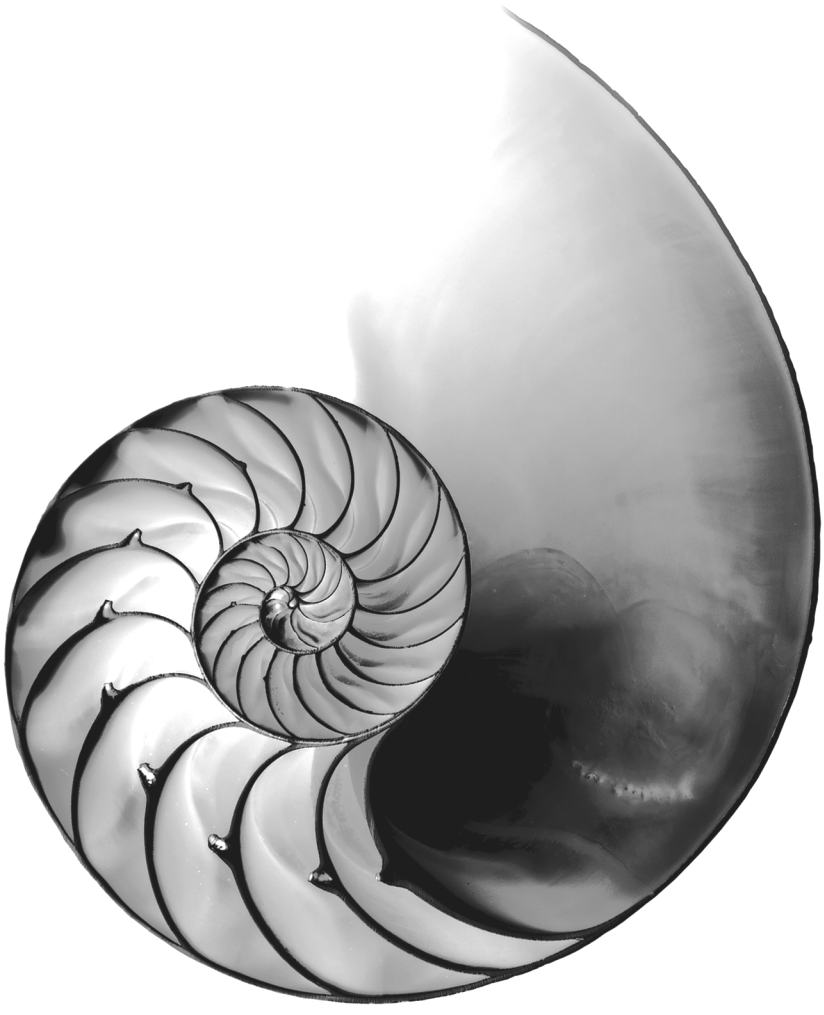
# Swing GUI Components: Part 1

# 26



## Objectives

In this chapter you'll:

- Learn how to use the Nimbus look-and-feel.
- Build GUIs and handle events generated by user interactions with GUIs.
- Understand the packages containing GUI components, event-handling classes and interfaces.
- Create and manipulate buttons, labels, lists, text fields and panels.
- Handle mouse events and keyboard events.
- Use layout managers to arrange GUI components.

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## 26.1 Introduction

[*Note:* JavaFX (Chapters 12, 13 and 22) is Java's GUI, graphics and multimedia API of the future. We provide this chapter and Chapters 27 and 35 *as is* from this book's Tenth Edition for those still interested in Swing GUIs.]

A **graphical user interface** (**GUI**) presents a user-friendly mechanism for interacting with an application. A GUI (pronounced "GOO-ee") gives an application a distinctive "look-and-feel." GUIs are built from **GUI components**. These are sometimes called *controls* or *widgets*—short for window gadgets. A GUI component is an object with which the user *interacts* via the mouse, the keyboard or another form of input, such as voice recognition. In this chapter and Chapter 35, Swing GUI Components: Part 2, you'll learn about many of Java's so-called **Swing GUI components** from the **`javax.swing`** package. We cover other GUI components as they're needed throughout the book. In Chapter 12 and two online chapters, you'll learn about JavaFX—Java's latest APIs for GUI, graphics and multimedia.


**Look-and-Feel Observation 26.1**

*Providing different applications with consistent, intuitive user-interface components gives users a sense of familiarity with a new application, so that they can learn it more quickly and use it more productively.*

### *IDE Support for GUI Design*

Many IDEs provide GUI design tools with which you can specify a component's *size*, *location* and other attributes in a visual manner by using the mouse, the keyboard and drag-and-drop. The IDEs generate the GUI code for you. This greatly simplifies creating GUIs,

but each IDE generates this code differently. For this reason, we wrote the GUI code by hand, as you'll see in the source-code files for this chapter's examples. We encourage you to build each GUI visually using your preferred IDE(s).

### *Sample GUI: The SwingSet3 Demo Application*

As an example of a GUI, consider Fig. 26.1, which shows the **SwingSet3** demo application from the JDK demos and samples download at `http://www.oracle.com/technetwork/java/javase/downloads/index.html`. This application is a nice way for you to browse through the various GUI components provided by Java's Swing GUI APIs. Simply click a component name (e.g., `JFrame`, `JTabbedPane`, etc.) in the **GUI Components** area at the left of the window to see a demonstration of the GUI component in the right side of the window. The source code for each demo is shown in the text area at the bottom of the window. We've labeled a few of the GUI components in the application. At the top of the window is a **title bar** that contains the window's title. Below that is a **menu bar** containing **menus** (**File** and **View**). In the top-right region of the window is a set of **buttons**—typically, users click buttons to perform tasks. In the **GUI Components** area of the window is a **combo box**; the user can click the down arrow at the right side of the box to select from a list of items. The menus, buttons and combo box are part of the application's GUI. They enable you to interact with the application.

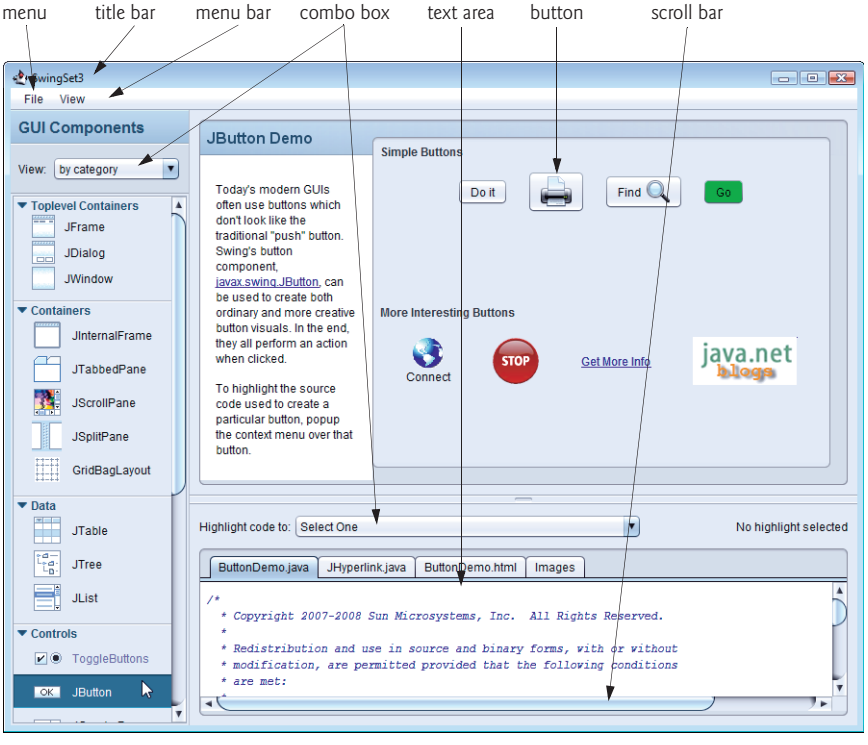



**Fig. 26.1** | **SwingSet3** application demonstrates many of Java's Swing GUI components.

## 26.2 Java's Nimbus Look-and-Feel

A GUI's look consists of its visual aspects, such as its colors and fonts, and its feel consists of the components you use to interact with the GUI, such as buttons and menus. Together these are known as the GUI's look-and-feel. Swing has a cross-platform look-and-feel known as **Nimbus**. For GUI screen captures like Fig. 26.1, we've configured our systems to use Nimbus as the default look-and-feel. There are three ways that you can use Nimbus:

1. Set it as the default for all Java applications that run on your computer.
2. Set it as the look-and-feel at the time that you launch an application by passing a command-line argument to the `java` command.
3. Set it as the look-and-feel programatically in your application (see Section 35.6).

To set Nimbus as the default for all Java applications, you must create a text file named `swing.properties` in the `lib` folder of both your JDK installation folder and your JRE installation folder. Place the following line of code in the file:

```
swing.defaultlaf=com.sun.java.swing.plaf.nimbus.NimbusLookAndFeel
```

In addition to the standalone JRE, there is a JRE nested in your JDK's installation folder. If you're using an IDE that depends on the JDK, you may also need to place the `swing.properties` file in the nested `jre` folder's `lib` folder.

If you prefer to select Nimbus on an application-by-application basis, place the following command-line argument after the `java` command and before the application's name when you run the application:

```
-Dswing.defaultlaf=com.sun.java.swing.plaf.nimbus.NimbusLookAndFeel
```

## 26.3 Simple GUI-Based Input/Output with `JOptionPane`

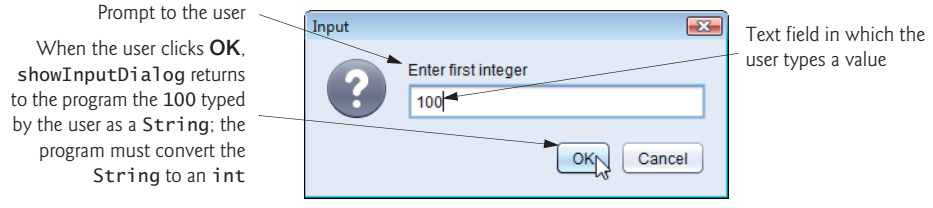
The applications in Chapters 2–10 display text in the command window and obtain input from the command window. Most applications you use on a daily basis use windows or **dialog boxes** (also called **dialogs**) to interact with the user. For example, an e-mail program allows you to type and read messages in a window the program provides. Dialog boxes are windows in which programs display important messages to the user or obtain information from the user. Java's **`JOptionPane`** class (package `javax.swing`) provides prebuilt dialog boxes for both input and output. These are displayed by invoking `static` `JOptionPane` methods. Figure 26.2 presents a simple addition application that uses two **input dialogs** to obtain integers from the user and a **message dialog** to display the sum of the integers the user enters.

```
1  // Fig. 26.2: Addition.java
2  // Addition program that uses JOptionPane for input and output.
3  import javax.swing.JOptionPane;
4
5  public class Addition
6  {
```

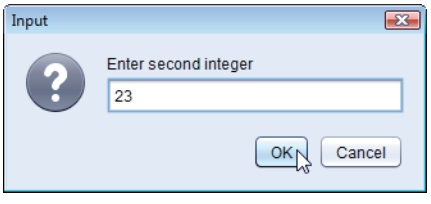
**Fig. 26.2** | Addition program that uses `JOptionPane` for input and output. (Part 1 of 2.)

```
7       public static void main(String[] args)
8       {
9          // obtain user input from JOptionPane input dialogs
10         String firstNumber =
11            JOptionPane.showInputDialog("Enter first integer");
12         String secondNumber =
13            JOptionPane.showInputDialog("Enter second integer");
14
15         // convert String inputs to int values for use in a calculation
16         int number1 = Integer.parseInt(firstNumber);
17         int number2 = Integer.parseInt(secondNumber);
18
19         int sum = number1 + number2;
20
21         // display result in a JOptionPane message dialog
22         JOptionPane.showMessageDialog(null, "The sum is " + sum,
23            "Sum of Two Integers", JOptionPane.PLAIN_MESSAGE);
24      }
25   }
```

(a) Input dialog displayed by lines 10–11




(b) Input dialog displayed by lines 12–13




(c) Message dialog displayed by lines 22–23—When the user clicks **OK**, the message dialog is dismissed (removed from the screen)

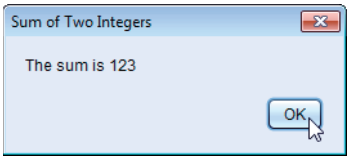



**Fig. 26.2** | Addition program that uses `JOptionPane` for input and output. (Part 2 of 2.)

### *Input Dialogs*

Line 3 imports class `JOptionPane`. Lines 10–11 declare the local `String` variable `firstNumber` and assign it the result of the call to `JOptionPane` `static` method **`showInputDialog`**. This method displays an input dialog (see the screen capture in Fig. 26.2(a)), using the method's `String` argument (`"Enter first integer"`) as a prompt.


**Look-and-Feel Observation 26.2**

*The prompt in an input dialog typically uses **sentence-style capitalization**—a style that capitalizes only the first letter of the first word in the text unless the word is a proper noun (for example, Jones).*

The user types characters in the text field, then clicks **OK** or presses the *Enter* key to submit the `String` to the program. Clicking **OK** also **dismisses (hides) the dialog**. [*Note:* If you type in the text field and nothing appears, activate the text field by clicking it with the mouse.] Unlike `Scanner`, which can be used to input values of *several* types from the user at the keyboard, *an input dialog can input only* `String`*s*. This is typical of most GUI components. The user can type *any* characters in the input dialog's text field. Our program assumes that the user enters a *valid* integer. If the user clicks **Cancel**, `showInputDialog` returns `null`. If the user either types a noninteger value or clicks the **Cancel** button in the input dialog, an exception will occur and the program will not operate correctly. Lines 12–13 display another input dialog that prompts the user to enter the second integer. Each `JOptionPane` dialog that you display is a so called **modal dialog**—while the dialog is on the screen, the user *cannot* interact with the rest of the application.


**Look-and-Feel Observation 26.3**

*Do not overuse modal dialogs, as they can reduce the usability of your applications. Use a modal dialog* only *when it's necessary to prevent users from interacting with the rest of an application until they dismiss the dialog.*

### *Converting* `String`*s to* `int` *Values*

To perform the calculation, we convert the `String`s that the user entered to `int` values. Recall that the `Integer` class's `static` method `parseInt` converts its `String` argument to an `int` value and might throw a `NumberFormatException`. Lines 16–17 assign the converted values to local variables `number1` and `number2`, and line 19 sums these values.

### *Message Dialogs*

Lines 22–23 use `JOptionPane` `static` method **`showMessageDialog`** to display a message dialog (the last screen of Fig. 26.2) containing the sum. The first argument helps the Java application determine where to *position* the dialog box. A dialog is typically displayed from a GUI application with its own window. The first argument refers to that window (known as the *parent window*) and causes the dialog to appear centered over the parent (as we'll do in Section 26.9). If the first argument is `null`, the dialog box is displayed at the *center* of your screen. The second argument is the *message* to display—in this case, the result of concatenating the `String` `"The sum is "` and the value of `sum`. The third argument—`"Sum of Two Integers"`—is the `String` that should appear in the *title bar* at the top of the dialog. The fourth argument—**`JOptionPane.PLAIN_MESSAGE`**—is the *type of message dialog to display*. A `PLAIN_MESSAGE` dialog does *not* display an *icon* to the left of the message. Class `JOptionPane` provides several overloaded versions of methods `showInputDialog` and `showMessageDialog`, as well as methods that display other dialog types. For complete information, visit `http://docs.oracle.com/javase/8/docs/api/javax/swing/JOptionPane.html`.


**Look-and-Feel Observation 26.4**

*The title bar of a window typically uses* ***book-title capitalization****—a style that capitalizes the first letter of each significant word in the text and does not end with any punctuation (for example, Capitalization in a Book Title).*

### *JOptionPane Message Dialog Constants*

The constants that represent the message dialog types are shown in Fig. 26.3. All message dialog types except `PLAIN_MESSAGE` display an icon to the *left* of the message. These icons provide a visual indication of the message's importance to the user. A `QUESTION_MESSAGE` icon is the *default icon* for an input dialog box (see Fig. 26.2).

| Message dialog type | Icon | Description |
|---|---|---|
| `ERROR_MESSAGE` |  | Indicates an error. |
| `INFORMATION_MESSAGE` |  | Indicates an informational message. |
| `WARNING_MESSAGE` |  | Warns of a potential problem. |
| `QUESTION_MESSAGE` |  | Poses a question. This dialog normally requires a response, such as clicking a **Yes** or a **No** button. |
| `PLAIN_MESSAGE` | no icon | A dialog that contains a message, but no icon. |

**Fig. 26.3** | `JOptionPane` `static` constants for message dialogs.

## 26.4 Overview of Swing Components

Though it's possible to perform input and output using the `JOptionPane` dialogs, most GUI applications require more elaborate user interfaces. The remainder of this chapter discusses many GUI components that enable application developers to create robust GUIs. Figure 26.4 lists several basic Swing GUI components that we discuss.

| Component | Description |
|---|---|
| `JLabel` | Displays *uneditable text* and/or icons. |
| `JTextField` | Typically *receives input* from the user. |
| `JButton` | Triggers an event when clicked with the mouse. |
| `JCheckBox` | Specifies an option that can be *selected* or *not selected*. |
| `JComboBox` | A *drop-down list of items* from which the *user* can make a *selection*. |
| `JList` | A *list of items* from which the user can make a *selection* by *clicking* on *any one* of them. *Multiple* elements *can* be selected. |
| `JPanel` | An area in which *components* can be *placed* and *organized*. |

**Fig. 26.4** | Some basic Swing GUI components.

### *Swing vs. AWT*

There are actually *two* sets of Java GUI components. In Java's early days, GUIs were built with components from the **Abstract Window Toolkit** (AWT) in package **`java.awt`**.

These look like the native GUI components of the platform on which a Java program executes. For example, a `Button` object displayed in a Java program running on Microsoft Windows looks like those in other *Windows* applications. On Apple macOS, the `Button` looks like those in other *Mac* applications. Sometimes, even the manner in which a user can interact with an AWT component *differs between platforms*. The component's appearance and the way in which the user interacts with it are known as its **look-and-feel**.


**Look-and-Feel Observation 26.5**

*Swing GUI components allow you to specify a uniform look-and-feel for your application across* all *platforms* or *to use each platform's custom look-and-feel. An application can even* change *the look-and-feel during execution to enable users to choose their own preferred look-and-feel.*

### *Lightweight vs. Heavyweight GUI Components*

Most Swing components are **lightweight components**—they're written, manipulated and displayed completely in Java. AWT components are **heavyweight components**, because they rely on the local platform's **windowing system** to determine their functionality and their look-and-feel. Several Swing components are *heavyweight* components.

### *Superclasses of Swing's Lightweight GUI Components*

The UML class diagram of Fig. 26.5 shows an *inheritance hierarchy* of classes from which lightweight Swing components inherit their common attributes and behaviors.

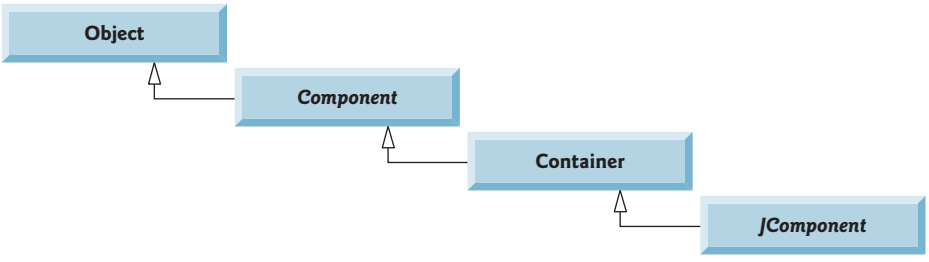



**Fig. 26.5** | Common superclasses of the lightweight Swing components.

Class **`Component`** (package `java.awt`) is a superclass that declares the common features of GUI components in packages `java.awt` and `javax.swing`. Any object that *is a* **`Container`** (package `java.awt`) can be used to organize `Components` by *attaching* the `Components` to the `Container`. `Containers` can be placed in other `Containers` to organize a GUI.

