is why the AWT is still a crucial part of Java. Swing also uses the same event handling mechanism as the AWT. Therefore, a basic understanding of the AWT and of event handling is required to use Swing.

Two Key Swing Features

Swing was created to address the limitations present in theAWT. It does this through two key features: lightweight components and a pluggable look and feel. Together they provide an elegant, yet easy-to-use solution to the problems of the AWT. More than anything else, it is these two features that define the essence of Swing. Each is examined here.

Swing Components Are Lightweight

With very few exceptions, Swing components are *lightweight*. This means that they are written entirely in Java and do not map directly to platform-specific peers. Thus, lightweight components are more efficient and more flexible.

Furthermore, because lightweight components do not translate into native peers, the look and feel of each component is determined by Swing, not by the underlying operating system. As a result, each component will work in a consistent manner across all platforms.

Swing Supports a Pluggable Look and Feel

Swing supports a *pluggable look and feel* (PLAF). Because each Swing component is rendered by Java code rather than by native peers, the look and feel of a component is under the control of Swing. This fact means that it is possible to separate the look and feel of a component from the logic of the component, and this is what Swing does. Separating out the look and feel provides a significant advantage: it becomes possible to change the way that a component is rendered without affecting any of its other aspects. In other words, it is possible to "plug in" a new look and feel for any given component without creating any side effects in the code that uses that component.
Moreover, it becomes possible to define entire sets of look-and-feels thatrepresent different GUI styles. To use a specific style, its look and feel is simply "plugged in." Once this is done, all components are automaticallyrendered using that style.

Pluggable look-and-feels offer several important advantages. It is possible to define a look and feel that is consistent across all platforms. Conversely, it is possible to create a look and feel that acts like a specific platform. It is also possible to design a custom look and feel. Finally, the look and feel can be changed dynamically at run time.

Java provides look-and-feels, such as metal and Nimbus, that are available to all Swing users. The metal look and feel is also called the *Java look and feel*. It is platform-independent and available in all Java execution environments. It is also the default look and feel.

The MVC Connection

In general, a visual component is a composite of three distinct aspects:

- The way that the component looks when rendered on the screen
- The way that the component reacts to the user
- The state information associated with the component

No matter what architecture is used to implement a component, it must implicitly contain these three parts. Over the years, one component architecture has proven itself to be exceptionally effective: *Model-View-Controller*, or MVC for short.

The MVC architecture is successful because each piece of the design corresponds to an aspect of a component. In MVC terminology, the *model* corresponds to the state information associated with the component. For example, in the case of a check box, the model contains a field that indicates if the box is checked or unchecked. The *view* determines how the component is displayed on the screen, including any aspects of the view that are affected by the current state of the model. The *controller* determines how the component reacts to the user. For example, when the user clicks a check box, the controller reacts by changing the model to reflect the user's choice (checked or unchecked). This then results in the view being updated. By separating a component into a model, a view, and a controller, the specific implementation of each can be changed without affecting the other two. For instance, different view implementations can render the same component in different ways without affecting the model or the controller.

Although the MVC architecture and the principles behind it are conceptually sound, the high level of separation between the view and the controller is not beneficial for Swing components. Instead, Swing uses a modified version of MVC that combines the view and the controller into a single logical entity called the *UI delegate*. For this reason, Swing's approach is called either the *Model-Delegate* architecture or the *Separable Model* architecture. Therefore, although Swing's component architecture is based on MVC, it does not use a classical implementation of it.

Swing's pluggable look and feel is made possible by its Model-Delegate architecture. Because the view (look) and controller (feel) are separate from the model, the look and feel can be changed without affecting how the component is used within a program. Conversely, it is possible to customize the model without affecting the way that the component appears on the screen or respondsto user input.

To support the Model-Delegate architecture, most Swing components contain two objects. The first represents the model. The second represents the UI delegate. Models are defined by interfaces. For example, the model for a button is defined by the **ButtonModel** interface. UI delegates are classes that inherit **ComponentUI**. For example, the UI delegate for a button is **ButtonUI**. Normally, your programs will not interact directly with the UI delegate.

Components and Containers

A Swing GUI consists of two key items: *components* and *containers*. However, this distinction is mostly conceptual because all containers are also components. The difference between the two is found in their intended purpose:As the term is commonly used, a *component* is an independent visual control, such as a push button or slider. A container holds a group of components. Thus, a container is a special type of component that is designed to hold other components. Furthermore, in order for a component to be displayed, it must be held within a container. Thus, all Swing GUIs will have at least one container. Because containers are components, a container can also hold other containers.This enables Swing to define what is called a *containment hierarchy*, at the topof which must be a *top-level container*.

Let's look a bit more closely at components and containers.

Components

In general, Swing components are derived from the **JComponent** class. (The only exceptions to this are the four top-level containers, described in the next section.) **JComponent** provides the functionality that is common to all components. For example, **JComponent** supports the pluggable look and feel. **JComponent** inherits the AWT classes **Container** and **Component**. Thus, a Swing component is built on and compatible with an AWT component.

All of Swing's components are represented by classes defined within the package **javax.swing**. The following table shows the class names for Swing components (including those used as containers).

JApplet (Deprecated)	JButton	JCheckBox	JCheckBoxMenuItem
JColorChooser	JComboBox	JComponent	JDesktopPane
JDialog	JEditorPane	JFileChooser	JFormattedTextField
JFrame	JInternalFrame	JLabel	JLayer
JLayeredPane	JList	JMenu	JMenuBar
JMenuItem	JOptionPane	JPanel	JPasswordField
JPopupMenu	JProgressBar	JRadioButton	JRadioButtonMenuItem
JRootPane	JScrollBar	JScrollPane	JSeparator
JSlider	JSpinner	JSplitPane	JTabbedPane
JTable	JTextArea	JTextField	JTextPane
JTogglebutton	JToolBar	JToolTip	JTree
JViewport	JWindow		

Notice that all component classes begin with the letter **J.** For example, the class for a label is **JLabel**; the class for a push button is **JButton**; and the classfor a scroll bar is **JScrollBar**.

Containers

Swing defines two types of containers. The first are top-level containers: **JFrame**, **JApplet**, **JWindow**, and **JDialog**. These containers do not inherit **JComponent**. They do, however, inherit the AWT classes **Component** and **Container**. Unlike

Swing's other components, which are lightweight, the top-level containers are heavyweight. This makes the top-level containers a specialcase in the Swing component library.

As the name implies, a top-level container must be at the top of a containment hierarchy. A top-level container is not contained within any other container. Furthermore, every containment hierarchy must begin with a top-level container. The one most commonly used for applications is **JFrame**. In the past, the one used for applets was **JApplet**.

The second type of containers supported by Swing are lightweight containers. Lightweight containers *do* inherit **JComponent**. An example of a lightweight container is **JPanel**, which is a general-purpose container. Lightweight containers are often used to organize and manage groups of related components because a lightweight container can be contained within another container. Thus, you can use lightweight containers such as **JPanel** to create subgroups of related controls that are contained within an outer container.