Class **`JComponent`** (package `javax.swing`) is a subclass of `Container`. `JComponent` is the superclass of all *lightweight* Swing components and declares their common attributes and behaviors. Because `JComponent` is a subclass of `Container`, all lightweight Swing components are also `Containers`. Some common features supported by `JComponent` include:

1. A **pluggable look-and-feel** for *customizing* the appearance of components (e.g., for use on particular platforms). You'll see an example of this in Section 35.6.
2. Shortcut keys (called **mnemonics**) for direct access to GUI components through the keyboard. You'll see an example of this in Section 35.4.

3. Brief descriptions of a GUI component's purpose (called **tool tips**) that are displayed when the *mouse cursor is positioned over the component* for a short time. You'll see an example of this in the next section.
4. Support for *accessibility*, such as braille screen readers for the visually impaired.
5. Support for user-interface **localization**—that is, customizing the user interface to display in different languages and use local cultural conventions.

## 26.5 Displaying Text and Images in a Window

Our next example introduces a framework for building GUI applications. Several concepts in this framework will appear in many of our GUI applications. This is our first example in which the application appears in its own window. Most windows you'll create that can contain Swing GUI components are instances of class `JFrame` or a subclass of `JFrame`. `JFrame` is an *indirect* subclass of class `java.awt.Window` that provides the basic attributes and behaviors of a window—a *title bar* at the top, and *buttons* to *minimize*, *maximize* and *close* the window. Since an application's GUI is typically specific to the application, most of our examples will consist of *two* classes—a subclass of `JFrame` that helps us demonstrate new GUI concepts and an application class in which `main` creates and displays the application's primary window.

### *Labeling GUI Components*

A typical GUI consists of many components. GUI designers often provide text stating the purpose of each. Such text is known as a **label** and is created with a **`JLabel`**—a subclass of `JComponent`. A `JLabel` displays read-only text, an image, or both text and an image. Applications rarely change a label's contents after creating it.


**Look-and-Feel Observation 26.6**

*Text in a `JLabel` normally uses sentence-style capitalization.*

The application of Figs. 26.6–26.7 demonstrates several `JLabel` features and presents the framework we use in most of our GUI examples. We did not highlight the code in this example, since most of it is new. [*Note:* There are many more features for each GUI component than we can cover in our examples. To learn the complete details of each GUI component, visit its page in the online documentation. For class `JLabel`, visit `http://docs.oracle.com/javase/8/docs/api/javax/swing/JLabel.html`.]

```
1  // Fig. 26.6: LabelFrame.java
2  // JLabels with text and icons.
3  import java.awt.FlowLayout; // specifies how components are arranged
4  import javax.swing.JFrame; // provides basic window features
5  import javax.swing.JLabel; // displays text and images
6  import javax.swing.SwingConstants; // common constants used with Swing
7  import javax.swing.Icon; // interface used to manipulate images
8  import javax.swing.ImageIcon; // loads images
9
```

**Fig. 26.6** | `JLabel`s with text and icons. (Part 1 of 2.)

```
10  public class LabelFrame extends JFrame
11  {
12     private final JLabel label1; // JLabel with just text
13     private final JLabel label2; // JLabel constructed with text and icon
14     private final JLabel label3; // JLabel with added text and icon
15
16     // LabelFrame constructor adds JLabels to JFrame
17     public LabelFrame()
18     {
19        super("Testing JLabel");
20        setLayout(new FlowLayout()); // set frame layout
21
22        // JLabel constructor with a string argument
23        label1 = new JLabel("Label with text");
24        label1.setToolTipText("This is label1");
25        add(label1); // add label1 to JFrame
26
27        // JLabel constructor with string, Icon and alignment arguments
28        Icon bug = new ImageIcon(getClass().getResource( "bug1.png"));
29        label2 = new JLabel("Label with text and icon", bug,
30           SwingConstants.LEFT);
31        label2.setToolTipText("This is label2");
32        add(label2); // add label2 to JFrame
33
34        label3 = new JLabel(); // JLabel constructor no arguments
35        label3.setText("Label with icon and text at bottom");
36        label3.setIcon(bug); // add icon to JLabel
37        label3.setHorizontalTextPosition(SwingConstants.CENTER);
38        label3.setVerticalTextPosition(SwingConstants.BOTTOM);
39        label3.setToolTipText("This is label3");
40        add(label3); // add label3 to JFrame
41     }
42  }
```

**Fig. 26.6** | `JLabel`s with text and icons. (Part 2 of 2.)

```
1  // Fig. 26.7: LabelTest.java
2  // Testing LabelFrame.
3  import javax.swing.JFrame;
4
5  public class LabelTest
6  {
7     public static void main(String[] args)
8     {
9        LabelFrame labelFrame = new LabelFrame();
10       labelFrame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
11       labelFrame.setSize(260, 180);
12       labelFrame.setVisible(true);
13    }
14 }
```

**Fig. 26.7** | Testing `LabelFrame`. (Part 1 of 2.)

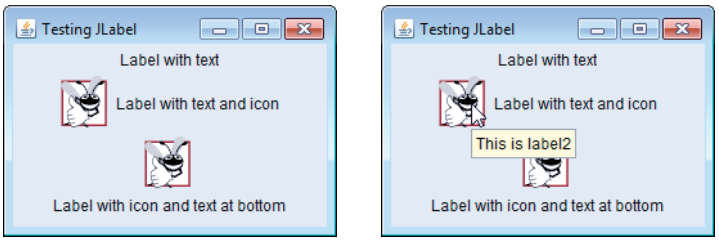



**Fig. 26.7** | Testing `LabelFrame`. (Part 2 of 2.)

Class `LabelFrame` (Fig. 26.6) extends `JFrame` to inherit the features of a window. We'll use an instance of class `LabelFrame` to display a window containing three `JLabel`s. Lines 12–14 declare the three `JLabel` instance variables that are instantiated in the `LabelFrame` constructor (lines 17–41). Typically, the `JFrame` subclass's constructor builds the GUI that's displayed in the window when the application executes. Line 19 invokes superclass `JFrame`'s constructor with the argument `"Testing JLabel"`. `JFrame`'s constructor uses this `String` as the text in the window's title bar.

### *Specifying the Layout*

When building a GUI, you must attach each GUI component to a container, such as a window created with a `JFrame`. Also, you typically must decide where to *position* each GUI component—known as *specifying the layout*. Java provides several **layout managers** that can help you position components, as you'll learn later in this chapter and in Chapter 35.

Many IDEs provide GUI design tools in which you can specify components' exact *sizes* and *locations* in a visual manner by using the mouse; then the IDE will generate the GUI code for you. Such IDEs can greatly simplify GUI creation.

To ensure that our GUIs can be used with *any* IDE, we did *not* use an IDE to create the GUI code. We use Java's layout managers to *size* and *position* components. With the **`FlowLayout`** layout manager, components are placed in a *container* from left to right in the order in which they're added. When no more components can fit on the current line, they continue to display left to right on the next line. If the container is *resized*, a `FlowLayout` *reflows* the components, possibly with fewer or more rows based on the new container width. Every container has a *default layout*, which we're changing for `LabelFrame` to a `FlowLayout` (line 20). Method **`setLayout`** is inherited into class `LabelFrame` indirectly from class `Container`. The argument to the method must be an object of a class that implements the `LayoutManager` interface (e.g., `FlowLayout`). Line 20 creates a new `FlowLayout` object and passes its reference as the argument to `setLayout`.

### *Creating and Attaching* `label1`

Now that we've specified the window's layout, we can begin creating and attaching GUI components to the window. Line 23 creates a `JLabel` object and passes `"Label with text"` to the constructor. The `JLabel` displays this text on the screen. Line 24 uses method **`setToolTipText`** (inherited by `JLabel` from `JComponent`) to specify the tool tip that's displayed when the user positions the mouse cursor over the `JLabel` in the GUI. You can see a sample tool tip in the second screen capture of Fig. 26.7. When you execute this appli-

cation, hover the mouse pointer over each `JLabel` to see its tool tip. Line 25 (Fig. 26.6) attaches `label1` to the `LabelFrame` by passing `label1` to the **`add`** method, which is inherited indirectly from class `Container`.

**Common Programming Error 26.1**

*If you do not* explicitly *add a GUI component to a container, the GUI component will not be displayed when the container appears on the screen.*


**Look-and-Feel Observation 26.7**

*Use tool tips to add descriptive text to your GUI components. This text helps the user determine the GUI component's purpose in the user interface.*

### *The `Icon` Interface and Class `ImageIcon`*

Icons are a popular way to enhance the look-and-feel of an application and are also commonly used to indicate functionality. For example, the same icon is used to play most of today's media on devices like DVD players and MP3 players. Several Swing components can display images. An icon is normally specified with an **`Icon`** (package `javax.swing`) argument to a constructor or to the component's **`setIcon`** method. Class **`ImageIcon`** supports several image formats, including Graphics Interchange Format (GIF), Portable Network Graphics (PNG) and Joint Photographic Experts Group (JPEG).

Line 28 declares an `ImageIcon`. The file `bug1.png` contains the image to load and store in the `ImageIcon` object. This image is included in the directory for this example. The `ImageIcon` object is assigned to `Icon` reference `bug`.

### *Loading an Image Resource*

In line 28, the expression `getClass().getResource("bug1.png")` invokes method **`getClass`** (inherited indirectly from class `Object`) to retrieve a reference to the `Class` object that represents the `LabelFrame` class declaration. That reference is then used to invoke `Class` method **`getResource`**, which returns the location of the image as a URL. The `ImageIcon` constructor uses the URL to locate the image, then loads it into memory. As we discussed in Chapter 1, the JVM loads class declarations into memory, using a class loader. The class loader knows where each class it loads is located on disk. Method `getResource` uses the `Class` object's class loader to determine the *location* of a resource, such as an image file. In this example, the image file is stored in the same location as the `LabelFrame.class` file. The techniques described here enable an application to load image files from locations that are relative to the class file's location.

### *Creating and Attaching `label2`*

Lines 29–30 use another `JLabel` constructor to create a `JLabel` that displays the text `"Label with text and icon"` and the `Icon bug` created in line 28. The last constructor argument indicates that the label's contents are left justified, or left aligned (i.e., the icon and text are at the left side of the label's area on the screen). Interface **`SwingConstants`** (package `javax.swing`) declares a set of common integer constants (such as `SwingConstants.LEFT`, `SwingConstants.CENTER` and `SwingConstants.RIGHT`) that are used with many Swing components. By default, the text appears to the right of the image when a label contains both text and an image. The horizontal and vertical alignments of a `JLabel` can be set with

methods **setHorizontalAlignment** and **setVerticalAlignment**, respectively. Line 31 specifies the tool-tip text for `label2`, and line 32 adds `label2` to the `JFrame`.

### *Creating and Attaching* `label3`

Class `JLabel` provides methods to change a `JLabel`'s appearance after it's been instantiated. Line 34 creates an empty `JLabel` with the no-argument constructor. Line 35 uses `JLabel` method **setText** to set the text displayed on the label. Method **getText** can be used to retrieve the `JLabel`'s current text. Line 36 uses `JLabel` method `setIcon` to specify the `Icon` to display. Method **getIcon** can be used to retrieve the current `Icon` displayed on a label. Lines 37–38 use `JLabel` methods **setHorizontalTextPosition** and **setVerticalTextPosition** to specify the text position in the label. In this case, the text will be centered *horizontally* and will appear at the *bottom* of the label. Thus, the `Icon` will appear *above* the text. The horizontal-position constants in `SwingConstants` are `LEFT`, `CENTER` and `RIGHT` (Fig. 26.8). The vertical-position constants in `SwingConstants` are `TOP`, `CENTER` and `BOTTOM` (Fig. 26.8). Line 39 (Fig. 26.6) sets the tool-tip text for `label3`. Line 40 adds `label3` to the `JFrame`.

| Constant | Description | Constant | Description |
|---|---|---|---|
| *Horizontal-position constants* | | *Vertical-position constants* | |
| `LEFT` | Place text on the left | `TOP` | Place text at the top |
| `CENTER` | Place text in the center | `CENTER` | Place text in the center |
| `RIGHT` | Place text on the right | `BOTTOM` | Place text at the bottom |

**Fig. 26.8** | Positioning constants (`static` members of interface `SwingConstants`).

### *Creating and Displaying a* `LabelFrame` *Window*

Class `LabelTest` (Fig. 26.7) creates an object of class `LabelFrame` (line 9), then specifies the default close operation for the window. By default, closing a window simply *hides* the window. However, when the user closes the `LabelFrame` window, we would like the application to *terminate*. Line 10 invokes `LabelFrame`'s **setDefaultCloseOperation** method (inherited from class `JFrame`) with constant **JFrame.EXIT_ON_CLOSE** as the argument to indicate that the program should *terminate* when the window is closed by the user. This line is important. Without it the application will *not* terminate when the user closes the window. Next, line 11 invokes `LabelFrame`'s **setSize** method to specify the *width* and *height* of the window in *pixels*. Finally, line 12 invokes `LabelFrame`'s **setVisible** method with the argument `true` to display the window on the screen. Try resizing the window to see how the `FlowLayout` changes the `JLabel` positions as the window width changes.

## 26.6 Text Fields and an Introduction to Event Handling with Nested Classes

Normally, a user interacts with an application's GUI to indicate the tasks that the application should perform. For example, when you write an e-mail in an e-mail application, clicking the **Send** button tells the application to send the e-mail to the specified e-mail addresses. GUIs are **event driven**. When the user interacts with a GUI component, the in-

teraction—known as an **event**—drives the program to perform a task. Some common user interactions that cause an application to perform a task include *clicking* a button, *typing* in a text field, *selecting* an item from a menu, *closing* a window and *moving* the mouse. The code that performs a task in response to an event is called an **event handler**, and the process of responding to events is known as **event handling**.

Let's consider two other GUI components that can generate events—**`JTextFields`** and **`JPasswordFields`** (package `javax.swing`). Class `JTextField` extends class **`JTextComponent`** (package `javax.swing.text`), which provides many features common to Swing's text-based components. Class `JPasswordField` extends `JTextField` and adds methods that are specific to processing passwords. Each of these components is a single-line area in which the user can enter text via the keyboard. Applications can also display text in a `JTextField` (see the output of Fig. 26.10). A `JPasswordField` shows that characters are being typed as the user enters them, but hides the actual characters with an **echo character**, assuming that they represent a password that should remain known only to the user.

When the user types in a `JTextField` or a `JPasswordField`, then presses *Enter*, an *event* occurs. Our next example demonstrates how a program can perform a task *in response* to that event. The techniques shown here are applicable to all GUI components that generate events.

The application of Figs. 26.9–26.10 uses classes `JTextField` and `JPasswordField` to create and manipulate four text fields. When the user types in one of the text fields, then presses *Enter*, the application displays a message dialog box containing the text the user typed. You can type only in the text field that's "in **focus**." When you *click* a component, it *receives the focus*. This is important, because the text field with the focus is the one that generates an event when you press *Enter*. In this example, when you press *Enter* in the `JPasswordField`, the password is revealed. We begin by discussing the setup of the GUI, then discuss the event-handling code.

```
1  // Fig. 26.9: TextFieldFrame.java
2  // JTextFields and JPasswordFields.
3  import java.awt.FlowLayout;
4  import java.awt.event.ActionListener;
5  import java.awt.event.ActionEvent;
6  import javax.swing.JFrame;
7  import javax.swing.JTextField;
8  import javax.swing.JPasswordField;
9  import javax.swing.JOptionPane;
10
11 public class TextFieldFrame extends JFrame
12 {
13    private final JTextField textField1; // text field with set size
14    private final JTextField textField2; // text field with text
15    private final JTextField textField3; // text field with text and size
16    private final JPasswordField passwordField; // password field with text
17
18    // TextFieldFrame constructor adds JTextFields to JFrame
19    public TextFieldFrame()
20    {
```

**Fig. 26.9** | `JTextFields` and `JPasswordFields`. (Part 1 of 3.)

```
21          super("Testing JTextField and JPasswordField");
22          setLayout(new FlowLayout());
23
24          // construct text field with 10 columns
25          textField1 = new JTextField(10);
26          add(textField1); // add textField1 to JFrame
27
28          // construct text field with default text
29          textField2 = new JTextField("Enter text here");
30          add(textField2); // add textField2 to JFrame
31
32          // construct text field with default text and 21 columns
33          textField3 = new JTextField("Uneditable text field", 21);
34          textField3.setEditable(false); // disable editing
35          add(textField3); // add textField3 to JFrame
36
37          // construct password field with default text
38          passwordField = new JPasswordField("Hidden text");
39          add(passwordField); // add passwordField to JFrame
40
41          // register event handlers
42          TextFieldHandler handler = new TextFieldHandler();
43          textField1.addActionListener(handler);
44          textField2.addActionListener(handler);
45          textField3.addActionListener(handler);
46          passwordField.addActionListener(handler);
47       }
48
49       // private inner class for event handling
50       private class TextFieldHandler implements ActionListener
51       {
52          // process text field events
53          @Override
54          public void actionPerformed(ActionEvent event)
55          {
56             String string = "";
57
58             // user pressed Enter in JTextField textField1
59             if (event.getSource() == textField1)
60                string = String.format("textField1: %s",
61                   event.getActionCommand());
62
63             // user pressed Enter in JTextField textField2
64             else if (event.getSource() == textField2)
65                string = String.format("textField2: %s",
66                   event.getActionCommand());
67
68             // user pressed Enter in JTextField textField3
69             else if (event.getSource() == textField3)
70                string = String.format("textField3: %s",
71                   event.getActionCommand());
72
```

**Fig. 26.9** | `JTextFields` and `JPasswordFields`. (Part 2 of 3.)

```
            // user pressed Enter in JTextField passwordField
            else if (event.getSource() == passwordField)
               string = String.format("passwordField: %s",
                  event.getActionCommand());

            // display JTextField content
            JOptionPane.showMessageDialog(null, string);
         }
      } // end private inner class TextFieldHandler
   }
```

**Fig. 26.9** | `JTextFields` and `JPasswordFields`. (Part 3 of 3.)

Class `TextFieldFrame` extends `JFrame` and declares three `JTextField` variables and a `JPasswordField` variable (lines 13–16). Each of the corresponding text fields is instantiated and attached to the `TextFieldFrame` in the constructor (lines 19–47).

### *Creating the GUI*

Line 22 sets the `TextFieldFrame`'s layout to `FlowLayout`. Line 25 creates `textField1` with `10` columns of text. A text column's width in *pixels* is determined by the average width of a character in the text field's current font. When text is displayed in a text field and the text is wider than the field itself, a portion of the text at the right side is not visible. If you're typing in a text field and the cursor reaches the right edge, the text at the left edge is pushed off the left side of the field and is no longer visible. Users can use the left and right arrow keys to move through the complete text. Line 26 adds `textField1` to the `JFrame`.

Line 29 creates `textField2` with the initial text `"Enter text here"` to display in the text field. The width of the field is determined by the width of the default text specified in the constructor. Line 30 adds `textField2` to the `JFrame`.

Line 33 creates `textField3` and calls the `JTextField` constructor with two arguments—the default text `"Uneditable text field"` to display and the text field's width in columns (`21`). Line 34 uses method **`setEditable`** (inherited by `JTextField` from class `JTextComponent`) to make the text field *uneditable*—i.e., the user cannot modify the text in the field. Line 35 adds `textField3` to the `JFrame`.

Line 38 creates `passwordField` with the text `"Hidden text"` to display in the text field. The width of the field is determined by the width of the default text. When you execute the application, notice that the text is displayed as a string of asterisks. Line 39 adds `passwordField` to the `JFrame`.

### *Steps Required to Set Up Event Handling for a GUI Component*

This example should display a message dialog containing the text from a text field when the user presses *Enter* in that text field. Before an application can respond to an event for a particular GUI component, you must:

1. Create a class that represents the event handler and implements an appropriate interface—known as an **event-listener interface**.
2. Indicate that an object of the class from *Step 1* should be notified when the event occurs—known as **registering the event handler**.