The Top-Level Container Panes

Each top-level container defines a set of *panes*. At the top of the hierarchy is an instance of **JRootPane**. **JRootPane** is a lightweight container whose purpose is to manage the other panes. It also helps manage the optional menu bar. The panes that comprise the root pane are called the *glass pane,* the *content pane,* and the *layered pane.*

The glass pane is the top-level pane. It sits above and completely covers all other panes. By default, it is a transparent instance of **JPanel**. The glass pane enables you to manage mouse events that affect the entire container (rather than an individual control) or to paint over any other component, for example. In most cases, you won't need to use the glass pane directly, but it is there if you need it.

The layered pane is an instance of **JLayeredPane**. The layered pane allows components to be given a depth value. This value determines which component overlays another. (Thus, the layered pane lets you specify a Z-order for a component, although this is not something that you will usually need to do.) The layered pane holds the content pane and the (optional) menu bar.

Although the glass pane and the layered panes are integral to the operation of a top-level container and serve important purposes, much of what they provide occurs behind the scene. The pane with which your application will interact the most is the content pane, because this is the pane to which you willadd visual components. In other words, when you add a component, such as a button, to a top-level container, you will add it to the content pane. By default,the content pane is an opaque instance of **JPanel**.

The Swing Packages

Swing is a very large subsystem and makes use of many packages. At the time of this writing, these are the packages defined by Swing.

javax.swing	javax.swing.plaf.basic	javax.swing.text
javax.swing.border	javax.swing.plaf.metal	javax.swing.text.html
javax.swing.colorchooser	javax.swing.plaf.multi	javax.swing.text.html.parser
javax.swing.event	javax.swing.plaf.nimbus	javax.swing.text.rtf
javax.swing.filechooser	javax.swing.plaf.synth	javax.swing.tree
javax.swing.plaf	javax.swing.table	javax.swing.undo

Beginning the JDK 9, the Swing packages are part of the **java.desktop** module.

The main package is **javax.swing**. This package must be imported into any program that uses Swing. It contains the classes that implement the basic Swing components, such as push buttons, labels, and check boxes.

A Simple Swing Application

Swing programs differ from both the console-based programs and the AWT-based programs shown earlier in this book. For example, they use a different set of components and a different container hierarchy than does the AWT. Swing programs also have special requirements that relate to threading. The best way to understand the structure of a Swing program is to work through anexample. Before we begin, it is necessary to point out that in the past there were two types of Java programs in which Swing was typically used. The first is a desktop application. This type of Swing application is widely used, and isthe type of Swing program described here. The second is the applet.

Although quite short, the following program shows one way to write a Swing application. In the process, it demonstrates several key features of Swing. It uses two Swing components: **JFrame** and **JLabel**. **JFrame** is the top-level container that is commonly used for Swing applications. **JLabel** is the Swing component that creates a label, which is a component that displays information.The label is Swing's simplest component because it is passive. That is, a label does not respond to user input. It just displays output. The program uses a **JFrame** container to hold an instance of a **JLabel**. The label displays a short text message.

```
// A simple Swing application.

import javax.swing.*;

class SwingDemo {

  SwingDemo() {

    // Create a new JFrame container.
    JFrame jfrm = new JFrame("A Simple Swing Application");

    // Give the frame an initial size.
    jfrm.setSize(275, 100);

    // Terminate the program when the user closes the application.
    jfrm.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);

    // Create a text-based label.
    JLabel jlab = new JLabel(" Swing means powerful GUIs.");

    // Add the label to the content pane.
    jfrm.add(jlab);

    // Display the frame.
    jfrm.setVisible(true);
  }

  public static void main(String args[]) {
    // Create the frame on the event dispatching thread.
    SwingUtilities.invokeLater(new Runnable() {
      public void run() {
        new SwingDemo();
      }
    });
  }
}
```

Swing programs are compiled and run in the same way as other Java applications. Thus, to compile this program, you can use this command line:

```
javac  SwingDemo.java
```

To run the program, use this command line:

```
java SwingDemo
```

When the program is run, it will produce a window similar to that shown inFigure 3-1.

Fig. 3.1 The window produced by the **SwingDemo** program

Because the **SwingDemo** program illustrates several core Swing concepts, we will examine it carefully, line by line. The program begins by importing **javax.swing**. As mentioned, this package contains the components and models defined by Swing. For example, **javax.swing** defines classes that implement labels, buttons, text controls, and menus. It will be included in all programs that use Swing.

Next, the program declares the **SwingDemo** class and a constructor for that class. The constructor is where most of the action of the program occurs. It begins by creating a **JFrame**, using this line of code:

```
JFrame jfrm = new JFrame("A Simple Swing Application");
```

This creates a container called **jfrm** that defines a rectangular window complete with a title bar; close, minimize, maximize, and restore buttons; and asystem menu. Thus, it creates a standard, top-level window. The title of the window is passed to the constructor.

Next, the window is sized using this statement:

```
jfrm.setSize(275, 100);
```

The **setSize( )** method (which is inherited by **JFrame** from the AWT class **Component**) sets the dimensions of the window, which are specified in pixels.

Its general form is shown here:

void setSize(int *width*, int *height*)

In this example, the width of the window is set to 275 and the height is set to 100.

By default, when a top-level window is closed (such as when the user clicks the close box), the window is removed from the screen, but the application is not terminated. While this default behavior is useful in some situations, it is not what is needed for most applications. Instead, you will usually want the entire application to terminate when its top-level window is closed. There are a couple of ways to achieve this. The easiest way is to call **setDefaultCloseOperation( )**, as the program does:

```
jfrm.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
```

After this call executes, closing the window causes the entire application to terminate. The general form of **setDefaultCloseOperation( )** is shown here:

void setDefaultCloseOperation(int *what*)

The value passed in *what* determines what happens when the window is closed. There are several other options in addition to **JFrame.EXIT_ON_CLOSE**. They are shown here:

DISPOSE_ON_CLOSE   HIDE_ON_CLOSE

DO_NOTHING_ON_CLOSE

Their names reflect their actions. These constants are declared in **WindowConstants**, which is an interface declared in **javax.swing** that is implemented by **JFrame**.

The next line of code creates a Swing **JLabel** component:

```
JLabel jlab = new JLabel(" Swing means powerful GUIs.");
```

JLabel is the simplest and easiest-to-use component because it does not accept user input. It simply displays information, which can consist of text, an icon, or a combination of the two. The label created by the program contains only text, which is passed to its constructor.