### *Using a Nested Class to Implement an Event Handler*

All the classes discussed so far were so-called **top-level classes**—that is, they *were* not declared *inside* another class. Java allows you to declare classes *inside* other classes—these are called **nested classes**. Nested classes can be `static` or non-`static`. Non-`static` nested classes are called **inner classes** and are frequently used to implement *event handlers*.

An inner-class object must be created by an object of the top-level class that contains the inner class. Each inner-class object *implicitly* has a reference to an object of its top-level class. The inner-class object is allowed to use this implicit reference to directly access all the variables and methods of the top-level class. A nested class that's `static` does not require an object of its top-level class and does not implicitly have a reference to an object of the top-level class. As you'll see in Chapter 27, Graphics and Java 2D, the Java 2D graphics API uses `static` nested classes extensively.

### *Inner Class* `TextFieldHandler`

The event handling in this example is performed by an object of the `private` *inner class* `TextFieldHandler` (lines 50–81). This class is `private` because it will be used only to create event handlers for the text fields in top-level class `TextFieldFrame`. As with other class members, *inner classes* can be declared `public`, `protected` or `private`. Since event handlers tend to be specific to the application in which they're defined, they're often implemented as `private` inner classes or as *anonymous inner classes* (Section 26.11).

GUI components can generate many events in response to user interactions. Each event is represented by a class and can be processed only by the appropriate type of event handler. Normally, a component's supported events are described in the Java API documentation for that component's class and its superclasses. When the user presses *Enter* in a `JTextField` or `JPasswordField`, an **`ActionEvent`** (package `java.awt.event`) occurs. Such an event is processed by an object that implements the interface **`ActionListener`** (package `java.awt.event`). The information discussed here is available in the Java API documentation for classes `JTextField` and `ActionEvent`. Since `JPasswordField` is a subclass of `JTextField`, `JPasswordField` supports the same events.

To prepare to handle the events in this example, inner class `TextFieldHandler` implements interface `ActionListener` and declares the only method in that interface—`actionPerformed` (lines 53–80). This method specifies the tasks to perform when an `ActionEvent` occurs. So, inner class `TextFieldHandler` satisfies *Step 1* listed earlier in this section. We'll discuss the details of method `actionPerformed` shortly.

### *Registering the Event Handler for Each Text Field*

In the `TextFieldFrame` constructor, line 42 creates a `TextFieldHandler` object and assigns it to variable `handler`. This object's `actionPerformed` method will be called automatically when the user presses *Enter* in any of the GUI's text fields. However, before this can occur, the program must register this object as the event handler for each text field. Lines 43–46 are the *event-registration* statements that specify `handler` as the event handler for the three `JTextFields` and the `JPasswordField`. The application calls `JTextField` method **`addActionListener`** to register the event handler for each component. This method receives as its argument an `ActionListener` object, which can be an object of any class that implements `ActionListener`. The object `handler` *is an* `ActionListener`, because class `TextFieldHandler` implements `ActionListener`. After lines 43–46 execute, the object `handler` **listens for events**. Now, when the user presses *Enter* in any of these four text

fields, method `actionPerformed` (line 53–80) in class `TextFieldHandler` is called to handle the event. If an event handler is *not* registered for a particular text field, the event that occurs when the user presses *Enter* in that text field is **consumed**—i.e., it's simply *ignored* by the application.

**Software Engineering Observation 26.1**

*The event listener for an event must implement the appropriate event-listener interface.*

**Common Programming Error 26.2**

*If you forget to register an event-handler object for a particular GUI component's event type, events of that type will be ignored.*

### *Details of Class `TextFieldHandler`'s `actionPerformed` Method*

In this example, we use one event-handling object's `actionPerformed` method (lines 53–80) to handle the events generated by four text fields. Since we'd like to output the name of each text field's instance variable for demonstration purposes, we must determine *which* text field generated the event each time `actionPerformed` is called. The **event source** is the component with which the user interacted. When the user presses *Enter* while a text field or the password field *has the focus*, the system creates a unique `ActionEvent` object that contains information about the event that just occurred, such as the event source and the text in the text field. The system passes this `ActionEvent` object to the event listener's `actionPerformed` method. Line 56 declares the `String` that will be displayed. The variable is initialized with the **empty string**—a `String` containing no characters. The compiler requires the variable to be initialized in case none of the branches of the nested `if` in lines 59–76 executes.

`ActionEvent` method `getSource` (called in lines 59, 64, 69 and 74) returns a reference to the event source. The condition in line 59 asks, "Is the event source `textField1`?" This condition compares references with the `==` operator to determine if they refer to the same object. If they *both* refer to `textField1`, the user pressed *Enter* in `textField1`. Then, lines 60–61 create a `String` containing the message that line 79 displays in a message dialog. Line 61 uses `ActionEvent` method **`getActionCommand`** to obtain the text the user typed in the text field that generated the event.

In this example, we display the text of the password in the `JPasswordField` when the user presses *Enter* in that field. Sometimes it's necessary to programatically process the characters in a password. Class `JPasswordField` method **`getPassword`** returns the password's characters as an array of type `char`.

### *Class `TextFieldTest`*

Class `TextFieldTest` (Fig. 26.10) contains the `main` method that executes this application and displays an object of class `TextFieldFrame`. When you execute the application, even the uneditable `JTextField` (`textField3`) can generate an `ActionEvent`. To test this, click the text field to give it the focus, then press *Enter*. Also, the actual text of the password is displayed when you press *Enter* in the `JPasswordField`. Of course, you would normally not display the password!

This application used a single object of class `TextFieldHandler` as the event listener for four text fields. Starting in Section 26.10, you'll see that it's possible to declare several

```
1  // Fig. 26.10: TextFieldTest.java
2  // Testing TextFieldFrame.
3  import javax.swing.JFrame;
4
5  public class TextFieldTest
6  {
7     public static void main(String[] args)
8     {
9        TextFieldFrame textFieldFrame = new TextFieldFrame();
10       textFieldFrame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
11       textFieldFrame.setSize(350, 100);
12       textFieldFrame.setVisible(true);
13    }
14 }
```

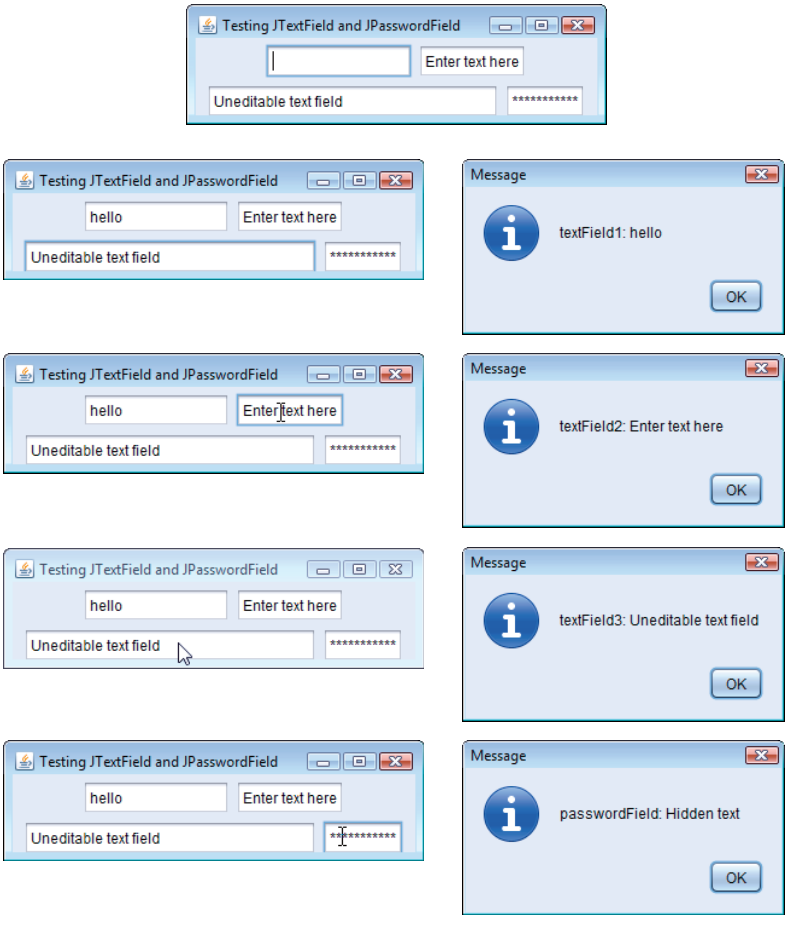



**Fig. 26.10** | Testing `TextFieldFrame`.

event-listener objects of the same type and register each object for a separate GUI component's event. This technique enables us to eliminate the `if...else` logic used in this example's event handler by providing separate event handlers for each component's events.

8 *Java SE 8: Implementing Event Listeners with Lambdas*
Recall that interfaces like `ActionListener` that have only one `abstract` method are functional interfaces in Java SE 8. In Section 17.16, we showed how to use lambdas to implement such event-listener interfaces.

## 26.7 Common GUI Event Types and Listener Interfaces

In Section 26.6, you learned that information about the event that occurs when the user presses *Enter* in a text field is stored in an `ActionEvent` object. Many different types of events can occur when the user interacts with a GUI. The event information is stored in an object of a class that extends `AWTEvent` (from package `java.awt`). Figure 26.11 illustrates a hierarchy containing many event classes from the package **`java.awt.event`**. Some of these are discussed in this chapter and Chapter 35. These event types are used with both AWT and Swing components. Additional event types that are specific to Swing GUI components are declared in package **`javax.swing.event`**.

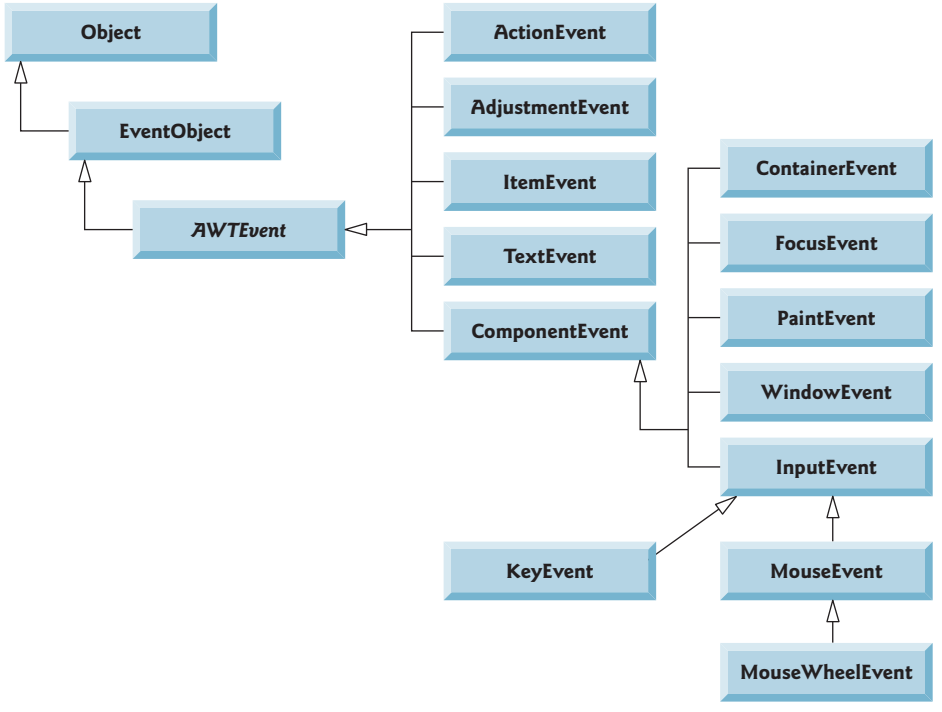



**Fig. 26.11** | Some event classes of package `java.awt.event`.

Let's summarize the three parts to the event-handling mechanism that you saw in Section 26.6—the *event source*, the *event object* and the *event listener*. The event source is

the GUI component with which the user interacts. The event object encapsulates information about the event that occurred, such as a reference to the event source and any event-specific information that may be required by the event listener for it to handle the event. The event listener is an object that's notified by the event source when an event occurs; in effect, it "listens" for an event, and one of its methods executes in response to the event. A method of the event listener receives an event object when the event listener is notified of the event. The event listener then uses the event object to respond to the event. This event-handling model is known as the **delegation event model**—an event's processing is delegated to an object (the event listener) in the application.

For each event-object type, there's typically a corresponding event-listener interface. An event listener for a GUI event is an object of a class that implements one or more of the event-listener interfaces from packages `java.awt.event` and `javax.swing.event`. Many of the event-listener types are common to both Swing and AWT components. Such types are declared in package `java.awt.event`, and some of them are shown in Fig. 26.12. Additional event-listener types that are specific to Swing components are declared in package `javax.swing.event`.

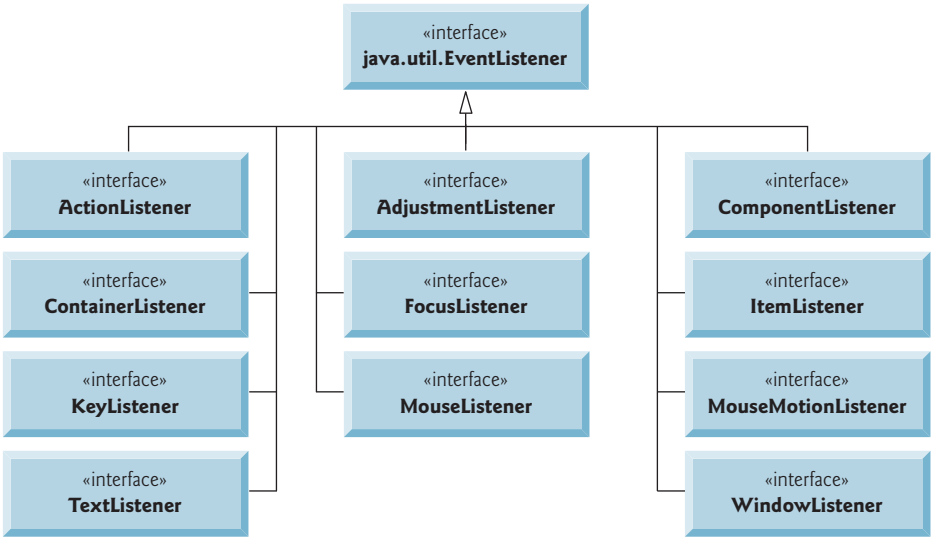



**Fig. 26.12** | Some common event-listener interfaces of package `java.awt.event`.

Each event-listener interface specifies one or more event-handling methods that *must* be declared in the class that implements the interface. Recall from Section 10.9 that any class which implements an interface must declare *all* the `abstract` methods of that interface; otherwise, the class is an `abstract` class and cannot be used to create objects.

When an event occurs, the GUI component with which the user interacted notifies its *registered listeners* by calling each listener's appropriate *event-handling method*. For example, when the user presses the *Enter* key in a `JTextField`, the registered listener's `actionPerformed` method is called. In the next section, we complete our discussion of how the event handling works in the preceding example.

## 26.8 How Event Handling Works

Let's illustrate how the event-handling mechanism works, using `textField1` from the example of Fig. 26.9. We have two remaining open questions from Section 26.7:

1. How did the *event handler* get *registered*?
2. How does the GUI component know to call `actionPerformed` rather than some other event-handling method?

The first question is answered by the event registration performed in lines 43–46 of Fig. 26.9. Figure 26.13 diagrams `JTextField` variable `textField1`, `TextFieldHandler` variable `handler` and the objects to which they refer.

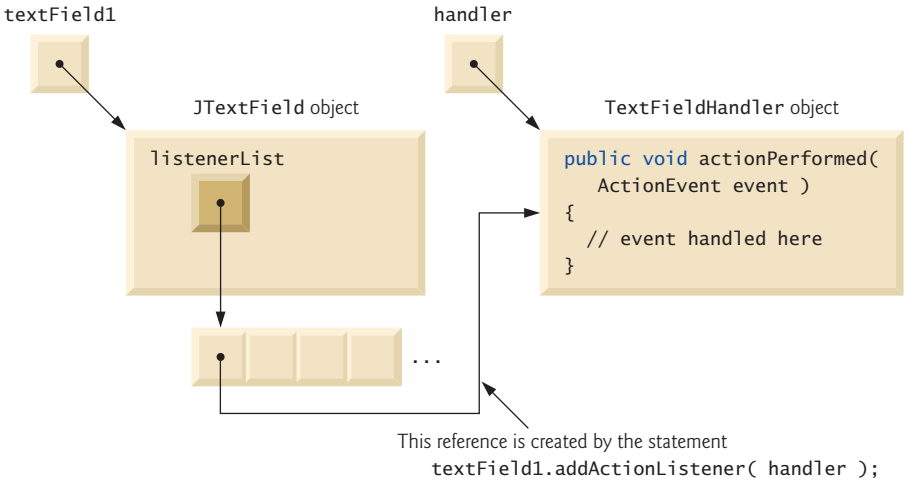



**Fig. 26.13** | Event registration for `JTextField` `textField1`.

### *Registering Events*

Every `JComponent` has an instance variable called `listenerList` that refers to an object of class **`EventListenerList`** (package `javax.swing.event`). Each object of a `JComponent` subclass maintains references to its *registered listeners* in the `listenerList`. For simplicity, we've diagramed `listenerList` as an array below the `JTextField` object in Fig. 26.13.

When the following statement (line 43 of Fig. 26.9) executes

```
textField1.addActionListener(handler);
```

a new entry containing a reference to the `TextFieldHandler` object is placed in `textField1`'s `listenerList`. Although not shown in the diagram, this new entry also includes the listener's type (`ActionListener`). Using this mechanism, each lightweight Swing component maintains its own list of *listeners* that were *registered* to *handle* the component's *events*.

### *Event-Handler Invocation*

The event-listener type is important in answering the second question: How does the GUI component know to call `actionPerformed` rather than another method? Every GUI component supports several *event types*, including **mouse events**, **key events** and others. When

an event occurs, the event is **dispatched** only to the *event listeners* of the appropriate type. Dispatching is simply the process by which the GUI component calls an event-handling method on each of its listeners that are registered for the event type that occurred.

Each *event type* has one or more corresponding *event-listener interfaces*. For example, `ActionEvents` are handled by `ActionListeners`, **`MouseEvents`** by **`MouseListeners`** and **`MouseMotionListeners`**, and **`KeyEvents`** by **`KeyListeners`**. When an event occurs, the GUI component receives (from the JVM) a unique *event ID* specifying the event type. The GUI component uses the event ID to decide the listener type to which the event should be dispatched and to decide which method to call on each listener object. For an `ActionEvent`, the event is dispatched to *every* registered `ActionListener`'s `actionPerformed` method (the only method in interface `ActionListener`). For a `MouseEvent`, the event is dispatched to *every* registered `MouseListener` or `MouseMotionListener`, depending on the mouse event that occurs. The `MouseEvent`'s event ID determines which of the several mouse event-handling methods are called. All these decisions are handled for you by the GUI components. All you need to do is register an event handler for the particular event type that your application requires, and the GUI component will ensure that the event handler's appropriate method gets called when the event occurs. We discuss other event types and event-listener interfaces as they're needed with each new component we introduce.

**Performance Tip 26.1**

*GUIs should always remain responsive to the user. Performing a long-running task in an event handler prevents the user from interacting with the GUI until that task completes. Section 23.11 demonstrates techniques prevent such problems.*

## 26.9 JButton

A **button** is a component the user clicks to trigger a specific action. A Java application can use several types of buttons, including **command buttons**, **checkboxes**, **toggle buttons** and **radio buttons**. Figure 26.14 shows the inheritance hierarchy of the Swing buttons we cover in this chapter. As you can see, all the button types are subclasses of **`AbstractButton`** (package `javax.swing`), which declares the common features of Swing buttons. In this section, we concentrate on buttons that are typically used to initiate a command.