The next line of code adds the label to the content pane of the frame:

```
jfrm.add(jlab);
```

As explained earlier, all top-level containers have a content pane in which components are stored. Thus, to add a component to a frame, you must add it to the frame's content pane. This is accomplished by calling **add( )** on the **JFrame** reference (**jfrm** in this case). The general form of **add( )** is shown here:

Component add(Component *comp*)

The **add( )** method is inherited by **JFrame** from the AWT class **Container.**

By default, the content pane associated with a **JFrame** uses border layout. The version of **add( )** just shown adds the label to the center location. Other versions of **add( )** enable you to specify one of the border regions. When a component is added to the center, its size is adjusted automatically to fit the size of the center.

Before continuing, an important historical point needs to be made. Prior to JDK 5, when adding a component to the content pane, you could not invoke the **add( )** method directly on a **JFrame** instance. Instead, you needed to call **add( )** on the content pane of the **JFrame** object. The content pane can be obtained by calling **getContentPane( )** on a **JFrame** instance. The **getContentPane( )** method is shown here:

Container getContentPane( )

It returns a **Container** reference to the content pane. The **add( )** method was then called on that reference to add a component to a content pane. Thus, in the past, you had to use the following statement to add **jlab** to **jfrm**:

```
jfrm.getContentPane().add(jlab);   //   old-style
```

Here, **getContentPane( )** first obtains a reference to content pane, and then **add( )** adds the component to the container linked to this pane. This same procedure was also required to invoke **remove( )** to remove a component and **setLayout( )** to set the layout manager for the content pane. This is why you will see explicit calls to **getContentPane( )** frequently throughout pre-5.0 legacy code. Today, the use of **getContentPane( )** is no longer necessary. Youcan simply call **add( )**, **remove( )**, and **setLayout( )** directly on **JFrame** because these methods have been changed so that they operate on the content pane automatically.

The last statement in the **SwingDemo** constructor causes the window to become visible:

```
jfrm.setVisible(true);
```

The **setVisible( )** method is inherited from the AWT **Component** class. If its argument is **true**, the window will be displayed. Otherwise, it will be hidden. By default, a **JFrame** is invisible, so **setVisible(true)** must be called to showit.

Inside **main( )**, a **SwingDemo** object is created, which causes the windowand the label to be displayed. Notice that the **SwingDemo** constructor is invoked using these lines of code:

```
SwingUtilities.invokeLater(new Runnable() {
  public void run() {
    new SwingDemo();
  }
});
```

This sequence causes a **SwingDemo** object to be created on the *event dispatching thread* rather than on the main thread of the application. Here's why. In general, Swing programs are event-driven. For example, when a user interacts with a component, an event is generated. An event is passed to the application by calling an event handler defined by the application. However, the handler is executed on the event dispatching thread provided by Swing and not on the main thread of the application. Thus, although event handlers are defined by your program, they are called on a thread that was not created by your program.

To avoid problems (including the potential for deadlock), all Swing GUI components must be created and updated from the event dispatching thread, notthe main thread of the application. However, **main( )** is executed on the main thread. Thus, **main( )** cannot directly instantiate a **SwingDemo** object. Instead, it must create a **Runnable** object that executes on the event dispatching thread and have this object create the GUI.

To enable the GUI code to be created on the event dispatching thread, you must use one of two methods that are defined by the **SwingUtilities** class. These methods are **invokeLater( )** and **invokeAndWait( )**. They are shownhere:

```
static void invokeLater(Runnable obj)

static void invokeAndWait(Runnable obj)
  throws InterruptedException, InvocationTargetException
```

Here, *obj* is a **Runnable** object that will have its **run( )** method called by the event dispatching thread. The difference between the two methods is that **invokeLater( )** returns immediately, but **invokeAndWait( )** waits until **obj.run( )** returns. You can use one of these methods to call a method that constructs the GUI for your Swing application, or whenever you need to modifythe state of the GUI from code not executed by the event dispatching thread.
You will normally want to use **invokeLater( )**, as the preceding program does. However, when the initial GUI for an applet is constructed, **invokeAndWait( )** is required. Thus, you will see its use in legacy applet code.

Event Handling

The preceding example showed the basic form of a Swing program, but it left out one important part: event handling. Because **JLabel** does not take input from the user, it does not generate events, so no event handling was needed. However, the other Swing components *do* respond to user input and the eventsgenerated by those interactions need to be handled. Events can also be generated in ways not directly related to user input. For example, an event is generated when a timer goes off. Whatever the case, event handling is a largepart of any Swing-based application.

The event handling mechanism used by Swing is the same as that used by the AWT. This approach is called the *delegation event model*. In many cases, Swing uses the same events as does theAWT, and these events are packaged in **java.awt.event**. Events specific to Swing are stored in **javax.swing.event**.

Although events are handled in Swing in the same way as they are with the AWT, it is still useful to work through a simple example. The following program handles the event generated by a Swing push button. Sample output isshown in Figure 3.2.

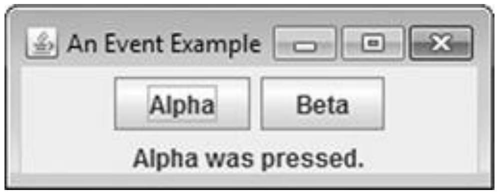


Fig. 3.2 Output from the **EventDemo** program

```
// Handle an event in a Swing program.

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

class EventDemo {

  JLabel jlab;

  EventDemo() {

    // Create a new JFrame container.
    JFrame jfrm = new JFrame("An Event Example");

    // Specify FlowLayout for the layout manager.
    jfrm.setLayout(new FlowLayout());

    // Give the frame an initial size.
    jfrm.setSize(220, 90);
```

```
    // Terminate the program when the user closes the application.
    jfrm.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);

    // Make two buttons.
    JButton jbtnAlpha = new JButton("Alpha");
    JButton jbtnBeta = new JButton("Beta");

    // Add action listener for Alpha.
    jbtnAlpha.addActionListener(new ActionListener() {
      public void actionPerformed(ActionEvent ae) {
        jlab.setText("Alpha was pressed.");
      }
    });

    // Add action listener for Beta.
    jbtnBeta.addActionListener(new ActionListener() {
      public void actionPerformed(ActionEvent ae) {
        jlab.setText("Beta was pressed.");
      }
    });

    // Add the buttons to the content pane.
    jfrm.add(jbtnAlpha);
    jfrm.add(jbtnBeta);

    // Create a text-based label.
    jlab = new JLabel("Press a button.");

    // Add the label to the content pane.
    jfrm.add(jlab);

    // Display the frame.
    jfrm.setVisible(true);
  }

  public static void main(String args[]) {
    // Create the frame on the event dispatching thread.
    SwingUtilities.invokeLater(new Runnable() {
      public void run() {
        new EventDemo();
      }
    });
  }
}
```

First, notice that the program now imports both the **java.awt** and **java.awt.event** packages. The **java.awt** package is needed because it contains the **FlowLayout** class, which supports the standard flow layout manager used to lay out components in a frame. (See Chapter 26 for coverage of layout managers.) The **java.awt.event** package is needed because it defines the **ActionListener** interface and the **ActionEvent** class.