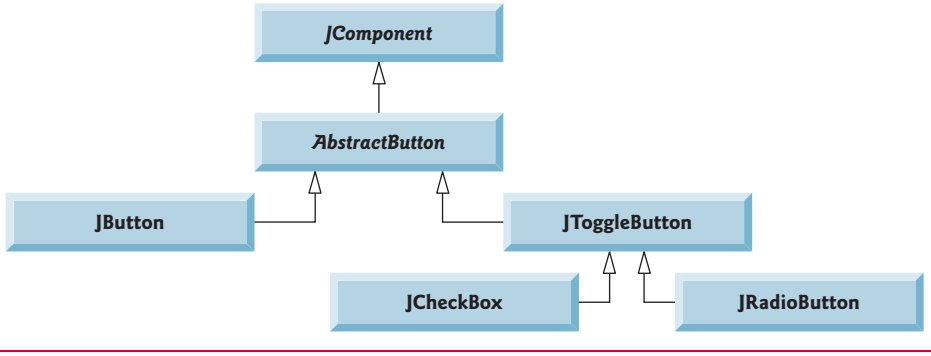



**Fig. 26.14** | Swing button hierarchy.

A *command button* (see Fig. 26.16's output) generates an `ActionEvent` when the user clicks it. Command buttons are created with class **`JButton`**. The text on the face of a `JButton` is called a **button label**.


### Look-and-Feel Observation 26.8

*The text on buttons typically uses book-title capitalization.*


### Look-and-Feel Observation 26.9

*A GUI can have many `JButtons`, but each button label should be unique in the portion of the GUI that's currently displayed. Having more than one `JButton` with the same label makes the `JButtons` ambiguous to the user.*

The application of Figs. 26.15 and 26.16 creates two `JButtons` and demonstrates that `JButtons` can display `Icons`. Event handling for the buttons is performed by a single instance of *inner class* `ButtonHandler` (Fig. 26.15, lines 39–48).

```
1  // Fig. 26.15: ButtonFrame.java
2  // Command buttons and action events.
3  import java.awt.FlowLayout;
4  import java.awt.event.ActionListener;
5  import java.awt.event.ActionEvent;
6  import javax.swing.JFrame;
7  import javax.swing.JButton;
8  import javax.swing.Icon;
9  import javax.swing.ImageIcon;
10 import javax.swing.JOptionPane;
11
12 public class ButtonFrame extends JFrame
13 {
14    private final JButton plainJButton; // button with just text
15    private final JButton fancyJButton; // button with icons
16
17    // ButtonFrame adds JButtons to JFrame
18    public ButtonFrame()
19    {
20       super("Testing Buttons");
21       setLayout(new FlowLayout());
22
23       plainJButton = new JButton("Plain Button"); // button with text
24       add(plainJButton); // add plainJButton to JFrame
25
26       Icon bug1 = new ImageIcon(getClass().getResource("bug1.gif"));
27       Icon bug2 = new ImageIcon(getClass().getResource("bug2.gif"));
28       fancyJButton = new JButton("Fancy Button", bug1); // set image
29       fancyJButton.setRolloverIcon(bug2); // set rollover image
30       add(fancyJButton); // add fancyJButton to JFrame
31
32       // create new ButtonHandler for button event handling
33       ButtonHandler handler = new ButtonHandler();
```

**Fig. 26.15** | Command buttons and action events. (Part 1 of 2.)

```
34          fancyJButton.addActionListener(handler);
35          plainJButton.addActionListener(handler);
36       }
37
38       // inner class for button event handling
39       private class ButtonHandler implements ActionListener
40       {
41          // handle button event
42          @Override
43          public void actionPerformed(ActionEvent event)
44          {
45             JOptionPane.showMessageDialog(ButtonFrame.this, String.format(
46                "You pressed: %s", event.getActionCommand()));
47          }
48       }
49    }
```

**Fig. 26.15** | Command buttons and action events. (Part 2 of 2.)

Lines 14–15 declare `JButton` variables `plainJButton` and `fancyJButton`. The corresponding objects are instantiated in the constructor. Line 23 creates `plainJButton` with the button label `"Plain Button"`. Line 24 adds the `JButton` to the `JFrame`.

A `JButton` can display an `Icon`. To provide the user with an extra level of visual interaction with the GUI, a `JButton` can also have a **rollover `Icon`**—an `Icon` that's displayed when the user positions the mouse over the `JButton`. The icon on the `JButton` changes as the mouse moves in and out of the `JButton`'s area on the screen. Lines 26–27 create two `ImageIcon` objects that represent the default `Icon` and rollover `Icon` for the `JButton` created at line 28. Both statements assume that the image files are stored in the *same* directory as the application. Images are commonly placed in the *same* directory as the application or a subdirectory like `images`). These image files have been provided for you with the example.

Line 28 creates `fancyButton` with the text `"Fancy Button"` and the icon `bug1`. By default, the text is displayed to the *right* of the icon. Line 29 uses **`setRolloverIcon`** (inherited from class `AbstractButton`) to specify the image displayed on the `JButton` when the user positions the mouse over it. Line 30 adds the `JButton` to the `JFrame`.


**Look-and-Feel Observation 26.10**

*Because class `AbstractButton` supports displaying text and images on a button, all subclasses of `AbstractButton` also support displaying text and images.*


**Look-and-Feel Observation 26.11**

*Rollover icons provide visual feedback indicating that an action will occur when when a `JButton` is clicked.*

`JButtons`, like `JTextFields`, generate `ActionEvents` that can be processed by any `ActionListener` object. Lines 33–35 create an object of `private` *inner class* `ButtonHandler` and use `addActionListener` to *register* it as the *event handler* for each `JButton`. Class `ButtonHandler` (lines 39–48) declares `actionPerformed` to display a message dialog box

containing the label for the button the user pressed. For a `JButton` event, `ActionEvent` method `getActionCommand` returns the label on the `JButton`.

```
1  // Fig. 26.16: ButtonTest.java
2  // Testing ButtonFrame.
3  import javax.swing.JFrame;
4
5  public class ButtonTest
6  {
7     public static void main(String[] args)
8     {
9        ButtonFrame buttonFrame = new ButtonFrame();
10       buttonFrame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
11       buttonFrame.setSize(275, 110);
12       buttonFrame.setVisible(true);
13    }
14 }
```

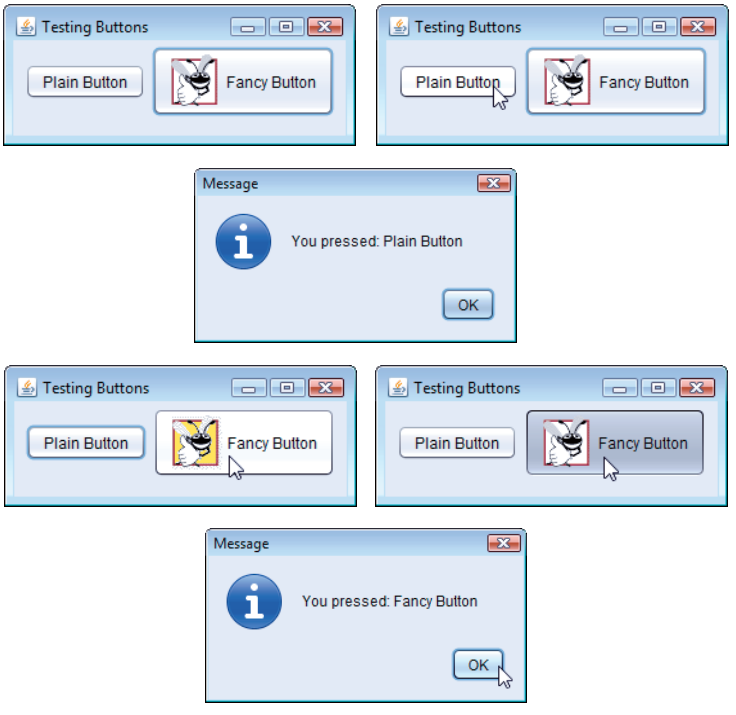



**Fig. 26.16** | Testing `ButtonFrame`.

### *Accessing the `this` Reference in an Object of a Top-Level Class from an Inner Class*

When you execute this application and click one of its buttons, notice that the message dialog that appears is centered over the application's window. This occurs because the call to `JOptionPane` method `showMessageDialog` (lines 45–46) uses `ButtonFrame.this` rather than `null` as the first argument. When this argument is not `null`, it represents the so-called

*parent GUI component* of the message dialog (in this case the application window is the parent component) and enables the dialog to be centered over that component when the dialog is displayed. `ButtonFrame.this` represents the `this` reference of the object of top-level class `ButtonFrame`.

**Software Engineering Observation 26.2**

*When used in an inner class, keyword `this` refers to the current inner-class object being manipulated. An inner-class method can use its outer-class object's `this` by preceding `this` with the outer-class name and a dot (.) separator, as in `ButtonFrame.this`.*

## 26.10 Buttons That Maintain State

The Swing GUI components contain three types of **state buttons**—**`JToggleButton`**, **`JCheckBox`** and **`JRadioButton`**—that have on/off or true/false values. Classes `JCheckBox` and `JRadioButton` are subclasses of `JToggleButton` (Fig. 26.14). A `JRadioButton` is different from a `JCheckBox` in that normally several `JRadioButtons` are grouped together and are *mutually exclusive*—only *one* in the group can be selected at any time, just like the buttons on a car radio. We first discuss class `JCheckBox`.

### 26.10.1 JCheckBox

The application of Figs. 26.17–26.18 uses two `JCheckBoxes` to select the desired font style of the text displayed in a `JTextField`. When selected, one applies a bold style and the other an italic style. If *both* are selected, the style is bold *and* italic. When the application initially executes, neither `JCheckBox` is checked (i.e., they're both `false`), so the font is plain. Class `CheckBoxTest` (Fig. 26.18) contains the `main` method that executes this application.

```
1  // Fig. 26.17: CheckBoxFrame.java
2  // JCheckBoxes and item events.
3  import java.awt.FlowLayout;
4  import java.awt.Font;
5  import java.awt.event.ItemListener;
6  import java.awt.event.ItemEvent;
7  import javax.swing.JFrame;
8  import javax.swing.JTextField;
9  import javax.swing.JCheckBox;
10
11 public class CheckBoxFrame extends JFrame
12 {
13    private final JTextField textField; // displays text in changing fonts
14    private final JCheckBox boldJCheckBox; // to select/deselect bold
15    private final JCheckBox italicJCheckBox; // to select/deselect italic
16
17    // CheckBoxFrame constructor adds JCheckBoxes to JFrame
18    public CheckBoxFrame()
19    {
20       super("JCheckBox Test");
21       setLayout(new FlowLayout());
22
```

**Fig. 26.17** | `JCheckBoxes` and item events. (Part 1 of 2.)

```
23          // set up JTextField and set its font
24          textField = new JTextField("Watch the font style change", 20);
25          textField.setFont(new Font("Serif", Font.PLAIN, 14));
26          add(textField); // add textField to JFrame
27
28          boldJCheckBox = new JCheckBox("Bold");
29          italicJCheckBox = new JCheckBox("Italic");
30          add(boldJCheckBox); // add bold checkbox to JFrame
31          add(italicJCheckBox); // add italic checkbox to JFrame
32
33          // register listeners for JCheckBoxes
34          CheckBoxHandler handler = new CheckBoxHandler();
35          boldJCheckBox.addItemListener(handler);
36          italicJCheckBox.addItemListener(handler);
37       }
38
39       // private inner class for ItemListener event handling
40       private class CheckBoxHandler implements ItemListener
41       {
42          // respond to checkbox events
43          @Override
44          public void itemStateChanged(ItemEvent event)
45          {
46             Font font = null; // stores the new Font
47
48             // determine which CheckBoxes are checked and create Font
49             if (boldJCheckBox.isSelected() && italicJCheckBox.isSelected())
50                font = new Font("Serif", Font.BOLD + Font.ITALIC, 14);
51             else if (boldJCheckBox.isSelected())
52                font = new Font("Serif", Font.BOLD, 14);
53             else if (italicJCheckBox.isSelected())
54                font = new Font("Serif", Font.ITALIC, 14);
55             else
56                font = new Font("Serif", Font.PLAIN, 14);
57
58             textField.setFont(font);
59          }
60       }
61    }
```

**Fig. 26.17** | JCheckBoxes and item events. (Part 2 of 2.)

```
1  // Fig. 26.18: CheckBoxTest.java
2  // Testing CheckBoxFrame.
3  import javax.swing.JFrame;
4
5  public class CheckBoxTest
6  {
7     public static void main(String[] args)
8     {
9        CheckBoxFrame checkBoxFrame = new CheckBoxFrame();
10       checkBoxFrame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
```

**Fig. 26.18** | Testing CheckBoxFrame. (Part 1 of 2.)

```
11          checkBoxFrame.setSize(275, 100);
12          checkBoxFrame.setVisible(true);
13       }
14    }
```

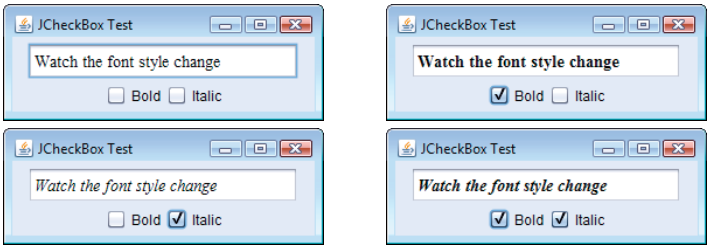



**Fig. 26.18** | Testing `CheckBoxFrame`. (Part 2 of 2.)

After the `JTextField` is created and initialized (Fig. 26.17, line 24), line 25 uses method **`setFont`** (inherited by `JTextField` indirectly from class `Component`) to set the font of the `JTextField` to a new object of class **`Font`** (package `java.awt`). The new `Font` is initialized with `"Serif"` (a generic font name that represents a font such as Times and is supported on all Java platforms), `Font.PLAIN` style and `14`-point size. Next, lines 28–29 create two `JCheckBox` objects. The `String` passed to the `JCheckBox` constructor is the **checkbox label** that appears to the right of the `JCheckBox` by default.

When the user clicks a `JCheckBox`, an **`ItemEvent`** occurs. This event can be handled by an **`ItemListener`** object, which *must* implement method **`itemStateChanged`**. In this example, the event handling is performed by an instance of `private` *inner class* `CheckBoxHandler` (lines 40–60). Lines 34–36 create an instance of class `CheckBoxHandler` and register it with method **`addItemListener`** as the listener for both the `JCheckBox` objects.

`CheckBoxHandler` method `itemStateChanged` (lines 43–59) is called when the user clicks the `boldJCheckBox` or `italicJCheckBox`. In this example, we do not determine which `JCheckBox` was clicked—we use both states to determine the font to display. Line 49 uses `JCheckBox` method **`isSelected`** to determine if both `JCheckBox`es are selected. If so, line 50 creates a bold italic font by adding the `Font` constants `Font.BOLD` and `Font.ITALIC` for the font-style argument of the `Font` constructor. Line 51 determines whether the `boldJCheckBox` is selected, and if so line 52 creates a bold font. Line 53 determines whether the `italicJCheckBox` is selected, and if so line 54 creates an italic font. If none of the preceding conditions are true, line 56 creates a plain font using the `Font` constant `Font.PLAIN`. Finally, line 58 sets `textField`'s new font, which changes the font in the `JTextField` on the screen.

### *Relationship Between an Inner Class and Its Top-Level Class*

Class `CheckBoxHandler` used variables `boldJCheckBox` (lines 49 and 51), `italicJCheckBox` (lines 49 and 53) and `textField` (line 58) even though they are *not* declared in the inner class. Recall that an *inner class* has a special relationship with its *top-level class*—it's allowed to access *all* the variables and methods of the top-level class. `CheckBoxHandler` method `itemStateChanged` (line 43–59) uses this relationship to determine which `JCheckBox`es are checked and to set the font on the `JTextField`. Notice that none of the code in inner class `CheckBoxHandler` requires an explicit reference to the top-level class object.

### 26.10.2 JRadioButton

**Radio buttons** (declared with class `JRadioButton`) are similar to checkboxes in that they have two states—*selected* and *not selected* (also called *deselected*). However, radio buttons normally appear as a **group** in which only *one* button can be selected at a time (see the output of Fig. 26.20). Radio buttons are used to represent **mutually exclusive options** (i.e., multiple options in the group *cannot* be selected at the same time). The logical relationship between radio buttons is maintained by a **`ButtonGroup`** object (package `javax.swing`), which itself is *not* a GUI component. A `ButtonGroup` object organizes a group of buttons and is *not* itself displayed in a user interface. Rather, the individual `JRadioButton` objects from the group are displayed in the GUI.

The application of Figs. 26.19–26.20 is similar to that of Figs. 26.17–26.18. The user can alter the font style of a `JTextField`'s text. The application uses radio buttons that permit only a single font style in the group to be selected at a time. Class `RadioButtonTest` (Fig. 26.20) contains the `main` method that executes this application.

```
1  // Fig. 26.19: RadioButtonFrame.java
2  // Creating radio buttons using ButtonGroup and JRadioButton.
3  import java.awt.FlowLayout;
4  import java.awt.Font;
5  import java.awt.event.ItemListener;
6  import java.awt.event.ItemEvent;
7  import javax.swing.JFrame;
8  import javax.swing.JTextField;
9  import javax.swing.JRadioButton;
10 import javax.swing.ButtonGroup;
11
12 public class RadioButtonFrame extends JFrame
13 {
14    private final JTextField textField; // used to display font changes
15    private final Font plainFont; // font for plain text
16    private final Font boldFont; // font for bold text
17    private final Font italicFont; // font for italic text
18    private final Font boldItalicFont; // font for bold and italic text
19    private final JRadioButton plainJRadioButton; // selects plain text
20    private final JRadioButton boldJRadioButton; // selects bold text
21    private final JRadioButton italicJRadioButton; // selects italic text
22    private final JRadioButton boldItalicJRadioButton; // bold and italic
23    private final ButtonGroup radioGroup; // holds radio buttons
24
25    // RadioButtonFrame constructor adds JRadioButtons to JFrame
26    public RadioButtonFrame()
27    {
28       super("RadioButton Test");
29       setLayout(new FlowLayout());
30
31       textField = new JTextField("Watch the font style change", 25);
32       add(textField); // add textField to JFrame
33
34       // create radio buttons
35       plainJRadioButton = new JRadioButton("Plain", true);
```

**Fig. 26.19** | Creating radio buttons using `ButtonGroup` and `JRadioButton`. (Part 1 of 2.)

```
36          boldJRadioButton = new JRadioButton("Bold", false);
37          italicJRadioButton = new JRadioButton("Italic", false);
38          boldItalicJRadioButton = new JRadioButton("Bold/Italic", false);
39          add(plainJRadioButton); // add plain button to JFrame
40          add(boldJRadioButton); // add bold button to JFrame
41          add(italicJRadioButton); // add italic button to JFrame
42          add(boldItalicJRadioButton); // add bold and italic button
43
44          // create logical relationship between JRadioButtons
45          radioGroup = new ButtonGroup(); // create ButtonGroup
46          radioGroup.add(plainJRadioButton); // add plain to group
47          radioGroup.add(boldJRadioButton); // add bold to group
48          radioGroup.add(italicJRadioButton); // add italic to group
49          radioGroup.add(boldItalicJRadioButton); // add bold and italic
50
51          // create font objects
52          plainFont = new Font("Serif", Font.PLAIN, 14);
53          boldFont = new Font("Serif", Font.BOLD, 14);
54          italicFont = new Font("Serif", Font.ITALIC, 14);
55          boldItalicFont = new Font("Serif", Font.BOLD + Font.ITALIC, 14);
56          textField.setFont(plainFont);
57
58          // register events for JRadioButtons
59          plainJRadioButton.addItemListener(
60             new RadioButtonHandler(plainFont));
61          boldJRadioButton.addItemListener(
62             new RadioButtonHandler(boldFont));
63          italicJRadioButton.addItemListener(
64             new RadioButtonHandler(italicFont));
65          boldItalicJRadioButton.addItemListener(
66             new RadioButtonHandler(boldItalicFont));
67       }
68
69       // private inner class to handle radio button events
70       private class RadioButtonHandler implements ItemListener
71       {
72          private Font font; // font associated with this listener
73
74          public RadioButtonHandler(Font f)
75          {
76             font = f;
77          }
78
79          // handle radio button events
80          @Override
81          public void itemStateChanged(ItemEvent event)
82          {
83             textField.setFont(font);
84          }
85       }
86    }
```

**Fig. 26.19** | Creating radio buttons using `ButtonGroup` and `JRadioButton`. (Part 2 of 2.)

```
1  // Fig. 26.20: RadioButtonTest.java
2  // Testing RadioButtonFrame.
3  import javax.swing.JFrame;
4
5  public class RadioButtonTest
6  {
7     public static void main(String[] args)
8     {
9        RadioButtonFrame radioButtonFrame = new RadioButtonFrame();
10       radioButtonFrame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
11       radioButtonFrame.setSize(300, 100);
12       radioButtonFrame.setVisible(true);
13    }
14 }
```

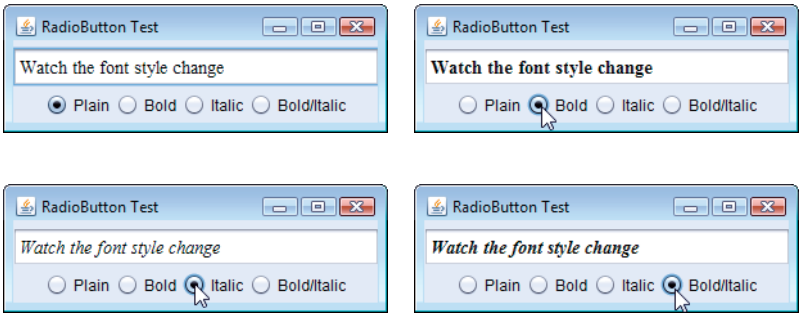



**Fig. 26.20** | Testing `RadioButtonFrame`.

Lines 35–42 (Fig. 26.19) in the constructor create four `JRadioButton` objects and add them to the `JFrame`. Each `JRadioButton` is created with a constructor call like that in line 35. This constructor specifies the label that appears to the right of the `JRadioButton` by default and the initial state of the `JRadioButton`. A `true` second argument indicates that the `JRadioButton` should appear *selected* when it's displayed.