The **EventDemo** constructor begins by creating a **JFrame** called **jfrm**. It then sets the layout manager for the content pane of **jfrm** to **FlowLayout**. By default, the content pane uses **BorderLayout** as its layout manager. However, for this example, **FlowLayout** is more convenient.

After setting the size and default close operation, **EventDemo( )** creates two push buttons, as shown here:

```
JButton jbtnAlpha = new JButton("Alpha");JButton jbtnBeta = new
JButton("Beta");
```

The first button will contain the text "Alpha" and the second will contain the text "Beta". Swing push buttons are instances of **JButton**. **JButton** supplies several constructors. The one used here is

JButton(String *msg*)

The *msg* parameter specifies the string that will be displayed inside the button.

When a push button is pressed, it generates an **ActionEvent.** Thus, **JButton** provides the **addActionListener( )** method, which is used to add an action listener. (**JButton** also provides **removeActionListener( )** to remove a listener,but this method is not used by the program.) The **ActionListener** interface defines only one method: **actionPerformed( )**. It is shown again here for your convenience:

void actionPerformed(ActionEvent *ae*)

This method is called when a button is pressed. In other words, it is the event handler that is called when a button press event has occurred.

Next, event listeners for the button’s action events are added by the code

```
// Add action listener for Alpha.
jbtnAlpha.addActionListener(new ActionListener() {
  public void actionPerformed(ActionEvent ae) {
    jlab.setText("Alpha was pressed.");
  }
});

// Add action listener for Beta.
jbtnBeta.addActionListener(new ActionListener() {
  public void actionPerformed(ActionEvent ae) {
    jlab.setText("Beta was pressed.");
  }
});
```

shown here:

Here, anonymous inner classes are used to provide the event handlers for the two buttons. Each time a button is pressed, the string displayed in **jlab** is changed to reflect which button was pressed.

Beginning with JDK 8, lambda expressions can also be used to implement some types of event handlers. For example, the event handler for the Alpha button could be written like this:

```
jbtnAlpha.addActionListener( (ae) -> jlab.setText("Alpha waspressed."));
```

As you can see, this code is shorter. Of course, the approach you choose will be determined by the situation and your own preferences.

Next, the buttons are added to the content pane of **jfrm**:

```
jfrm.add(jbtnAlpha);jfrm.add(jbtnBeta);
```

Finally, **jlab** is added to the content pane and the window is made visible. When you run the program, each time you press a button, a message is displayed in the label that indicates which button was pressed.

One last point: Remember that all event handlers, such as **actionPerformed( )**, are called on the event dispatching thread. Therefore, an event handler must return quickly in order to avoid slowing down the application. If your application needs to do something time consuming as the result of an event, it must use a separate thread.

Painting in Swing

Although the Swing component set is quite powerful, you are not limited to using it because Swing also lets you write directly into the display area of a frame, panel, or one of Swing's other components, such as **JLabel.** Although many (perhaps most) uses of Swing will *not* involve drawing directly to the surface of a component, it is available for those applications that need this capability. To write output directly to the surface of a component, you will use one or more drawing methods defined by the AWT, such as **drawLine( )** or **drawRect( )**.

Painting Fundamentals

Swing's approach to painting is built on the original AWT-based mechanism, but Swing's implementation offers more finally grained control. Before examining the specifics of Swing-based painting, it is useful to review the AWT-based mechanism that underlies it.

The AWT class **Component** defines a method called **paint( )** that is used to draw output directly to the surface of a component. For the most part, **paint( )** is not called by your program. (In fact, only in the most unusual cases should itever be called by your program.) Rather, **paint( )** is called by the run-time system whenever a component must be rendered. This situation can occur for several reasons. For example, the window in which the component is displayed can be overwritten by another window and then uncovered. Or, the window might be minimized and then restored. The **paint( )** method is also called when a program begins running. When writing AWT-based code, an application will override **paint( )** when it needs to write output directly to the surface of the component.

Because **JComponent** inherits **Component**, all Swing's lightweight components inherit the **paint( )** method. However, you *will not* override it to paint directly to the surface of a component. The reason is that Swing uses a bit more sophisticated approach to painting that involves three distinct methods: **paintComponent( )**, **paintBorder( )**, and **paintChildren( )**. These methods paint the indicated portion of a component and divide the painting process into its three distinct, logical actions. In a lightweight component, the original AWTmethod **paint( )** simply executes calls to these methods, in the order just shown.

To paint to the surface of a Swing component, you will create a subclass of the component and then override its **paintComponent( )** method. This is the method that paints the interior of the component. You will not normally override the other two painting methods. When overriding **paintComponent( )**, the first thing you must do is call **super.paintComponent( )**, so that the superclass portion of the painting process takes place. (The only time this is not required is when you are taking complete, manual control over how a component is displayed.) After that, write the output that you want to display. The **paintComponent( )** method is shown here:

protected void paintComponent(Graphics *g*)

The parameter *g* is the graphics context to which output is written.

To cause a component to be painted under program control, call **repaint( )**. It works in Swing just as it does for the AWT. The **repaint( )** method is defined by **Component**. Calling it causes the system to call **paint( )** as soon as it is possible to do so. Because painting is a time-consuming operation, this mechanism allows the run-time system to defer painting momentarily until some higher-priority task has completed, for example. Of course, in Swing the call to **paint( )** results in a call to **paintComponent( )**. Therefore, to output to the surface of a component, your program will store the output until **paintComponent( )** is called. Inside the overridden **paintComponent( )**, you will draw the stored output.

Compute the Paintable Area

When drawing to the surface of a component, you must be careful to restrict your output to the area that is inside the border. Although Swing automatically clips any output that will exceed the boundaries of a component, it is still possible to paint into the border, which will then get overwritten when the border is drawn. To avoid this, you must compute the *paintable area* of the component. This is the area defined by the current size of the component minus the space used by the border. Therefore, before you paint to a component, you must obtain the width of the border and then adjust your drawing accordingly.

To obtain the border width, call **getInsets( )**, shown here:

Insets getInsets( )

This method is defined by **Container** and overridden by **JComponent**. It returns an **Insets** object that contains the dimensions of the border. The inset values can be obtained by using these fields:int top;

int

bottom; int

left;

int right;

These values are then used to compute the drawing area given the width and the height of the component. You can obtain the width and height of the componentby calling **getWidth( )** and **getHeight( )** on the component. They are shown here:

int getWidth( )

int getHeight( )

By subtracting the value of the insets, you can compute the usable width and height of the component.

A Paint Example

Here is a program that puts into action the preceding discussion. It creates a class called **PaintPanel** that extends **JPanel**. The program then uses an object of that class to display lines whose endpoints have been generated randomly. Sample output is shown in Figure 3-3.

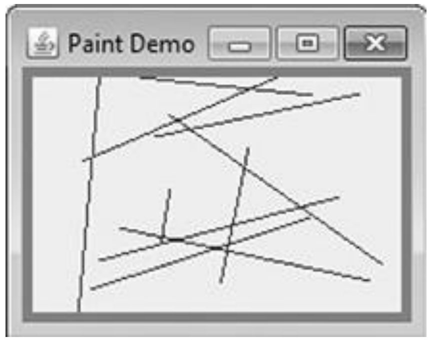


Fig. 3-3 Sample output from the **PaintPanel** program

```
// Paint lines to a panel.

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

// This class extends JPanel. It overrides
// the paintComponent() method so that random
// lines are plotted in the panel.
class PaintPanel extends JPanel {
  Insets ins; // holds the panel's insets

  Random rand; // used to generate random numbers

  // Construct a panel.
  PaintPanel() {

    // Put a border around the panel.
    setBorder(
      BorderFactory.createLineBorder(Color.RED, 5));

    rand = new Random();
  }
```

```
  // Override the paintComponent() method.
  protected void paintComponent(Graphics g) {
    // Always call the superclass method first.
    super.paintComponent(g);

    int x, y, x2, y2;

    // Get the height and width of the component.
    int height = getHeight();
    int width = getWidth();

    // Get the insets.
    ins = getInsets();

    // Draw ten lines whose endpoints are randomly generated.
    for(int i=0; i < 10; i++) {
      // Obtain random coordinates that define
      // the endpoints of each line.
      x = rand.nextInt(width-ins.left);
      y = rand.nextInt(height-ins.bottom);
      x2 = rand.nextInt(width-ins.left);
      y2 = rand.nextInt(height-ins.bottom);

      // Draw the line.
      g.drawLine(x, y, x2, y2);
    }
  }
}

// Demonstrate painting directly onto a panel.
class PaintDemo {

   JLabel jlab;
   PaintPanel pp;

   PaintDemo() {

     // Create a new JFrame container.
     JFrame jfrm = new JFrame("Paint Demo");

     // Give the frame an initial size.
     jfrm.setSize(200, 150);

     // Terminate the program when the user closes the application.
     jfrm.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);

     // Create the panel that will be painted.
     pp = new PaintPanel();

     // Add the panel to the content pane. Because the default
     // border layout is used, the panel will automatically be
     // sized to fit the center region.
     jfrm.add(pp);
```

```
    // Display the frame.
    jfrm.setVisible(true);
  }

  public static void main(String args[]) {
    // Create the frame on the event dispatching thread.
    SwingUtilities.invokeLater(new Runnable() {
      public void run() {
        new PaintDemo();
      }
    });
  }
}
```

Let's examine this program closely. The **PaintPanel** class extends **JPanel**. **JPanel** is one of Swing's lightweight containers, which means that it is a component that can be added to the content pane of a **JFrame**. To handle painting, **PaintPanel** overrides the **paintComponent( )** method. This enables **PaintPanel** to write directly to the surface of the component when painting takes place. The size of the panel is not specified because the program uses the default border layout and the panel is added to the center. This results in the panel being sized to fill the center. If you change the size of the window, the size of the panel will be adjusted accordingly.

Notice that the constructor also specifies a 5-pixel wide, red border. This is accomplished by setting the border by using the **setBorder( )** method, shown here:

void setBorder(Border *border*)

Border is the Swing interface that encapsulates a border. You can obtain a border by calling one of the factory methods defined by the **BorderFactory**class. The one used in the program is **createLineBorder( )**, which creates asimple line border. It is shown here:

static Border createLineBorder(Color *clr*, int *width*)

Here, *clr* specifies the color of the border and *width* specifies its width inpixels.

Inside the override of **paintComponent( )**, notice that it first calls **super.paintComponent( )**. As explained, this is necessary to ensure that the component is properly drawn. Next, the width and height of the panel are obtained along with the insets. These values are used to ensure the lines lie within the drawing area of the panel. The drawing area is the overall width and height of a component less the border width. The computations are designed to work with differently sized **PaintPanel**s and borders. To prove this, try changing the size of the window. The lines will still all lie within the borders of the panel.

The **PaintDemo** class creates a **PaintPanel** and then adds the panel to the content pane. When the application is first displayed, the overridden **paintComponent( )** method is called, and the lines are drawn. Each time you resize or hide and restore the window, a new set of lines are drawn. In all cases, the lines fall within the paintable area.

Exploring Swing

The previous chapter described several of the core concepts relating to Swing and showed the general form of a Swing application. This chapter continues the discussion of Swing by presenting an overview of several Swing components, such as buttons, check boxes, trees, and tables. The Swing components provide rich functionality and allow a high level of customization. Because of space limitations, it is not possible to describe all of their features and attributes. Rather, the purpose of this overview is to give you a feel for the capabilities of the Swing component set.

The Swing component classes described in this chapter are shown here:

JButton	JCheckBox	JComboBox	JLabel
JList	JRadioButton	JScrollPane	JTabbedPane
JTable	JTextField	JToggleButton	JTree

These components are all lightweight, which means that they are all derived from **JComponent**.

Also discussed is the **ButtonGroup** class, which encapsulates a mutually exclusive set of Swing buttons, and **ImageIcon**, which encapsulates a graphics image. Both are defined by Swing and packaged in **javax.swing**.

JLabel and ImageIcon

JLabel is Swing's easiest-to-use component. It creates a label and was introduced in the preceding chapter. Here, we will look at **JLabel** a bit more closely. **JLabel** can be used to display text and/or an icon. It is a passive component in that it does not respond to user input. **JLabel** defines several constructors. Here are three of them:

JLabel(Icon *icon*) JLabel(String
str)
JLabel(String *str*, Icon *icon*, int *align*)

Here, *str* and *icon* are the text and icon used for the label. The *align* argument specifies the horizontal alignment of the text and/or icon within the dimensions of the label. It must be one of the following values: **LEFT**, **RIGHT, CENTER**, **LEADING**, or **TRAILING**. These constants are defined in the **SwingConstants** interface, along with several others used by the Swing classes.

Notice that icons are specified by objects of type **Icon**, which is an interface defined by Swing. The easiest way to obtain an icon is to use the **ImageIcon** class. **ImageIcon** implements **Icon** and encapsulates an image. Thus, an object of type **ImageIcon** can be passed as an argument to the **Icon** parameter of **JLabel**'s constructor. There are several ways to provide the image, including reading it from a file or downloading it from a URL. Here is the **ImageIcon** constructor used by the example in this section:

ImageIcon(String *filename*)

It obtains the image in the file named *filename*.