Line 45 instantiates `ButtonGroup` object `radioGroup`. This object is the "glue" that forms the logical relationship between the four `JRadioButton` objects and allows only one of the four to be selected at a time. It's possible that no `JRadioButtons` in a `ButtonGroup` are selected, but this can occur *only* if *no* preselected `JRadioButtons` are added to the `ButtonGroup` and the user has *not* selected a `JRadioButton` yet. Lines 46–49 use `ButtonGroup` method **`add`** to associate each of the `JRadioButtons` with `radioGroup`. If more than one selected `JRadioButton` object is added to the group, the selected one that was added *first* will be selected when the GUI is displayed.

`JRadioButtons`, like `JCheckBoxes`, generate `ItemEvents` when they're *clicked*. Lines 59–66 create four instances of inner class `RadioButtonHandler` (declared at lines 70–85). In this example, each event-listener object is registered to handle the `ItemEvent` generated when the user clicks a particular `JRadioButton`. Notice that each `RadioButtonHandler` object is initialized with a particular `Font` object (created in lines 52–55).

Class `RadioButtonHandler` (line 70–85) implements interface `ItemListener` so it can handle `ItemEvents` generated by the `JRadioButtons`. The constructor stores the `Font`

object it receives as an argument in the event-listener object's instance variable `font` (declared at line 72). When the user clicks a `JRadioButton`, `radioGroup` turns off the previously selected `JRadioButton`, and method `itemStateChanged` (lines 80–84) sets the font in the `JTextField` to the `Font` stored in the `JRadioButton`'s corresponding event-listener object. Notice that line 83 of inner class `RadioButtonHandler` uses the top-level class's `textField` instance variable to set the font.

## 26.11 JComboBox; Using an Anonymous Inner Class for Event Handling

A combo box (sometimes called a **drop-down list**) enables the user to select *one* item from a list (Fig. 26.22). Combo boxes are implemented with class **`JComboBox`**, which extends class `JComponent`. `JComboBox` is a generic class, like the class `ArrayList` (Chapter 7). When you create a `JComboBox`, you specify the type of the objects that it manages—the `JComboBox` then displays a `String` representation of each object.

```
1  // Fig. 26.21: ComboBoxFrame.java
2  // JComboBox that displays a list of image names.
3  import java.awt.FlowLayout;
4  import java.awt.event.ItemListener;
5  import java.awt.event.ItemEvent;
6  import javax.swing.JFrame;
7  import javax.swing.JLabel;
8  import javax.swing.JComboBox;
9  import javax.swing.Icon;
10 import javax.swing.ImageIcon;
11
12 public class ComboBoxFrame extends JFrame
13 {
14    private final JComboBox<String> imagesJComboBox; // holds icon names
15    private final JLabel label; // displays selected icon
16
17    private static final String[] names =
18       {"bug1.gif", "bug2.gif",  "travelbug.gif", "buganim.gif"};
19    private final Icon[] icons = {
20       new ImageIcon(getClass().getResource(names[0])),
21       new ImageIcon(getClass().getResource(names[1])),
22       new ImageIcon(getClass().getResource(names[2])),
23       new ImageIcon(getClass().getResource(names[3]))};
24
25    // ComboBoxFrame constructor adds JComboBox to JFrame
26    public ComboBoxFrame()
27    {
28       super("Testing JComboBox");
29       setLayout(new FlowLayout()); // set frame layout
30
31       imagesJComboBox = new JComboBox<String>(names); // set up JComboBox
32       imagesJComboBox.setMaximumRowCount(3); // display three rows
33
```

**Fig. 26.21** | `JComboBox` that displays a list of image names. (Part 1 of 2.)

```
34          imagesJComboBox.addItemListener(
35             new ItemListener() // anonymous inner class
36             {
37                // handle JComboBox event
38                @Override
39                public void itemStateChanged(ItemEvent event)
40                {
41                   // determine whether item selected
42                   if (event.getStateChange() == ItemEvent.SELECTED)
43                      label.setIcon(icons[
44                         imagesJComboBox.getSelectedIndex()]);
45                }
46             } // end anonymous inner class
47          ); // end call to addItemListener
48
49          add(imagesJComboBox); // add combo box to JFrame
50          label = new JLabel(icons[0]); // display first icon
51          add(label); // add label to JFrame
52       }
53    }
```

**Fig. 26.21** | `JComboBox` that displays a list of image names. (Part 2 of 2.)

`JComboBox`es generate `ItemEvent`s just as `JCheckBox`es and `JRadioButton`s do. This example also demonstrates a special form of inner class that's used frequently in event handling. The application (Figs. 26.21–26.22) uses a `JComboBox` to provide a list of four image filenames from which the user can select one image to display. When the user selects a name, the application displays the corresponding image as an `Icon` on a `JLabel`. Class `ComboBoxTest` (Fig. 26.22) contains the `main` method that executes this application. The screen captures for this application show the `JComboBox` list after the selection was made to illustrate which image filename was selected.

Lines 19–23 (Fig. 26.21) declare and initialize array `icons` with four new `ImageIcon` objects. `String` array `names` (lines 17–18) contains the names of the four image files that are stored in the same directory as the application.

```
1  // Fig. 26.22: ComboBoxTest.java
2  // Testing ComboBoxFrame.
3  import javax.swing.JFrame;
4
5  public class ComboBoxTest
6  {
7     public static void main(String[] args)
8     {
9        ComboBoxFrame comboBoxFrame = new ComboBoxFrame();
10       comboBoxFrame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
11       comboBoxFrame.setSize(350, 150);
12       comboBoxFrame.setVisible(true);
13    }
14 }
```

**Fig. 26.22** | Testing `ComboBoxFrame`. (Part 1 of 2.)

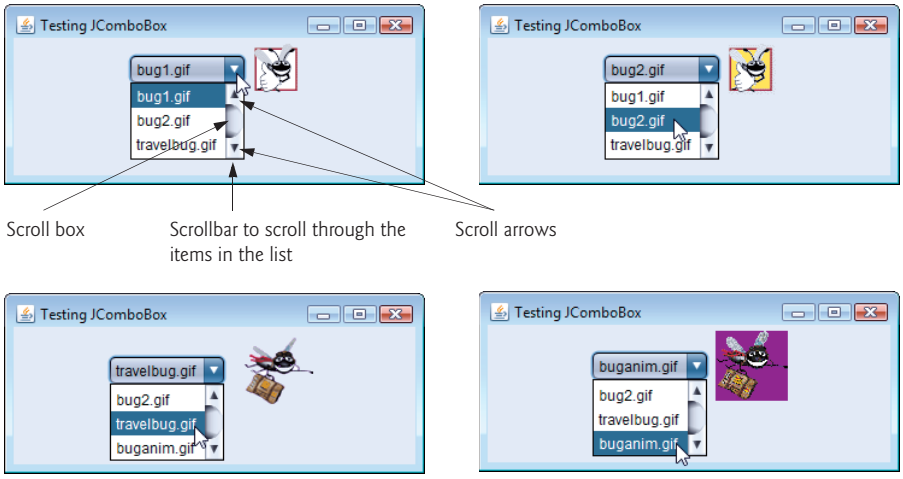



**Fig. 26.22** | Testing `ComboBoxFrame`. (Part 2 of 2.)

At line 31, the constructor initializes a `JComboBox` object with the `Strings` in array `names` as the elements in the list. Each item in the list has an **index**. The first item is added at index 0, the next at index 1 and so forth. The first item added to a `JComboBox` appears as the currently selected item when the `JComboBox` is displayed. Other items are selected by clicking the `JComboBox`, then selecting an item from the list that appears.

Line 32 uses `JComboBox` method **`setMaximumRowCount`** to set the maximum number of elements that are displayed when the user clicks the `JComboBox`. If there are additional items, the `JComboBox` provides a **scrollbar** (see the first screen) that allows the user to scroll through all the elements in the list. The user can click the **scroll arrows** at the top and bottom of the scrollbar to move up and down through the list one element at a time, or else drag the **scroll box** in the middle of the scrollbar up and down. To drag the scroll box, position the mouse cursor on it, hold the mouse button down and move the mouse. In this example, the drop-down list is too short to drag the scroll box, so you can click the up and down arrows or use your mouse's wheel to scroll through the four items in the list. Line 49 attaches the `JComboBox` to the `ComboBoxFrame`'s `FlowLayout` (set in line 29). Line 50 creates the `JLabel` that displays `ImageIcons` and initializes it with the first `ImageIcon` in array `icons`. Line 51 attaches the `JLabel` to the `ComboBoxFrame`'s `FlowLayout`.


**Look-and-Feel Observation 26.12**

*Set the maximum row count for a `JComboBox` to a number of rows that prevents the list from expanding outside the bounds of the window in which it's used.*

### *Using an Anonymous Inner Class for Event Handling*

Lines 34–46 are one statement that declares the event listener's class, creates an object of that class and registers it as `imagesJComboBox`'s `ItemEvent` listener. This event-listener object is an instance of an **anonymous inner class**—a class that's declared without a name and typically appears inside a method declaration. *As with other inner classes, an anonymous*

*inner class can access its top-level class's members.* However, an anonymous inner class has limited access to the local variables of the method in which it's declared. Since an anonymous inner class has no name, one object of the class must be created at the point where the class is declared (starting at line 35).

**Software Engineering Observation 26.3**

*An anonymous inner class declared in a method can access the instance variables and methods of the top-level class object that declared it, as well as the method's* `final` *local variables, but cannot access the method's non-*`final` *local variables. As of Java SE 8, anonymous inner classes may also access a methods "effectively* `final`*" local variables—see Chapter 17 for more information.*

Lines 34–47 are a call to `imagesJComboBox`'s `addItemListener` method. The argument to this method must be an object that *is an* `ItemListener` (i.e., any object of a class that implements `ItemListener`). Lines 35–46 are a class-instance creation expression that declares an anonymous inner class and creates one object of that class. A reference to that object is then passed as the argument to `addItemListener`. The syntax `ItemListener()` after `new` begins the declaration of an anonymous inner class that implements interface `ItemListener`. This is similar to beginning a class declaration with

```
public class MyHandler implements ItemListener
```

The opening left brace at line 36 and the closing right brace at line 46 delimit the body of the anonymous inner class. Lines 38–45 declare the `ItemListener`'s `itemStateChanged` method. When the user makes a selection from `imagesJComboBox`, this method sets `label`'s `Icon`. The `Icon` is selected from array `icons` by determining the index of the selected item in the `JComboBox` with method **`getSelectedIndex`** in line 44. For each item selected from a `JComboBox`, another item is first deselected—so two `ItemEvents` occur when an item is selected. We wish to display only the icon for the item the user just selected. For this reason, line 42 determines whether `ItemEvent` method **`getStateChange`** returns `ItemEvent.SELECTED`. If so, lines 43–44 set `label`'s icon.

**Software Engineering Observation 26.4**

*Like any other class, when an anonymous inner class implements an interface, the class must implement every* `abstract` *method in the interface.*

The syntax shown in lines 35–46 for creating an event handler with an anonymous inner class is similar to the code that would be generated by a Java integrated development environment (IDE). Typically, an IDE enables you to design a GUI visually, then it generates code that implements the GUI. You simply insert statements in the event-handling methods that declare how to handle each event.

## 26.12 JList

A list displays a series of items from which the user may *select one or more items* (see the output of Fig. 26.24). Lists are created with class `JList`, which directly extends class `JComponent`. Class `JList`—which like `JComboBox` is a generic class—supports **single-selection lists** (which allow only one item to be selected at a time) and **multiple-selection lists** (which allow any number of items to be selected). In this section, we discuss single-selection lists.

The application of Figs. 26.23–26.24 creates a `JList` containing 13 color names. When a color name is clicked in the `JList`, a **`ListSelectionEvent`** occurs and the application changes the background color of the application window to the selected color. Class `ListTest` (Fig. 26.24) contains the `main` method that executes this application.

Line 29 (Fig. 26.23) creates `JList` object `colorJList`. The argument to the `JList` constructor is the array of `Objects` (in this case `Strings`) to display in the list. Line 30 uses `JList` method **`setVisibleRowCount`** to determine the number of items *visible* in the list.

Line 33 uses `JList` method **`setSelectionMode`** to specify the list's **selection mode**. Class **`ListSelectionModel`** (of package `javax.swing`) declares three constants that specify a `JList`'s selection mode—**`SINGLE_SELECTION`** (which allows only one item to be selected at a time), **`SINGLE_INTERVAL_SELECTION`** (for a multiple-selection list that allows selection of several contiguous items) and **`MULTIPLE_INTERVAL_SELECTION`** (for a multiple-selection list that does not restrict the items that can be selected).

```
1  // Fig. 26.23: ListFrame.java
2  // JList that displays a list of colors.
3  import java.awt.FlowLayout;
4  import java.awt.Color;
5  import javax.swing.JFrame;
6  import javax.swing.JList;
7  import javax.swing.JScrollPane;
8  import javax.swing.event.ListSelectionListener;
9  import javax.swing.event.ListSelectionEvent;
10 import javax.swing.ListSelectionModel;
11
12 public class ListFrame extends JFrame
13 {
14    private final JList<String> colorJList; // list to display colors
15    private static final String[] colorNames = {"Black", "Blue", "Cyan",
16       "Dark Gray", "Gray", "Green", "Light Gray", "Magenta",
17       "Orange", "Pink", "Red", "White", "Yellow"};
18    private static final Color[] colors = {Color.BLACK, Color.BLUE,
19       Color.CYAN, Color.DARK_GRAY, Color.GRAY, Color.GREEN,
20       Color.LIGHT_GRAY, Color.MAGENTA, Color.ORANGE, Color.PINK,
21       Color.RED, Color.WHITE, Color.YELLOW};
22
23    // ListFrame constructor add JScrollPane containing JList to JFrame
24    public ListFrame()
25    {
26       super("List Test");
27       setLayout(new FlowLayout());
28
29       colorJList = new JList<String>(colorNames); // list of colorNames
30       colorJList.setVisibleRowCount(5); // display five rows at once
31
32       // do not allow multiple selections
33       colorJList.setSelectionMode(ListSelectionModel.SINGLE_SELECTION);
34
35       // add a JScrollPane containing JList to frame
36       add(new JScrollPane(colorJList));
```

**Fig. 26.23** | `JList` that displays a list of colors. (Part 1 of 2.)

```
37
38          colorJList.addListSelectionListener(
39             new ListSelectionListener() // anonymous inner class
40             {
41                // handle list selection events
42                @Override
43                public void valueChanged(ListSelectionEvent event)
44                {
45                   getContentPane().setBackground(
46                      colors[colorJList.getSelectedIndex()]);
47                }
48             }
49          );
50       }
51    }
```

**Fig. 26.23** | `JList` that displays a list of colors. (Part 2 of 2.)

```
1  // Fig. 26.24: ListTest.java
2  // Selecting colors from a JList.
3  import javax.swing.JFrame;
4
5  public class ListTest
6  {
7     public static void main(String[] args)
8     {
9        ListFrame listFrame = new ListFrame(); // create ListFrame
10       listFrame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
11       listFrame.setSize(350, 150);
12       listFrame.setVisible(true);
13    }
14 }
```

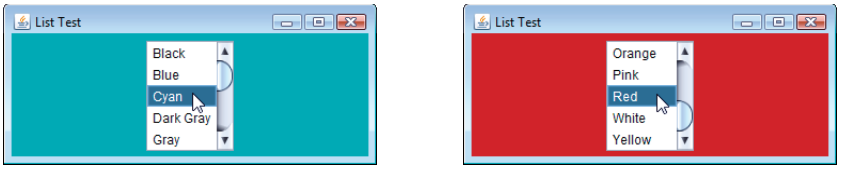



**Fig. 26.24** | Selecting colors from a `JList`.

Unlike a `JComboBox`, a `JList` *does not provide a scrollbar* if there are more items in the list than the number of visible rows. In this case, a **`JScrollPane`** object is used to provide the scrolling capability. Line 36 adds a new instance of class `JScrollPane` to the `JFrame`. The `JScrollPane` constructor receives as its argument the `JComponent` that needs scrolling functionality (in this case, `colorJList`). Notice in the screen captures that a scrollbar created by the `JScrollPane` appears at the right side of the `JList`. By default, the scrollbar appears only when the number of items in the `JList` exceeds the number of visible items.

Lines 38–49 use `JList` method **`addListSelectionListener`** to register an object that implements **`ListSelectionListener`** (package `javax.swing.event`) as the listener for the

`JList`'s selection events. Once again, we use an instance of an anonymous inner class (lines 39–48) as the listener. In this example, when the user makes a selection from `colorJList`, method **`valueChanged`** (line 42–47) should change the background color of the `ListFrame` to the selected color. This is accomplished in lines 45–46. Note the use of `JFrame` method **`getContentPane`** in line 45. Each `JFrame` actually consists of *three layers*—the *background*, the *content pane* and the *glass pane*. The content pane appears in front of the background and is where the GUI components in the `JFrame` are displayed. The glass pane is used to display tool tips and other items that should appear in front of the GUI components on the screen. The content pane completely hides the background of the `JFrame`; thus, to change the background color behind the GUI components, you must change the content pane's background color. Method `getContentPane` returns a reference to the `JFrame`'s content pane (an object of class `Container`). In line 45, we then use that reference to call method **`setBackground`**, which sets the content pane's background color to an element in the `colors` array. The color is selected from the array by using the selected item's index. `JList` method **`getSelectedIndex`** returns the selected item's index. As with arrays and `JComboBoxes`, `JList` indexing is zero based.

## 26.13 Multiple-Selection Lists

A **multiple-selection list** enables the user to select many items from a `JList` (see the output of Fig. 26.26). A `SINGLE_INTERVAL_SELECTION` list allows selecting a contiguous range of items. To do so, click the first item, then press and hold the *Shift* key while clicking the last item in the range. A `MULTIPLE_INTERVAL_SELECTION` list (the default) allows continuous range selection as described for a `SINGLE_INTERVAL_SELECTION` list. Such a list also allows miscellaneous items to be selected by pressing and holding the *Ctrl* key while clicking each item to select. To *deselect* an item, press and hold the *Ctrl* key while clicking the item a second time.