The icon and text associated with the label can be obtained by the following methods:

Icon getIcon( )
String getText( )

The icon and text associated with a label can be set by these methods:

void setIcon(Icon *icon*)

void setText(String *str*)

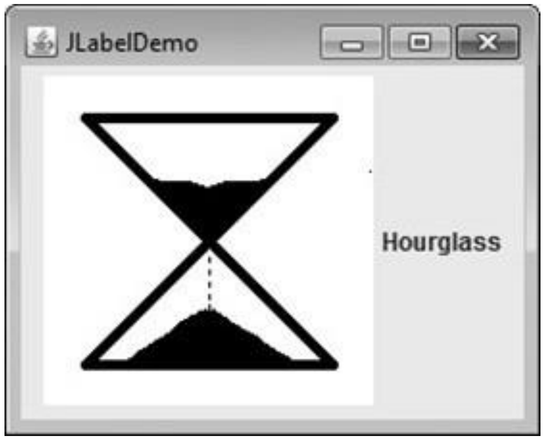
Here, *icon* and *str* are the icon and text, respectively. Therefore, using **setText( )** it is possible to change the text inside a label during program execution.

The following program illustrates how to create and display a label containing both an icon and a string. It begins by creating an **ImageIcon** object for the file **hourglass.png**, which depicts an hourglass. This is used as the second argument to the **JLabel** constructor. The first and last arguments for the **JLabel** constructor are the label text and the alignment. Finally, the label is added to the content pane.

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

public class JLabelDemo {

  public JLabelDemo() {

    // Set up the JFrame.
    JFrame jfrm = new JFrame("JLabelDemo");
    jfrm.setLayout(new FlowLayout());
    jfrm.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
    jfrm.setSize(260, 210);

    // Create an icon.
    ImageIcon ii = new ImageIcon("hourglass.png");

    // Create a label.
    JLabel jl = new JLabel("Hourglass", ii, JLabel.CENTER);
```

```
    // Add the label to the content pane.
    jfrm.add(jl);

    // Display the frame.
    jfrm.setVisible(true);
  }

  public static void main(String[] args) {
    // Create the frame on the event dispatching thread.

    SwingUtilities.invokeLater(
      new Runnable() {
        public void run() {
          new JLabelDemo();
        }
      }
    );

  }
}
```

Output from the label example is shown here:



JTextField

JTextField is the simplest Swing text component. It is also probably its most widely used text component. **JTextField** allows you to edit one line of text. It is derived from **JTextComponent**, which provides the basic functionality common to Swing text components. **JTextField** uses the **Document** interface for its model. Three of **JTextField**'s constructors are shown here:

JTextField(int *cols*) JTextField(String *str*, int *cols*)JTextField(String *str*)

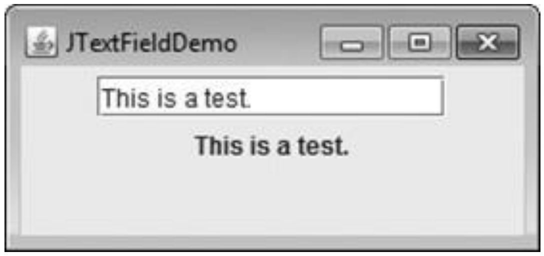
Here, *str* is the string to be initially presented, and *cols* is the number of columns in the text field. If no string is specified, the text field is initially empty. If the number of columns is not specified, the text field is sized to fit the specified string.

JTextField generates events in response to user interaction. For example, an **ActionEvent** is fired when the user presses enter. A **CaretEvent** is fired each time the caret (i.e., the cursor) changes position. (**CaretEvent** is packaged in **javax.swing.event**.) Other events are also possible. In many cases, your program will not need to handle these events. Instead, you will simply obtain the string currently in the text field when it is needed. To obtain the text currently in the text field, call **getText( )**.

The following example illustrates **JTextField**. It creates a **JTextField** andadds it to the content pane. When the user presses enter, an action event is generated. This is handled by displaying the text in a label.

```
// Demonstrate JTextField.
import java.awt.*;
import java.awt.event.*;
import javax.swing.*;

public class JTextFieldDemo {

  public JTextFieldDemo() {

    // Set up the JFrame.
    JFrame jfrm = new JFrame("JTextFieldDemo");
    jfrm.setLayout(new FlowLayout());
    jfrm.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
    jfrm.setSize(260, 120);

    // Add a text field to content pane.
    JTextField jtf = new JTextField(15);
    jfrm.add(jtf);

    // Add a label.
    JLabel jlab = new JLabel();
    jfrm.add(jlab);

    // Handle action events.
    jtf.addActionListener(new ActionListener() {
      public void actionPerformed(ActionEvent ae) {
        // Show text when user presses ENTER.
        jlab.setText(jtf.getText());
      }
    });

    // Display the frame.
    jfrm.setVisible(true);
  }

  public static void main(String[] args) {
    // Create the frame on the event dispatching thread.

    SwingUtilities.invokeLater(
      new Runnable() {
        public void run() {
          new JTextFieldDemo();
        }
      }
    );

  }
}
```

Output from the text field example is shown here:



The Swing Buttons

Swing defines four types of buttons: **JButton**, **JToggleButton**, **JCheckBox**,and **JRadioButton**. All are subclasses of the **AbstractButton** class, which extends **JComponent**. Thus, all buttons share a set of common traits.

AbstractButton contains many methods that allow you to control the behavior of buttons. For example, you can define different icons that are displayed for the button when it is disabled, pressed, or selected. Another icon can be used as a *rollover* icon, which is displayed when the mouse is positioned over a button. The following methods set these icons:

void setDisabledIcon(Icon *di*)
void setPressedIcon(Icon *pi*)
void setSelectedIcon(Icon *si*)
void setRolloverIcon(Icon *ri*)

Here, *di, pi, si*, and *ri* are the icons to be used for the indicated purpose.

The text associated with a button can be read and written via the following methods:

String getText( )
void setText(String *str*)

Here, *str* is the text to be associated with the button.

The model used by all buttons is defined by the **ButtonModel** interface. A button generates an action event when it is pressed. Other events are possible.Each of the concrete button classes is examined next.

JButton

The **JButton** class provides the functionality of a push button. You have already seen a simple form of it in the preceding chapter. **JButton** allows anicon, a string, or both to be associated with the push button. Three of its constructors are shown here:

JButton(Icon *icon*)
JButton(String *str*)
JButton(String *str*, Icon *icon*)

Here, *str* and *icon* are the string and icon used for the button.

When the button is pressed, an **ActionEvent** is generated. Using the **ActionEvent** object passed to the **actionPerformed( )** method of the registered **ActionListener**, you can obtain the *action command* string associated with the button. By default, this is the string displayed inside the button. However, you can set the action command by calling **setActionCommand( )** on the button.
You can obtain the action command by calling **getActionCommand( )** on the event object. It is declared like this:

String getActionCommand( )

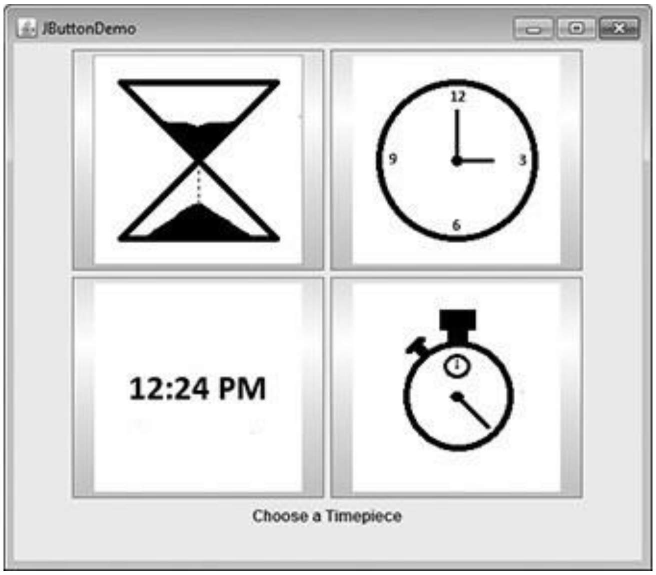
The action command identifies the button. Thus, when using two or more buttons within the same application, the action command gives you an easy way to determine which button was pressed.

The following demonstrates an icon-based button. It displays four push buttons anda label. Each button displays an icon that represents a timepiece. When a buttonis pressed, the name of that timepiece is displayed in the label.