The application of Figs. 26.25–26.26 uses multiple-selection lists to copy items from one `JList` to another. One list is a `MULTIPLE_INTERVAL_SELECTION` list and the other is a `SINGLE_INTERVAL_SELECTION` list. When you execute the application, try using the selection techniques described previously to select items in both lists.

```
1  // Fig. 26.25: MultipleSelectionFrame.java
2  // JList that allows multiple selections.
3  import java.awt.FlowLayout;
4  import java.awt.event.ActionListener;
5  import java.awt.event.ActionEvent;
6  import javax.swing.JFrame;
7  import javax.swing.JList;
8  import javax.swing.JButton;
9  import javax.swing.JScrollPane;
10 import javax.swing.ListSelectionModel;
11
12 public class MultipleSelectionFrame extends JFrame
13 {
14    private final JList<String> colorJList; // list to hold color names
15    private final JList<String> copyJList; // list to hold copied names
```

**Fig. 26.25** | `JList` that allows multiple selections. (Part 1 of 2.)

```
16      private JButton copyJButton; // button to copy selected names
17      private static final String[] colorNames = {"Black", "Blue", "Cyan",
18         "Dark Gray", "Gray", "Green", "Light Gray", "Magenta", "Orange",
19         "Pink", "Red", "White", "Yellow"};
20
21      // MultipleSelectionFrame constructor
22      public MultipleSelectionFrame()
23      {
24         super("Multiple Selection Lists");
25         setLayout(new FlowLayout());
26
27         colorJList = new JList<String>(colorNames); // list of color names
28         colorJList.setVisibleRowCount(5); // show five rows
29         colorJList.setSelectionMode(
30            ListSelectionModel.MULTIPLE_INTERVAL_SELECTION);
31         add(new JScrollPane(colorJList)); // add list with scrollpane
32
33         copyJButton = new JButton("Copy >>>");
34         copyJButton.addActionListener(
35            new ActionListener() // anonymous inner class
36            {
37               // handle button event
38               @Override
39               public void actionPerformed(ActionEvent event)
40               {
41                  // place selected values in copyJList
42                  copyJList.setListData(
43                     colorJList.getSelectedValuesList().toArray(
44                        new String[0]));
45               }
46            }
47         );
48
49         add(copyJButton); // add copy button to JFrame
50
51         copyJList = new JList<String>(); // list to hold copied color names
52         copyJList.setVisibleRowCount(5); // show 5 rows
53         copyJList.setFixedCellWidth(100); // set width
54         copyJList.setFixedCellHeight(15); // set height
55         copyJList.setSelectionMode(
56            ListSelectionModel.SINGLE_INTERVAL_SELECTION);
57         add(new JScrollPane(copyJList)); // add list with scrollpane
58      }
59   }
```

**Fig. 26.25** | `JList` that allows multiple selections. (Part 2 of 2.)

```
1  // Fig. 26.26: MultipleSelectionTest.java
2  // Testing MultipleSelectionFrame.
3  import javax.swing.JFrame;
4
```

**Fig. 26.26** | Testing `MultipleSelectionFrame`. (Part 1 of 2.)

```
5  public class MultipleSelectionTest
6  {
7     public static void main(String[] args)
8     {
9        MultipleSelectionFrame multipleSelectionFrame =
10          new MultipleSelectionFrame();
11       multipleSelectionFrame.setDefaultCloseOperation(
12          JFrame.EXIT_ON_CLOSE);
13       multipleSelectionFrame.setSize(350, 150);
14       multipleSelectionFrame.setVisible(true);
15    }
16 }
```

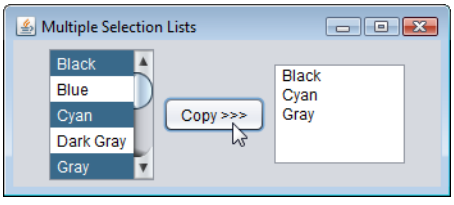



**Fig. 26.26** | Testing `MultipleSelectionFrame`. (Part 2 of 2.)

Line 27 of Fig. 26.25 creates `JList` `colorJList` and initializes it with the `String`s in the array `colorNames`. Line 28 sets the number of visible rows in `colorJList` to `5`. Lines 29–30 specify that `colorJList` is a `MULTIPLE_INTERVAL_SELECTION` list. Line 31 adds a new `JScrollPane` containing `colorJList` to the `JFrame`. Lines 51–57 perform similar tasks for `copyJList`, which is declared as a `SINGLE_INTERVAL_SELECTION` list. If a `JList` does not contain items, it will not diplay in a `FlowLayout`. For this reason, lines 53–54 use `JList` methods **`setFixedCellWidth`** and **`setFixedCellHeight`** to set `copyJList`'s width to 100 pixels and the height of each item in the `JList` to 15 pixels, respectively.

Normally, an event generated by another GUI component (known as an **external event**) specifies when the multiple selections in a `JList` should be processed. In this example, the user clicks the `JButton` called `copyJButton` to trigger the event that copies the selected items in `colorJList` to `copyJList`.

Lines 34–47 declare, create and register an `ActionListener` for the `copyJButton`. When the user clicks `copyJButton`, method `actionPerformed` (lines 38–45) uses `JList` method **`setListData`** to set the items displayed in `copyJList`. Lines 43–44 call `colorJList`'s method **`getSelectedValuesList`**, which returns a `List<String>` (because the `JList` was created as a `JList<String>`) representing the selected items in `colorJList`. We call the `List<String>`'s `toArray` method to convert this into an array of `String`s that can be passed as the argument to `copyJList`'s `setListData` method. `List` method `toArray` receives as its argument an array representing the type of array that the method will return. You'll learn more about `List` and `toArray` in Chapter 16.

You might be wondering why `copyJList` can be used in line 42 even though the application does not create the object to which it refers until line 49. Remember that method `actionPerformed` (lines 38–45) does not execute until the user presses the `copyJButton`, which cannot occur until after the constructor completes execution and the

application displays the GUI. At that point in the application's execution, `copyJList` is already initialized with a new `JList` object.

## 26.14 Mouse Event Handling

This section presents the **`MouseListener`** and **`MouseMotionListener`** event-listener interfaces for handling **mouse events**. Mouse events can be processed for any GUI component that derives from `java.awt.Component`. The methods of interfaces `MouseListener` and `MouseMotionListener` are summarized in Figure 26.27. Package `javax.swing.event` contains interface **`MouseInputListener`**, which extends interfaces `MouseListener` and `MouseMotionListener` to create a single interface containing all the `MouseListener` and `MouseMotionListener` methods. The `MouseListener` and `MouseMotionListener` methods are called when the mouse interacts with a `Component` if appropriate event-listener objects are registered for that `Component`.

`MouseListener` and `MouseMotionListener` interface methods

*Methods of interface* `MouseListener`

`public void mousePressed(MouseEvent event)`
Called when a mouse button is *pressed* while the mouse cursor is on a component.

`public void mouseClicked(MouseEvent event)`
Called when a mouse button is *pressed and released* while the mouse cursor remains stationary on a component. Always preceded by a call to `mousePressed` and `mouseReleased`.

`public void mouseReleased(MouseEvent event)`
Called when a mouse button is *released after being pressed*. Always preceded by a call to `mousePressed` and one or more calls to `mouseDragged`.

`public void mouseEntered(MouseEvent event)`
Called when the mouse cursor *enters* the bounds of a component.

`public void mouseExited(MouseEvent event)`
Called when the mouse cursor *leaves* the bounds of a component.

*Methods of interface* `MouseMotionListener`

`public void mouseDragged(MouseEvent event)`
Called when the mouse button is *pressed* while the mouse cursor is on a component and the mouse is *moved* while the mouse button *remains pressed*. Always preceded by a call to `mousePressed`. All drag events are sent to the component on which the user began to drag the mouse.

`public void mouseMoved(MouseEvent event)`
Called when the mouse is *moved* (with no mouse buttons pressed) when the mouse cursor is on a component. All move events are sent to the component over which the mouse is currently positioned.

**Fig. 26.27** | `MouseListener` and `MouseMotionListener` interface methods.

Each of the mouse event-handling methods receives as an argument a **`MouseEvent`** object that contains information about the mouse event that occurred, including the *x*- and *y*-coordinates of its location. These coordinates are measured from the *upper-left corner*

of the GUI component on which the event occurred. The *x*-coordinates start at 0 and *increase from left to right*. The *y*-coordinates start at 0 and *increase from top to bottom*. The methods and constants of class `InputEvent` (`MouseEvent`'s superclass) enable you to determine which mouse button the user clicked.

**Software Engineering Observation 26.5**

*Calls to `mouseDragged` are sent to the `MouseMotionListener` for the `Component` on which the drag started. Similarly, the `mouseReleased` call at the end of a drag operation is sent to the `MouseListener` for the `Component` on which the drag operation started.*

Java also provides interface `MouseWheelListener` to enable applications to respond to the *rotation of a mouse wheel*. This interface declares method `mouseWheelMoved`, which receives a `MouseWheelEvent` as its argument. Class `MouseWheelEvent` (a subclass of `MouseEvent`) contains methods that enable the event handler to obtain information about the amount of wheel rotation.

### *Tracking Mouse Events on a `JPanel`*

The `MouseTracker` application (Figs. 26.28–26.29) demonstrates the `MouseListener` and `MouseMotionListener` interface methods. The event-handler class (lines 36–97 of Fig. 26.28) implements both interfaces. You *must* declare all seven methods from these two interfaces when your class implements them both. Each mouse event in this example displays a `String` in the `JLabel` called `statusBar` that is attached to the bottom of the window.

```
1  // Fig. 26.28: MouseTrackerFrame.java
2  // Mouse event handling.
3  import java.awt.Color;
4  import java.awt.BorderLayout;
5  import java.awt.event.MouseListener;
6  import java.awt.event.MouseMotionListener;
7  import java.awt.event.MouseEvent;
8  import javax.swing.JFrame;
9  import javax.swing.JLabel;
10 import javax.swing.JPanel;
11
12 public class MouseTrackerFrame extends JFrame
13 {
14    private final JPanel mousePanel; // panel in which mouse events occur
15    private final JLabel statusBar; // displays event information
16
17    // MouseTrackerFrame constructor sets up GUI and
18    // registers mouse event handlers
19    public MouseTrackerFrame()
20    {
21       super("Demonstrating Mouse Events");
22
23       mousePanel = new JPanel();
24       mousePanel.setBackground(Color.WHITE);
25       add(mousePanel, BorderLayout.CENTER); // add panel to JFrame
26
```

**Fig. 26.28** | Mouse event handling. (Part 1 of 3.)

```
27          statusBar = new JLabel("Mouse outside JPanel");
28          add(statusBar, BorderLayout.SOUTH); // add label to JFrame
29
30          // create and register listener for mouse and mouse motion events
31          MouseHandler handler = new MouseHandler();
32          mousePanel.addMouseListener(handler);
33          mousePanel.addMouseMotionListener(handler);
34       }
35
36       private class MouseHandler implements MouseListener,
37          MouseMotionListener
38       {
39          // MouseListener event handlers
40          // handle event when mouse released immediately after press
41          @Override
42          public void mouseClicked(MouseEvent event)
43          {
44             statusBar.setText(String.format("Clicked at [%d, %d]",
45                event.getX(), event.getY()));
46          }
47
48          // handle event when mouse pressed
49          @Override
50          public void mousePressed(MouseEvent event)
51          {
52             statusBar.setText(String.format("Pressed at [%d, %d]",
53                event.getX(), event.getY()));
54          }
55
56          // handle event when mouse released
57          @Override
58          public void mouseReleased(MouseEvent event)
59          {
60             statusBar.setText(String.format("Released at [%d, %d]",
61                event.getX(), event.getY()));
62          }
63
64          // handle event when mouse enters area
65          @Override
66          public void mouseEntered(MouseEvent event)
67          {
68             statusBar.setText(String.format("Mouse entered at [%d, %d]",
69                event.getX(), event.getY()));
70             mousePanel.setBackground(Color.GREEN);
71          }
72
73          // handle event when mouse exits area
74          @Override
75          public void mouseExited(MouseEvent event)
76          {
77             statusBar.setText("Mouse outside JPanel");
78             mousePanel.setBackground(Color.WHITE);
79          }
```

**Fig. 26.28** | Mouse event handling. (Part 2 of 3.)

```
80
81          // MouseMotionListener event handlers
82          // handle event when user drags mouse with button pressed
83          @Override
84          public void mouseDragged(MouseEvent event)
85          {
86             statusBar.setText(String.format("Dragged at [%d, %d]",
87                event.getX(), event.getY()));
88          }
89
90          // handle event when user moves mouse
91          @Override
92          public void mouseMoved(MouseEvent event)
93          {
94             statusBar.setText(String.format("Moved at [%d, %d]",
95                event.getX(), event.getY()));
96          }
97       } // end inner class MouseHandler
98    }
```

**Fig. 26.28** | Mouse event handling. (Part 3 of 3.)

```
1  // Fig. 26.29: MouseTrackerFrame.java
2  // Testing MouseTrackerFrame.
3  import javax.swing.JFrame;
4
5  public class MouseTracker
6  {
7     public static void main(String[] args)
8     {
9        MouseTrackerFrame mouseTrackerFrame = new MouseTrackerFrame();
10       mouseTrackerFrame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
11       mouseTrackerFrame.setSize(300, 100);
12       mouseTrackerFrame.setVisible(true);
13    }
14 }
```

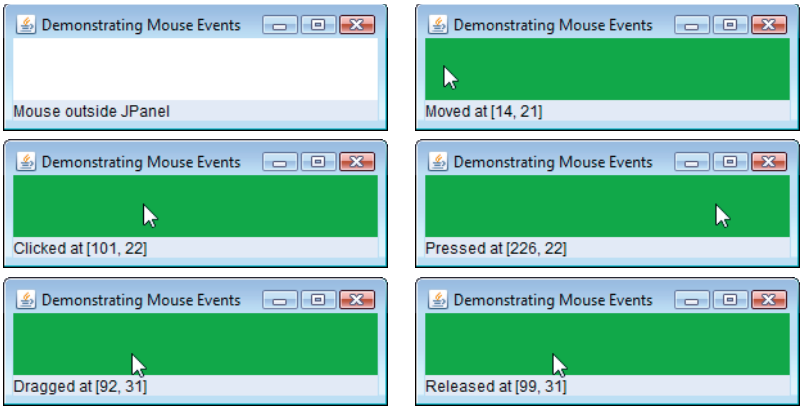



**Fig. 26.29** | Testing `MouseTrackerFrame`.

Line 23 creates `JPanel mousePanel`. This `JPanel`'s mouse events are tracked by the app. Line 24 sets `mousePanel`'s background color to white. When the user moves the mouse into the `mousePanel`, the application will change `mousePanel`'s background color to green. When the user moves the mouse out of the `mousePanel`, the application will change the background color back to white. Line 25 attaches `mousePanel` to the `JFrame`. As you've learned, you typically must specify the layout of the GUI components in a `JFrame`. In that section, we introduced the layout manager `FlowLayout`. Here we use the default layout of a `JFrame`'s content pane—**`BorderLayout`**, which arranges component **`NORTH`**, **`SOUTH`**, **`EAST`**, **`WEST`** and **`CENTER`** regions. `NORTH` corresponds to the container's top. This example uses the `CENTER` and `SOUTH` regions. Line 25 uses a two-argument version of method `add` to place `mousePanel` in the `CENTER` region. The `BorderLayout` automatically sizes the component in the `CENTER` to use all the space in the `JFrame` that is not occupied by components in the other regions. Section 26.18.2 discusses `BorderLayout` in more detail.

Lines 27–28 in the constructor declare `JLabel statusBar` and attach it to the `JFrame`'s `SOUTH` region. This `JLabel` occupies the width of the `JFrame`. The region's height is determined by the `JLabel`.

Line 31 creates an instance of inner class `MouseHandler` (lines 36–97) called `handler` that responds to mouse events. Lines 32–33 register `handler` as the listener for `mousePanel`'s mouse events. Methods **`addMouseListener`** and **`addMouseMotionListener`** are inherited indirectly from class `Component` and can be used to register `MouseListener`s and `MouseMotionListener`s, respectively. A `MouseHandler` object *is a* `MouseListener` and *is a* `MouseMotionListener` because the class implements *both* interfaces. We chose to implement both interfaces here to demonstrate a class that implements more than one interface, but we could have implemented interface `MouseInputListener` instead.

When the mouse enters and exits `mousePanel`'s area, methods `mouseEntered` (lines 65–71) and `mouseExited` (lines 74–79) are called, respectively. Method `mouseEntered` displays a message in the `statusBar` indicating that the mouse entered the `JPanel` and changes the background color to green. Method `mouseExited` displays a message in the `statusBar` indicating that the mouse is outside the `JPanel` (see the first sample output window) and changes the background color to white.

The other five events display a string in the `statusBar` that includes the event and the coordinates at which it occurred. `MouseEvent` methods **`getX`** and **`getY`** return the *x*- and *y*-coordinates, respectively, of the mouse at the time the event occurred.

## 26.15 Adapter Classes

Many event-listener interfaces, such as `MouseListener` and `MouseMotionListener`, contain multiple methods. It's not always desirable to declare every method in an event-listener interface. For example, an application may need only the `mouseClicked` handler from `MouseListener` or the `mouseDragged` handler from `MouseMotionListener`. Interface `WindowListener` specifies seven window event-handling methods. For many of the listener interfaces that have multiple methods, packages `java.awt.event` and `javax.swing.event` provide event-listener adapter classes. An **adapter class** implements an interface and provides a default implementation (with an empty method body) of each method in the interface. Figure 26.30 shows several `java.awt.event` adapter classes and the interfaces they

implement. You can extend an adapter class to inherit the default implementation of every method and subsequently override only the method(s) you need for event handling.

### Software Engineering Observation 26.6

*When a class implements an interface, the class has an* is-a *relationship with that interface. All direct and indirect subclasses of that class inherit this interface. Thus, an object of a class that extends an event-adapter class* is an *object of the corresponding event-listener type (e.g., an object of a subclass of* `MouseAdapter` is a `MouseListener`*).*

| Event-adapter class in `java.awt.event` | Implements interface |
|---|---|
| `ComponentAdapter` | `ComponentListener` |
| `ContainerAdapter` | `ContainerListener` |
| `FocusAdapter` | `FocusListener` |
| `KeyAdapter` | `KeyListener` |
| `MouseAdapter` | `MouseListener` |
| `MouseMotionAdapter` | `MouseMotionListener` |
| `WindowAdapter` | `WindowListener` |

**Fig. 26.30** | Event-adapter classes and the interfaces they implement.

### *Extending* `MouseAdapter`

The application of Figs. 26.31–26.32 demonstrates how to determine the number of mouse clicks (i.e., the click count) and how to distinguish between the different mouse buttons. The event listener in this application is an object of inner class `MouseClickHandler` (Fig. 26.31, lines 25–46) that extends `MouseAdapter`, so we can declare just the `mouseClicked` method we need in this example.

### Common Programming Error 26.3

*If you extend an adapter class and misspell the name of the method you're overriding, and you do not declare the method with* `@Override`*, your method simply becomes another method in the class. This is a logic error that is difficult to detect, since the program will call the empty version of the method inherited from the adapter class.*

```
1  // Fig. 26.31: MouseDetailsFrame.java
2  // Demonstrating mouse clicks and distinguishing between mouse buttons.
3  import java.awt.BorderLayout;
4  import java.awt.event.MouseAdapter;
5  import java.awt.event.MouseEvent;
6  import javax.swing.JFrame;
7  import javax.swing.JLabel;
8
9  public class MouseDetailsFrame extends JFrame
10 {
11    private String details; // String displayed in the statusBar
12    private final JLabel statusBar; // JLabel at bottom of window
13
```

**Fig. 26.31** | Demonstrating mouse clicks and distinguishing between mouse buttons. (Part 1 of 2.)

```
14    // constructor sets title bar String and register mouse listener
15    public MouseDetailsFrame()
16    {
17       super("Mouse clicks and buttons");
18
19       statusBar = new JLabel("Click the mouse");
20       add(statusBar, BorderLayout.SOUTH);
21       addMouseListener(new MouseClickHandler()); // add handler
22    }
23
24    // inner class to handle mouse events
25    private class MouseClickHandler extends MouseAdapter
26    {
27       // handle mouse-click event and determine which button was pressed
28       @Override
29       public void mouseClicked(MouseEvent event)
30       {
31          int xPos = event.getX(); // get x-position of mouse
32          int yPos = event.getY(); // get y-position of mouse
33
34          details = String.format("Clicked %d time(s)",
35             event.getClickCount());
36
37          if (event.isMetaDown()) // right mouse button
38             details += " with right mouse button";
39          else if (event.isAltDown()) // middle mouse button
40             details += " with center mouse button";
41          else // left mouse button
42             details += " with left mouse button";
43
44          statusBar.setText(details); // display message in statusBar
45       }
46    }
47 }
```

**Fig. 26.31** | Demonstrating mouse clicks and distinguishing between mouse buttons. (Part 2 of 2.)

```
1  // Fig. 26.32: MouseDetails.java
2  // Testing MouseDetailsFrame.
3  import javax.swing.JFrame;
4
5  public class MouseDetails
6  {
7     public static void main(String[] args)
8     {
9        MouseDetailsFrame mouseDetailsFrame = new MouseDetailsFrame();
10       mouseDetailsFrame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
11       mouseDetailsFrame.setSize(400, 150);
12       mouseDetailsFrame.setVisible(true);
13    }
14 }
```

**Fig. 26.32** | Testing `MouseDetailsFrame`. (Part 1 of 2.)

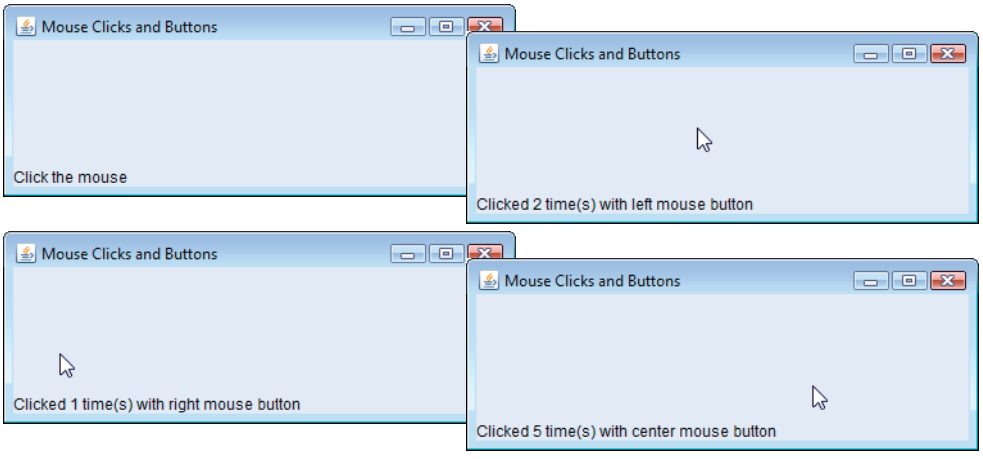



**Fig. 26.32** | Testing `MouseDetailsFrame`. (Part 2 of 2.)

A user of a Java application may be on a system with a one-, two- or three-button mouse. Class `MouseEvent` inherits several methods from class `InputEvent` that can distinguish among mouse buttons on a multibutton mouse or can mimic a multibutton mouse with a combined keystroke and mouse-button click. Figure 26.33 shows the `InputEvent` methods used to distinguish among mouse-button clicks. Java assumes that every mouse contains a left mouse button. Thus, it's simple to test for a left-mouse-button click. However, users with a one- or two-button mouse must use a combination of keystrokes and mouse-button clicks at the same time to simulate the missing buttons on the mouse. In the case of a one- or two-button mouse, a Java application assumes that the center mouse button is clicked if the user holds down the *Alt* key and clicks the left mouse button on a two-button mouse or the only mouse button on a one-button mouse. In the case of a one-button mouse, a Java application assumes that the right mouse button is clicked if the user holds down the *Meta* key (sometimes called the *Command* key or the "Apple" key on a Mac) and clicks the mouse button.

| `InputEvent` method | Description |
|---|---|
| `isMetaDown()` | Returns `true` when the user clicks the *right mouse button* on a mouse with two or three buttons. To simulate a right-mouse-button click on a one-button mouse, the user can hold down the *Meta* key on the keyboard and click the mouse button. |
| `isAltDown()` | Returns `true` when the user clicks the *middle mouse button* on a mouse with three buttons. To simulate a middle-mouse-button click on a one- or two-button mouse, the user can press the *Alt* key and click the only or left mouse button, respectively. |

**Fig. 26.33** | `InputEvent` methods that help determine whether the right or center mouse button was clicked.

Line 21 of Fig. 26.31 registers a `MouseListener` for the `MouseDetailsFrame`. The event listener is an object of class `MouseClickHandler`, which extends `MouseAdapter`. This enables us to declare only method `mouseClicked` (lines 28–45). This method first captures the coordinates where the event occurred and stores them in local variables `xPos` and `yPos` (lines 31–32). Lines 34–35 create a `String` called `details` containing the number of consecutive mouse clicks, which is returned by `MouseEvent` method **`getClickCount`** at line 35. Lines 37–42 use methods **`isMetaDown`** and **`isAltDown`** to determine which mouse button the user clicked and append an appropriate `String` to `details` in each case. The resulting `String` is displayed in the `statusBar`. Class `MouseDetails` (Fig. 26.32) contains the `main` method that executes the application. Try clicking with each of your mouse's buttons repeatedly to see the click count increment.

## 26.16 JPanel Subclass for Drawing with the Mouse

Section 26.14 showed how to track mouse events in a `JPanel`. In this section, we use a `JPanel` as a **dedicated drawing area** in which the user can draw by dragging the mouse. In addition, this section demonstrates an event listener that extends an adapter class.

### *Method* `paintComponent`

Lightweight Swing components that extend class `JComponent` (such as `JPanel`) contain method **`paintComponent`**, which is called when a lightweight Swing component is displayed. By overriding this method, you can specify how to draw shapes using Java's graphics capabilities. When customizing a `JPanel` for use as a dedicated drawing area, the subclass should override method `paintComponent` and call the superclass version of `paintComponent` as the first statement in the body of the overridden method to ensure that the component displays correctly. The reason is that subclasses of `JComponent` support **transparency**. To display a component correctly, the program must determine whether the component is transparent. The code that determines this is in superclass `JComponent`'s `paintComponent` implementation. When a component is transparent, `paintComponent` will not clear its background when the program displays the component. When a component is **opaque**, `paintComponent` clears the component's background before the component is displayed. The transparency of a Swing lightweight component can be set with method **`setOpaque`** (a `false` argument indicates that the component is transparent).

**Error-Prevention Tip 26.1**

*In a `JComponent` subclass's `paintComponent` method, the first statement should always call the superclass's `paintComponent` method to ensure that an object of the subclass displays correctly.*

**Common Programming Error 26.4**

*If an overridden `paintComponent` method does not call the superclass's version, the subclass component may not display properly. If an overridden `paintComponent` method calls the superclass's version after other drawing is performed, the drawing will be erased.*

### *Defining the Custom Drawing Area*

The `Painter` application of Figs. 26.34–26.35 demonstrates a customized subclass of `JPanel` that's used to create a dedicated drawing area. The application uses the `mouse-`

Dragged event handler to create a simple drawing application. The user can draw pictures by dragging the mouse on the JPanel. This example does not use method mouseMoved, so our *event-listener class* (the *anonymous inner class* at lines 20–29 of Fig. 26.34) extends MouseMotionAdapter. Since this class already declares both mouseMoved and mouseDragged, we can simply override mouseDragged to provide the event handling this application requires.

```
1  // Fig. 26.34: PaintPanel.java
2  // Adapter class used to implement event handlers.
3  import java.awt.Point;
4  import java.awt.Graphics;
5  import java.awt.event.MouseEvent;
6  import java.awt.event.MouseMotionAdapter;
7  import java.util.ArrayList;
8  import javax.swing.JPanel;
9
10 public class PaintPanel extends JPanel
11 {
12    // list of Point references
13    private final ArrayList<Point> points = new ArrayList<>();
14
15    // set up GUI and register mouse event handler
16    public PaintPanel()
17    {
18       // handle frame mouse motion event
19       addMouseMotionListener(
20          new MouseMotionAdapter() // anonymous inner class
21          {
22             // store drag coordinates and repaint
23             @Override
24             public void mouseDragged(MouseEvent event)
25             {
26                points.add(event.getPoint());
27                repaint(); // repaint JFrame
28             }
29          }
30       );
31    }
32
33    // draw ovals in a 4-by-4 bounding box at specified locations on window
34    @Override
35    public void paintComponent(Graphics g)
36    {
37       super.paintComponent(g); // clears drawing area
38
39       // draw all points
40       for (Point point : points)
41          g.fillOval(point.x, point.y, 4, 4);
42    }
43 }
```

**Fig. 26.34** | Adapter class used to implement event handlers.

Class `PaintPanel` (Fig. 26.34) extends `JPanel` to create the dedicated drawing area. Class **`Point`** (package `java.awt`) represents an *x*-*y* coordinate. We use objects of this class to store the coordinates of each mouse drag event. Class **`Graphics`** is used to draw. In this example, we use an `ArrayList` of `Point`s (line 13) to store the location at which each mouse drag event occurs. As you'll see, method `paintComponent` uses these `Point`s to draw.

Lines 19–30 register a `MouseMotionListener` to listen for the `PaintPanel`'s mouse motion events. Lines 20–29 create an object of an anonymous inner class that extends the adapter class `MouseMotionAdapter`. Recall that `MouseMotionAdapter` implements `MouseMotionListener`, so the *anonymous inner class* object is a `MouseMotionListener`. The anonymous inner class inherits default `mouseMoved` and `mouseDragged` implementations, so it already implements all the interface's methods. However, the default implementations do nothing when they're called. So, we override method `mouseDragged` at lines 23–28 to capture the coordinates of a mouse drag event and store them as a `Point` object. Line 26 invokes the `MouseEvent`'s **`getPoint`** method to obtain the `Point` where the event occurred and stores it in the `ArrayList`. Line 27 calls method **`repaint`** (inherited indirectly from class `Component`) to indicate that the `PaintPanel` should be refreshed on the screen as soon as possible with a call to the `PaintPanel`'s `paintComponent` method.

Method `paintComponent` (lines 34–42), which receives a `Graphics` parameter, is called automatically any time the `PaintPanel` needs to be displayed on the screen—such as when the GUI is first displayed—or refreshed on the screen—such as when method `repaint` is called or when the GUI component has been *hidden* by another window on the screen and subsequently becomes visible again.


**Look-and-Feel Observation 26.13**

*Calling `repaint` for a Swing GUI component indicates that the component should be refreshed on the screen as soon as possible. The component's background is cleared* only if *the component is opaque. `JComponent` method `setOpaque` can be passed a `boolean` argument indicating whether the component is opaque (`true`) or transparent (`false`).*

Line 37 invokes the superclass version of `paintComponent` to clear the `PaintPanel`'s background (`JPanel`s are opaque by default). Lines 40–41 draw an oval at the location specified by each `Point` in the `ArrayList`. `Graphics` method **`fillOval`** draws a solid oval. The method's four parameters represent a rectangular area (called the *bounding box*) in which the oval is displayed. The first two parameters are the upper-left *x*-coordinate and the upper-left *y*-coordinate of the rectangular area. The last two coordinates represent the rectangular area's width and height. Method `fillOval` draws the oval so it touches the middle of each side of the rectangular area. In line 41, the first two arguments are specified by using class `Point`'s two `public` instance variables—`x` and `y`. You'll learn more `Graphics` features in Chapter 27.


**Look-and-Feel Observation 26.14**

*Drawing on any GUI component is performed with coordinates that are measured from the upper-left corner (0, 0) of that GUI component,* not *the upper-left corner of the screen.*

### *Using the Custom `JPanel` in an Application*

Class `Painter` (Fig. 26.35) contains the `main` method that executes this application. Line 14 creates a `PaintPanel` object on which the user can drag the mouse to draw. Line 15 attaches the `PaintPanel` to the `JFrame`.

```
1  // Fig. 26.35: Painter.java
2  // Testing PaintPanel.
3  import java.awt.BorderLayout;
4  import javax.swing.JFrame;
5  import javax.swing.JLabel;
6
7  public class Painter
8  {
9     public static void main(String[] args)
10    {
11       // create JFrame
12       JFrame application = new JFrame("A simple paint program");
13
14       PaintPanel paintPanel = new PaintPanel();
15       application.add(paintPanel, BorderLayout.CENTER);
16
17       // create a label and place it in SOUTH of BorderLayout
18       application.add(new JLabel("Drag the mouse to draw"),
19          BorderLayout.SOUTH);
20
21       application.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
22       application.setSize(400, 200);
23       application.setVisible(true);
24    }
25 }
```

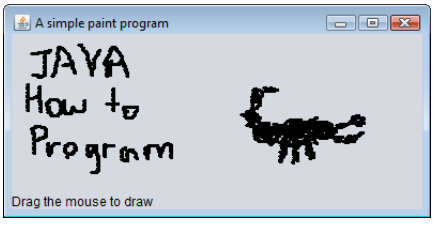



**Fig. 26.35** | Testing `PaintPanel`.

## 26.17 Key Event Handling

This section presents the `KeyListener` interface for handling **key events**. Key events are generated when keys on the keyboard are pressed and released. A class that implements `KeyListener` must provide declarations for methods **`keyPressed`**, **`keyReleased`** and **`keyTyped`**, each of which receives a `KeyEvent` as its argument. Class `KeyEvent` is a subclass of `InputEvent`. Method `keyPressed` is called in response to pressing any key. Method `keyTyped` is called in response to pressing any key that is not an **action key**. (The action keys are any arrow key, *Home*, *End*, *Page Up*, *Page Down*, any function key, etc.) Method `keyReleased` is called when the key is released after any `keyPressed` or `keyTyped` event.

The application of Figs. 26.36–26.37 demonstrates the `KeyListener` methods. Class `KeyDemoFrame` implements the `KeyListener` interface, so all three methods are declared in the application. The constructor (Fig. 26.36, lines 17–28) registers the application to handle its own key events by using method **`addKeyListener`** at line 27. Method `addKey-`

`Listener` is declared in class `Component`, so every subclass of `Component` can notify `KeyListener` objects of key events for that `Component`.

```
1  // Fig. 26.36: KeyDemoFrame.java
2  // Key event handling.
3  import java.awt.Color;
4  import java.awt.event.KeyListener;
5  import java.awt.event.KeyEvent;
6  import javax.swing.JFrame;
7  import javax.swing.JTextArea;
8
9  public class KeyDemoFrame extends JFrame implements KeyListener
10 {
11    private final String line1 = ""; // first line of text area
12    private final String line2 = ""; // second line of text area
13    private final String line3 = ""; // third line of text area
14    private final JTextArea textArea; // text area to display output
15
16    // KeyDemoFrame constructor
17    public KeyDemoFrame()
18    {
19       super("Demonstrating Keystroke Events");
20
21       textArea = new JTextArea(10, 15); // set up JTextArea
22       textArea.setText("Press any key on the keyboard...");
23       textArea.setEnabled(false);
24       textArea.setDisabledTextColor(Color.BLACK);
25       add(textArea); // add text area to JFrame
26
27       addKeyListener(this); // allow frame to process key events
28    }
29
30    // handle press of any key
31    @Override
32    public void keyPressed(KeyEvent event)
33    {
34       line1 = String.format("Key pressed: %s",
35          KeyEvent.getKeyText(event.getKeyCode())); // show pressed key
36       setLines2and3(event); // set output lines two and three
37    }
38
39    // handle release of any key
40    @Override
41    public void keyReleased(KeyEvent event)
42    {
43       line1 = String.format("Key released: %s",
44          KeyEvent.getKeyText(event.getKeyCode())); // show released key
45       setLines2and3(event); // set output lines two and three
46    }
47
```

**Fig. 26.36** | Key event handling. (Part 1 of 2.)

```
48      // handle press of an action key
49      @Override
50      public void keyTyped(KeyEvent event)
51      {
52         line1 = String.format("Key typed: %s", event.getKeyChar());
53         setLines2and3(event); // set output lines two and three
54      }
55
56      // set second and third lines of output
57      private void setLines2and3(KeyEvent event)
58      {
59         line2 = String.format("This key is %san action key",
60            (event.isActionKey() ? "" : "not "));
61
62         String temp = KeyEvent.getKeyModifiersText(event.getModifiers());
63
64         line3 = String.format("Modifier keys pressed: %s",
65            (temp.equals("") ? "none" : temp)); // output modifiers
66
67         textArea.setText(String.format("%s\n%s\n%s\n",
68            line1, line2, line3)); // output three lines of text
69      }
70   }
```

**Fig. 26.36** | Key event handling. (Part 2 of 2.)

At line 25, the constructor adds the `JTextArea` `textArea` (where the application's output is displayed) to the `JFrame`. A `JTextArea` is a *multiline area* in which you can display text. (We discuss `JTextArea`s in more detail in Section 26.20.) Notice in the screen captures that `textArea` occupies the *entire window*. This is due to the `JFrame`'s default `BorderLayout` (discussed in Section 26.18.2 and demonstrated in Fig. 26.41). When a single `Component` is added to a `BorderLayout`, the `Component` occupies the *entire* `Container`. Line 23 disables the `JTextArea` so the user cannot type in it. This causes the text in the `JTextArea` to become gray. Line 24 uses method **`setDisabledTextColor`** to change the text color in the `JTextArea` to black for readability.

```
1   // Fig. 26.37: KeyDemo.java
2   // Testing KeyDemoFrame.
3   import javax.swing.JFrame;
4
5   public class KeyDemo
6   {
7      public static void main(String[] args)
8      {
9         KeyDemoFrame keyDemoFrame = new KeyDemoFrame();
10        keyDemoFrame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
11        keyDemoFrame.setSize(350, 100);
12        keyDemoFrame.setVisible(true);
13     }
14  }
```

**Fig. 26.37** | Testing `KeyDemoFrame`. (Part 1 of 2.)


**Fig. 26.37** | Testing `KeyDemoFrame`. (Part 2 of 2.)

Methods `keyPressed` (lines 31–37) and `keyReleased` (lines 40–46) use `KeyEvent` method **`getKeyCode`** to get the **virtual key code** of the pressed key. Class `KeyEvent` contains virtual key-code constants that represent every key on the keyboard. These constants can be compared with `getKeyCode`'s return value to test for individual keys on the keyboard. The value returned by `getKeyCode` is passed to `static` `KeyEvent` method **`getKeyText`**, which returns a string containing the name of the key that was pressed. For a complete list of virtual key constants, see the online documentation for class `KeyEvent` (package `java.awt.event`). Method `keyTyped` (lines 49–54) uses `KeyEvent` method **`getKeyChar`** (which returns a `char`) to get the Unicode value of the character typed.

All three event-handling methods finish by calling method `setLines2and3` (lines 57–69) and passing it the `KeyEvent` object. This method uses `KeyEvent` method **`isActionKey`** (line 60) to determine whether the key in the event was an action key. Also, `InputEvent` method **`getModifiers`** is called (line 62) to determine whether any modifier keys (such as *Shift*, *Alt* and *Ctrl*) were pressed when the key event occurred. The result of this method is passed to `static` `KeyEvent` method **`getKeyModifiersText`**, which produces a `String` containing the names of the pressed modifier keys.

[*Note:* If you need to test for a specific key on the keyboard, class `KeyEvent` provides a **key constant** for each one. These constants can be used from the key event handlers to determine whether a particular key was pressed. Also, to determine whether the *Alt*, *Ctrl*, *Meta* and *Shift* keys are pressed individually, `InputEvent` methods **`isAltDown`**, **`isControlDown`**, **`isMetaDown`** and **`isShiftDown`** each return a `boolean` indicating whether the particular key was pressed during the key event.]