```
// Demonstrate an icon-based JButton.
import java.awt.*;
import java.awt.event.*;
import javax.swing.*;

public class JButtonDemo implements ActionListener {
  JLabel jlab;

  public JButtonDemo() {

    // Set up the JFrame.
    JFrame jfrm = new JFrame("JButtonDemo");
    jfrm.setLayout(new FlowLayout());
    jfrm.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
    jfrm.setSize(500, 450);

    // Add buttons to content pane.
    ImageIcon hourglass = new ImageIcon("hourglass.png");
    JButton jb = new JButton(hourglass);
    jb.setActionCommand("Hourglass");
    jb.addActionListener(this);
    jfrm.add(jb);

    ImageIcon analog = new ImageIcon("analog.png");
    jb = new JButton(analog);
    jb.setActionCommand("Analog Clock");
    jb.addActionListener(this);
    jfrm.add(jb);

    ImageIcon digital = new ImageIcon("digital.png");
    jb = new JButton(digital);
    jb.setActionCommand("Digital Clock");
    jb.addActionListener(this);
    jfrm.add(jb);

    ImageIcon stopwatch = new ImageIcon("stopwatch.png");
    jb = new JButton(stopwatch);
    jb.setActionCommand("Stopwatch");
    jb.addActionListener(this);
    jfrm.add(jb);
```

```
    // Create and add the label to content pane.
    jlab = new JLabel("Choose a Timepiece");
    jfrm.add(jlab);

    // Display the frame.
    jfrm.setVisible(true);
  }

  // Handle button events.
  public void actionPerformed(ActionEvent ae) {
    jlab.setText("You selected " + ae.getActionCommand());
  }

  public static void main(String[] args) {
    // Create the frame on the event dispatching thread.

    SwingUtilities.invokeLater(
      new Runnable() {
        public void run() {
          new JButtonDemo();
        }
      }
    );

  }
}
```

Output from the button example is shown here:



JToggleButton

A useful variation on the push button is called a *toggle button*. A toggle button looks just like a push button, but it acts differently because it has two states: pushed and released. That is, when you press a toggle button, it stays pressed rather than popping back up as a regular push button does. When you press the toggle button a second time, it releases (pops up). Therefore, each time a toggle button is pushed, it toggles between its two states.

Toggle buttons are objects of the **JToggleButton** class. **JToggleButton** implements **AbstractButton**. In addition to creating standard toggle buttons, **JToggleButton** is a superclass for two other Swing components that also represent two-state controls. These are **JCheckBox** and **JRadioButton**, whichare described later in this chapter. Thus, **JToggleButton** defines the basic functionality of all two-state components.

JToggleButton defines several constructors. The one used by the example in this section is shown here:

JToggleButton(String *str*)

This creates a toggle button that contains the text passed in *str*. By default, the button is in the off position. Other constructors enable you to create toggle buttons that contain images, or images and text.

JToggleButton uses a model defined by a nested class called **JToggleButton.Toggle-ButtonModel**. Normally, you won't need to interact directly with the model to use a standard toggle button.

Like **JButton**, **JToggleButton** generates an action event each time it is pressed. Unlike **JButton**, however, **JToggleButton** also generates an item event. This event is used by those components that support the concept ofselection. When a **JToggleButton** is pressed in, it is selected. When it is popped out, it is deselected.

To handle item events, you must implement the **ItemListener** interface. Each time an item event is generated, it is passedto the **itemStateChanged( )** method defined by **ItemListener**. Inside **itemStateChanged( )**, the **getItem( )** method can be called on the **ItemEvent**object to obtain a reference to the **JToggleButton** instance that generated theevent. It is shown here:

Object getItem( )

A reference to the button is returned. You will need to cast this reference to **JToggleButton**.

The easiest way to determine a toggle button's state is by calling the **isSelected( )** method (inherited from **AbstractButton**) on the button that generated the event. It is shown here:

boolean isSelected( )

It returns **true** if the button is selected and **false** otherwise.

Here is an example that uses a toggle button. Notice how the item listener works. It simply calls **isSelected( )** to determine the button's state.

```
// Demonstrate JToggleButton.
import java.awt.*;
import java.awt.event.*;
import javax.swing.*;

public class JToggleButtonDemo {

  public JToggleButtonDemo() {
```

```
    // Set up the JFrame.
    JFrame jfrm = new JFrame("JToggleButtonDemo");
    jfrm.setLayout(new FlowLayout());
    jfrm.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
    jfrm.setSize(200, 100);

    // Create a label.
    JLabel jlab = new JLabel("Button is off.");

    // Make a toggle button.
    JToggleButton jtbn =  new JToggleButton("On/Off");

    // Add an item listener for the toggle button.
    jtbn.addItemListener(new ItemListener() {
      public void itemStateChanged(ItemEvent ie) {
        if(jtbn.isSelected())
          jlab.setText("Button is on.");
        else
          jlab.setText("Button is off.");
      }
    });

    // Add the toggle button and label to the content pane.
    jfrm.add(jtbn);
    jfrm.add(jlab);

    // Display the frame.
    jfrm.setVisible(true);
  }

  public static void main(String[] args) {
    // Create the frame on the event dispatching thread.

    SwingUtilities.invokeLater(
      new Runnable() {
        public void run() {
          new JToggleButtonDemo();
        }
      }
    );

  }
}
```

The output from the toggle button example is shown here:

Check Boxes

The **JCheckBox** class provides the functionality of a check box. Its immediate superclass is **JToggleButton**, which provides support for two-state buttons, as just described. **JCheckBox** defines several constructors. The one used here is

JCheckBox(String *str*)

It creates a check box that has the text specified by *str* as a label. Other constructors let you specify the initial selection state of the button and specify an icon.

When the user selects or deselects a check box, an **ItemEvent** is generated. You can obtain a reference to the **JCheckBox** that generated the event by calling **getItem( )** on the **ItemEvent** passed to the **itemStateChanged( )** method defined by **ItemListener**. The easiest way to determine the selectedstate of a check box is to call **isSelected( )** on the **JCheckBox** instance.

The following example illustrates check boxes. It displays four check boxesand a label. When the user clicks a check box, an **ItemEvent** is generated. Inside the **itemStateChanged( )** method, **getItem( )** is called to obtain a reference to the **JCheckBox** object that generated the event. Next, a call to **isSelected( )** determines if the box was selected or cleared. The **getText( )** method gets the text for that check box and uses it to set the text inside the label.

```
// Demonstrate JCheckbox.
import java.awt.*;
import java.awt.event.*;
import javax.swing.*;

public class JCheckBoxDemo implements ItemListener {
  JLabel jlab;

  public JCheckBoxDemo() {

    // Set up the JFrame.
    JFrame jfrm = new JFrame("JCheckBoxDemo");
    jfrm.setLayout(new FlowLayout());
    jfrm.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
    jfrm.setSize(250, 100);

    // Add check boxes to the content pane.
    JCheckBox cb = new JCheckBox("C");
    cb.addItemListener(this);
    jfrm.add(cb);

    cb = new JCheckBox("C++");
    cb.addItemListener(this);
    jfrm.add(cb);

    cb = new JCheckBox("Java");
    cb.addItemListener(this);
    jfrm.add(cb);
```

```
    cb = new JCheckBox("Perl");
    cb.addItemListener(this);
    jfrm.add(cb);

    // Create the label and add it to the content pane.
    jlab = new JLabel("Select languages");
    jfrm.add(jlab);

    // Display the frame.
    jfrm.setVisible(true);
  }

  // Handle item events for the check boxes.
  public void itemStateChanged(ItemEvent ie) {
    JCheckBox cb = (JCheckBox)ie.getItem();

    if(cb.isSelected())
      jlab.setText(cb.getText() + " is selected");
    else
      jlab.setText(cb.getText() + " is cleared");
  }

  public static void main(String[] args) {
    // Create the frame on the event dispatching thread.

    SwingUtilities.invokeLater(
      new Runnable() {
        public void run() {
          new JCheckBoxDemo();
        }
      }
    );

  }
}
```

Output from this example is shown here:

Radio Buttons

Radio buttons are a group of mutually exclusive buttons, in which only one button can be selected at any one time. They are supported by the **JRadioButton** class, which extends **JToggleButton**. **JRadioButton** providesseveral constructors. The one used in the example is shown here:

JRadioButton(String *str*)

Here, *str* is the label for the button. Other constructors let you specify the initial selection state of the button and specify an icon.

In order for their mutually exclusive nature to be activated, radio buttons must be configured into a group. Only one of the buttons in the group can be selected at any time. For example, if a user presses a radio button that is in a group, any previously selected button in that group is automatically deselected. A button group is created by the **ButtonGroup** class. Its default constructor is invoked for this purpose. Elements are then added to the button group via the following method:

void add(AbstractButton *ab*)

Here, *ab* is a reference to the button to be added to the group.

A **JRadioButton** generates action events, item events, and change events each time the button selection changes. Most often, it is the action event that ishandled, which means that you will normally implement the **ActionListener** interface. Recall that the only method defined by **ActionListener** is **actionPerformed( )**. Inside this method, you can use a number of different ways to determine which button was selected. First, you can check its action command by calling **getActionCommand( )**. By default, the action command is the same as the button label, but you can set the action command to something else by calling **setActionCommand( )** on the radio button. Second, you can call **getSource( )** on the **ActionEvent** object and check that reference against the buttons. Third, you can check each radio button to find out which one is currently selected by calling **isSelected( )** on each button. Finally, each button could use its own action event handler implemented as either an anonymous inner class or a lambda expression. Remember, each time an actionevent occurs, it means that the button being selected has changed and that one and only one button will be selected.

The following example illustrates how to use radio buttons. Three radio buttons are created. The buttons are then added to a button group. As explained, this is necessary to cause their mutually exclusive behavior. Pressing a radio button generates an action event, which is handled by **actionPerformed( )**.
Within that handler, the **getActionCommand( )** method gets the text that is associated with the radio button and uses it to set the text within a label.

```
// Demonstrate JRadioButton
import java.awt.*;
import java.awt.event.*;
import javax.swing.*;

public class JRadioButtonDemo implements ActionListener {
  JLabel jlab;

  public JRadioButtonDemo() {

    // Set up the JFrame.
    JFrame jfrm = new JFrame("JRadioButtonDemo");
    jfrm.setLayout(new FlowLayout());
    jfrm.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
    jfrm.setSize(250, 100);
```

```
    // Create radio buttons and add them to content pane.
    JRadioButton b1 = new JRadioButton("A");
    b1.addActionListener(this);
    jfrm.add(b1);

    JRadioButton b2 = new JRadioButton("B");
    b2.addActionListener(this);
    jfrm.add(b2);

    JRadioButton b3 = new JRadioButton("C");
    b3.addActionListener(this);
    jfrm.add(b3);

    // Define a button group.
    ButtonGroup bg = new ButtonGroup();
    bg.add(b1);
    bg.add(b2);
    bg.add(b3);

    // Create a label and add it to the content pane.
    jlab = new JLabel("Select One");
    jfrm.add(jlab);

    // Display the frame.
    jfrm.setVisible(true);
  }

  // Handle button selection.
  public void actionPerformed(ActionEvent ae) {
    jlab.setText("You selected " + ae.getActionCommand());
  }

  public static void main(String[] args) {
    // Create the frame on the event dispatching thread.

    SwingUtilities.invokeLater(
      new Runnable() {
        public void run() {
          new JRadioButtonDemo();
        }
      }
    );

  }
}
```

Output from the radio button example is shown here:

JTabbedPane

JTabbedPane encapsulates a *tabbed pane.* It manages a set of components by linking them with tabs. Selecting a tab causes the component associated with that tab to come to the forefront. Tabbed panes are very common in the modern GUI, and you have no doubt used them many times. Given the complex natureof a tabbed pane, they are surprisingly easy to create and use.

JTabbedPane defines three constructors. We will use its default constructor, which creates an empty control with the tabs positioned across thetop of the pane. The other two constructors let you specify the location of the tabs, which can be along any of the four sides. **JTabbedPane** uses the **SingleSelectionModel** model.

Tabs are added by calling **addTab( )**. Here is one of its forms:void

addTab(String *name*, Component *comp*)

Here, *name* is the name for the tab, and *comp* is the component that should beadded to the tab. Often, the component added to a tab is a **JPanel** that containsa group of related components. This technique allows a tab to hold a set of components.

The general procedure to use a tabbed pane is outlined here:

1. Create an instance of **JTabbedPane**.
2. Add eachn tab by calling **addTab( )**.
3. Add the tabbed pane to the content pane.