## 26.18 Introduction to Layout Managers

**Layout managers** *arrange* GUI components in a container for presentation purposes. You can use the layout managers for basic layout capabilities instead of determining every GUI component's exact position and size. This functionality enables you to concentrate on the basic look-and-feel and lets the layout managers process most of the layout details. All layout managers implement the interface **`LayoutManager`** (in package `java.awt`). Class `Container`'s `setLayout` method takes an object that implements the `LayoutManager` interface as an argument. There are basically three ways for you to arrange components in a GUI:

1. *Absolute positioning:* This provides the greatest level of control over a GUI's appearance. By setting a `Container`'s layout to `null`, you can specify the *absolute position of each GUI component* with respect to the upper-left corner of the `Container` by using `Component` methods `setSize` and `setLocation` or `setBounds`. If you do this, you also must specify each GUI component's size. Programming a GUI with absolute positioning can be tedious, unless you have an integrated development environment (IDE) that can generate the code for you.
2. *Layout managers:* Using layout managers to position elements can be simpler and faster than creating a GUI with absolute positioning, and makes your GUIs more resizable, but you lose some control over the size and the precise positioning of each component.
3. *Visual programming in an IDE:* IDEs provide tools that make it easy to create GUIs. Each IDE typically provides a **GUI design tool** that allows you to drag and drop GUI components from a tool box onto a design area. You can then position, size and align GUI components as you like. The IDE generates the Java code that creates the GUI. In addition, you can typically add event-handling code for a particular component by double-clicking the component. Some design tools also allow you to use the layout managers described in this chapter and in Chapter 35.


**Look-and-Feel Observation 26.15**

*Most Java IDEs provide GUI design tools for visually designing a GUI; the tools then write Java code that creates the GUI. Such tools often provide greater control over the size, position and alignment of GUI components than do the built-in layout managers.*


**Look-and-Feel Observation 26.16**

*It's possible to set a `Container`'s layout to `null`, which indicates that no layout manager should be used. In a `Container` without a layout manager, you must position and size the components and take care that, on resize events, all components are repositioned as necessary. A component's resize events can be processed by a `ComponentListener`.*

Figure 26.38 summarizes the layout managers presented in this chapter. A couple of additional layout managers are discussed in Chapter 35.

| Layout manager | Description |
|---|---|
| `FlowLayout` | Default for `javax.swing.JPanel`. Places components *sequentially, left to right*, in the order they were added. It's also possible to specify the order of the components by using the `Container` method `add`, which takes a `Component` and an integer index position as arguments. |
| `BorderLayout` | Default for `JFrames` (and other windows). Arranges the components into five areas: `NORTH`, `SOUTH`, `EAST`, `WEST` and `CENTER`. |
| `GridLayout` | Arranges the components into rows and columns. |

**Fig. 26.38** | Layout managers.

### 26.18.1 FlowLayout

`FlowLayout` is the *simplest* layout manager. GUI components are placed in a container from left to right in the order in which they're added to the container. When the edge of the container is reached, components continue to display on the next line. Class `FlowLayout` allows GUI components to be *left aligned*, *centered* (the default) and *right aligned*.

The application of Figs. 26.39–26.40 creates three `JButton` objects and adds them to the application, using a `FlowLayout`. The components are center aligned by default. When the user clicks **Left**, the `FlowLayout`'s alignment is changed to left aligned. When the user clicks **Right**, the `FlowLayout`'s alignment is changed to right aligned. When the user clicks **Center**, the `FlowLayout`'s alignment is changed to center aligned. The sample output windows show each alignment. The last sample output shows the centered alignment after the window has been resized to a smaller width so that the button **Right** flows onto a new line.

As seen previously, a container's layout is set with method `setLayout` of class `Container`. Line 25 (Fig. 26.39) sets the layout manager to the `FlowLayout` declared at line 23. Normally, the layout is set before any GUI components are added to a container.


**Look-and-Feel Observation 26.17**

*Each individual container can have only one layout manager, but multiple containers in the same application can each use different layout managers.*

```
1  // Fig. 26.39: FlowLayoutFrame.java
2  // FlowLayout allows components to flow over multiple lines.
3  import java.awt.FlowLayout;
4  import java.awt.Container;
5  import java.awt.event.ActionListener;
6  import java.awt.event.ActionEvent;
7  import javax.swing.JFrame;
8  import javax.swing.JButton;
9
10 public class FlowLayoutFrame extends JFrame
11 {
12    private final JButton leftJButton; // button to set alignment left
13    private final JButton centerJButton; // button to set alignment center
```

**Fig. 26.39** | `FlowLayout` allows components to flow over multiple lines. (Part 1 of 3.)

```
14      private final JButton rightJButton; // button to set alignment right
15      private final FlowLayout layout; // layout object
16      private final Container container; // container to set layout
17
18      // set up GUI and register button listeners
19      public FlowLayoutFrame()
20      {
21         super("FlowLayout Demo");
22
23         layout = new FlowLayout();
24         container = getContentPane(); // get container to layout
25         setLayout(layout);
26
27         // set up leftJButton and register listener
28         leftJButton = new JButton("Left");
29         add(leftJButton); // add Left button to frame
30         leftJButton.addActionListener(
31            new ActionListener() // anonymous inner class
32            {
33               // process leftJButton event
34               @Override
35               public void actionPerformed(ActionEvent event)
36               {
37                  layout.setAlignment(FlowLayout.LEFT);
38
39                  // realign attached components
40                  layout.layoutContainer(container);
41               }
42            }
43         );
44
45         // set up centerJButton and register listener
46         centerJButton = new JButton("Center");
47         add(centerJButton); // add Center button to frame
48         centerJButton.addActionListener(
49            new ActionListener() // anonymous inner class
50            {
51               // process centerJButton event
52               @Override
53               public void actionPerformed(ActionEvent event)
54               {
55                  layout.setAlignment(FlowLayout.CENTER);
56
57                  // realign attached components
58                  layout.layoutContainer(container);
59               }
60            }
61         );
62
63         // set up rightJButton and register listener
64         rightJButton = new JButton("Right");
65         add(rightJButton); // add Right button to frame
```

**Fig. 26.39** | `FlowLayout` allows components to flow over multiple lines. (Part 2 of 3.)

```
66          rightJButton.addActionListener(
67             new ActionListener() // anonymous inner class
68             {
69                // process rightJButton event
70                @Override
71                public void actionPerformed(ActionEvent event)
72                {
73                   layout.setAlignment(FlowLayout.RIGHT);
74
75                   // realign attached components
76                   layout.layoutContainer(container);
77                }
78             }
79          );
80       } // end FlowLayoutFrame constructor
81    }
```

**Fig. 26.39** | `FlowLayout` allows components to flow over multiple lines. (Part 3 of 3.)

```
1  // Fig. 26.40: FlowLayoutDemo.java
2  // Testing FlowLayoutFrame.
3  import javax.swing.JFrame;
4
5  public class FlowLayoutDemo
6  {
7     public static void main(String[] args)
8     {
9        FlowLayoutFrame flowLayoutFrame = new FlowLayoutFrame();
10       flowLayoutFrame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
11       flowLayoutFrame.setSize(300, 75);
12       flowLayoutFrame.setVisible(true);
13    }
14 }
```

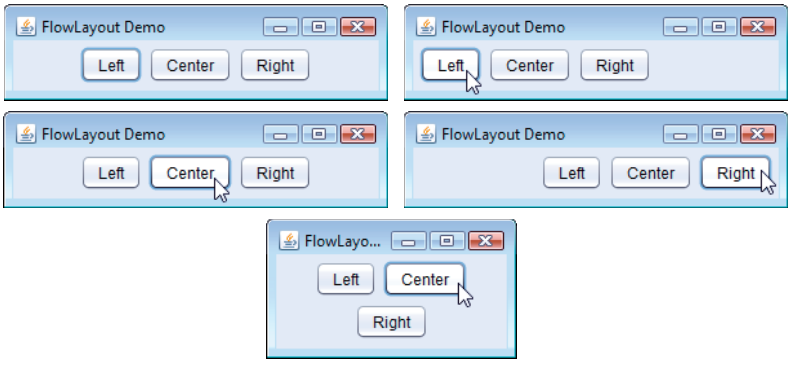



**Fig. 26.40** | Testing `FlowLayoutFrame`.

Each button's event handler is specified with a separate anonymous inner-class object (lines 30–43, 48–61 and 66–79, respectively), and method `actionPerformed` in each case

executes two statements. For example, line 37 in the event handler for `leftJButton` uses `FlowLayout` method **`setAlignment`** to change the alignment for the `FlowLayout` to a left-aligned (**`FlowLayout.LEFT`**) `FlowLayout`. Line 40 uses `LayoutManager` interface method **`layoutContainer`** (which is inherited by all layout managers) to specify that the `JFrame` should be rearranged based on the adjusted layout. According to which button was clicked, the `actionPerformed` method for each button sets the `FlowLayout`'s alignment to `FlowLayout.LEFT` (line 37), **`FlowLayout.CENTER`** (line 55) or **`FlowLayout.RIGHT`** (line 73).

### 26.18.2 BorderLayout

The `BorderLayout` layout manager (the default layout manager for a `JFrame`) arranges components into five regions: `NORTH`, `SOUTH`, `EAST`, `WEST` and `CENTER`. `NORTH` corresponds to the top of the container. Class `BorderLayout` extends `Object` and implements interface **`LayoutManager2`** (a subinterface of `LayoutManager` that adds several methods for enhanced layout processing).

A `BorderLayout` limits a `Container` to containing *at most five components*—one in each region. The component placed in each region can be a container to which other components are attached. The components placed in the `NORTH` and `SOUTH` regions extend horizontally to the sides of the container and are as tall as the components placed in those regions. The `EAST` and `WEST` regions expand vertically between the `NORTH` and `SOUTH` regions and are as wide as the components placed in those regions. The component placed in the `CENTER` region *expands to fill all remaining space in the layout* (which is the reason the `JTextArea` in Fig. 26.37 occupies the entire window). If all five regions are occupied, the entire container's space is covered by GUI components. If the `NORTH` or `SOUTH` region is not occupied, the GUI components in the `EAST`, `CENTER` and `WEST` regions expand vertically to fill the remaining space. If the `EAST` or `WEST` region is not occupied, the GUI component in the `CENTER` region *expands horizontally to fill the remaining space*. If the `CENTER` region is *not* occupied, the area is left *empty*—the other GUI components do *not* expand to fill the remaining space. The application of Figs. 26.41–26.42 demonstrates the `BorderLayout` layout manager by using five `JButtons`.

```
1  // Fig. 26.41: BorderLayoutFrame.java
2  // BorderLayout containing five buttons.
3  import java.awt.BorderLayout;
4  import java.awt.event.ActionListener;
5  import java.awt.event.ActionEvent;
6  import javax.swing.JFrame;
7  import javax.swing.JButton;
8
9  public class BorderLayoutFrame extends JFrame implements ActionListener
10 {
11    private final JButton[] buttons; // array of buttons to hide portions
12    private static final String[] names = {"Hide North", "Hide South",
13       "Hide East", "Hide West", "Hide Center"};
14    private final BorderLayout layout;
15
```

**Fig. 26.41** | `BorderLayout` containing five buttons. (Part 1 of 2.)

```
16      // set up GUI and event handling
17      public BorderLayoutFrame()
18      {
19         super("BorderLayout Demo");
20
21         layout = new BorderLayout(5, 5); // 5 pixel gaps
22         setLayout(layout);
23         buttons = new JButton[names.length];
24
25         // create JButtons and register listeners for them
26         for (int count = 0; count < names.length; count++)
27         {
28            buttons[count] = new JButton(names[count]);
29            buttons[count].addActionListener(this);
30         }
31
32         add(buttons[0], BorderLayout.NORTH);
33         add(buttons[1], BorderLayout.SOUTH);
34         add(buttons[2], BorderLayout.EAST);
35         add(buttons[3], BorderLayout.WEST);
36         add(buttons[4], BorderLayout.CENTER);
37      }
38
39      // handle button events
40      @Override
41      public void actionPerformed(ActionEvent event)
42      {
43         // check event source and lay out content pane correspondingly
44         for (JButton button : buttons)
45         {
46            if (event.getSource() == button)
47               button.setVisible(false); // hide the button that was clicked
48            else
49               button.setVisible(true); // show other buttons
50         }
51
52         layout.layoutContainer(getContentPane()); // lay out content pane
53      }
54   }
```

**Fig. 26.41** | `BorderLayout` containing five buttons. (Part 2 of 2.)

Line 21 of Fig. 26.41 creates a `BorderLayout`. The constructor arguments specify the number of pixels between components that are arranged horizontally (**horizontal gap space**) and between components that are arranged vertically (**vertical gap space**), respectively. The default is one pixel of gap space horizontally and vertically. Line 22 uses method `setLayout` to set the content pane's layout to `layout`.

We add `Components` to a `BorderLayout` with another version of `Container` method `add` that takes two arguments—the `Component` to add and the region in which the `Component` should appear. For example, line 32 specifies that `buttons[0]` should appear in the `NORTH` region. The components can be added in *any* order, but only *one* component should be added to each region.


### Look-and-Feel Observation 26.18

*If no region is specified when adding a* `Component` *to a* `BorderLayout`*, the layout manager assumes that the* `Component` *should be added to region* `BorderLayout.CENTER`*.*

### Common Programming Error 26.5

*When more than one component is added to a region in a* `BorderLayout`*, only the last component added to that region will be displayed. There's no error that indicates this problem.*

Class `BorderLayoutFrame` implements `ActionListener` directly in this example, so the `BorderLayoutFrame` will handle the events of the `JButton`s. For this reason, line 29 passes the `this` reference to the `addActionListener` method of each `JButton`. When the user clicks a particular `JButton` in the layout, method `actionPerformed` (lines 40–53) executes. The enhanced `for` statement at lines 44–50 uses an `if...else` to hide the particular `JButton` that generated the event. Method **`setVisible`** (inherited into `JButton` from class `Component`) is called with a `false` argument (line 47) to hide the `JButton`. If the current `JButton` in the array is not the one that generated the event, method `setVisible` is called with a `true` argument (line 49) to ensure that the `JButton` is displayed on the screen. Line 52 uses `LayoutManager` method `layoutContainer` to recalculate the layout of the content pane. Notice in the screen captures of Fig. 26.42 that certain regions in the `BorderLayout` change shape as `JButton`s are *hidden* and displayed in other regions. Try resizing the application window to see how the various regions resize based on the window's width and height. *For more complex layouts, group components in* `JPanel`*s, each with a separate layout manager.* Place the `JPanel`s on the `JFrame` using either the default `BorderLayout` or some other layout.

```
1  // Fig. 26.42: BorderLayoutDemo.java
2  // Testing BorderLayoutFrame.
3  import javax.swing.JFrame;
4
5  public class BorderLayoutDemo
6  {
7     public static void main(String[] args)
8     {
9        BorderLayoutFrame borderLayoutFrame = new BorderLayoutFrame();
10       borderLayoutFrame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
11       borderLayoutFrame.setSize(300, 200);
12       borderLayoutFrame.setVisible(true);
13    }
14 }
```

**Fig. 26.42** | Testing `BorderLayoutFrame`. (Part 1 of 2.)

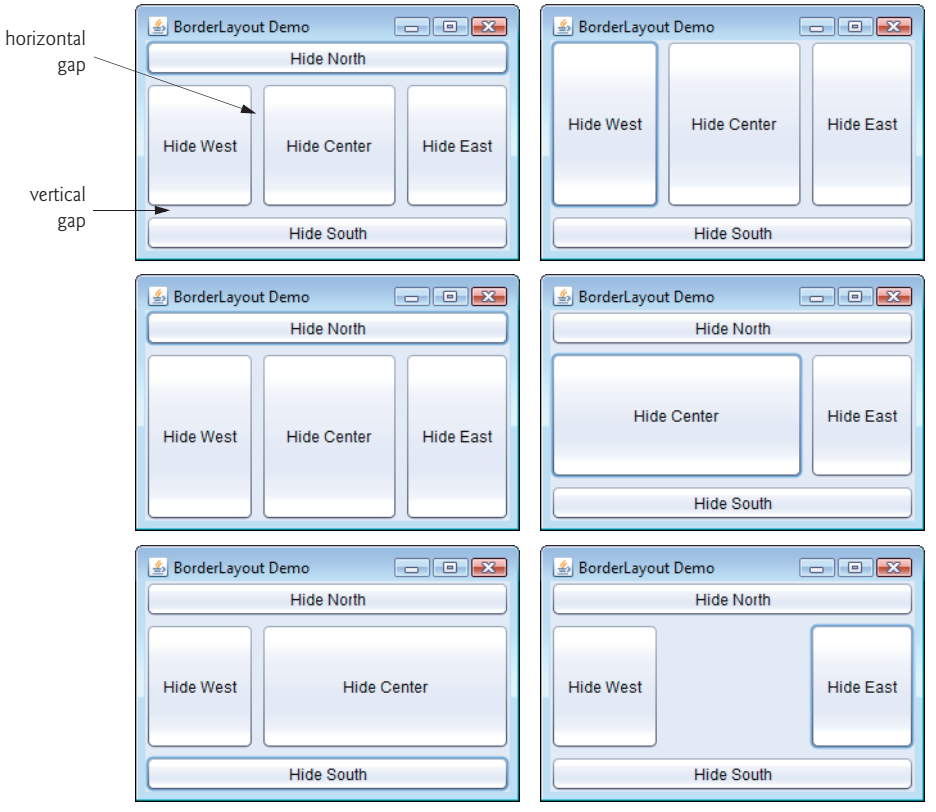



**Fig. 26.42** | Testing `BorderLayoutFrame`. (Part 2 of 2.)

### 26.18.3 GridLayout

The **`GridLayout`** layout manager divides the container into a *grid* so that components can be placed in *rows* and *columns*. Class `GridLayout` inherits directly from class `Object` and implements interface `LayoutManager`. Every `Component` in a `GridLayout` has the *same* width and height. Components are added to a `GridLayout` starting at the top-left cell of the grid and proceeding left to right until the row is full. Then the process continues left to right on the next row of the grid, and so on. The application of Figs. 26.43–26.44 demonstrates the `GridLayout` layout manager by using six `JButtons`.

```
1  // Fig. 26.43: GridLayoutFrame.java
2  // GridLayout containing six buttons.
3  import java.awt.GridLayout;
4  import java.awt.Container;
5  import java.awt.event.ActionListener;
6  import java.awt.event.ActionEvent;
7  import javax.swing.JFrame;
8  import javax.swing.JButton;
```

**Fig. 26.43** | `GridLayout` containing six buttons. (Part 1 of 2.)

```
9
10 public class GridLayoutFrame extends JFrame implements ActionListener
11 {
12    private final JButton[] buttons; // array of buttons
13    private static final String[] names =
14       { "one", "two", "three", "four", "five", "six" };
15    private boolean toggle = true; // toggle between two layouts
16    private final Container container; // frame container
17    private final GridLayout gridLayout1; // first gridlayout
18    private final GridLayout gridLayout2; // second gridlayout
19
20    // no-argument constructor
21    public GridLayoutFrame()
22    {
23       super("GridLayout Demo");
24       gridLayout1 = new GridLayout(2, 3, 5, 5); // 2 by 3; gaps of 5
25       gridLayout2 = new GridLayout(3, 2); // 3 by 2; no gaps
26       container = getContentPane();
27       setLayout(gridLayout1);
28       buttons = new JButton[names.length];
29
30       for (int count = 0; count < names.length; count++)
31       {
32          buttons[count] = new JButton(names[count]);
33          buttons[count].addActionListener(this); // register listener
34          add(buttons[count]); // add button to JFrame
35       }
36    }
37
38    // handle button events by toggling between layouts
39    @Override
40    public void actionPerformed(ActionEvent event)
41    {
42       if (toggle) // set layout based on toggle
43          container.setLayout(gridLayout2);
44       else
45          container.setLayout(gridLayout1);
46
47       toggle = !toggle;
48       container.validate(); // re-lay out container
49    }
50 }
```

**Fig. 26.43** | `GridLayout` containing six buttons. (Part 2 of 2.)

```
1 // Fig. 26.44: GridLayoutDemo.java
2 // Testing GridLayoutFrame.
3 import javax.swing.JFrame;
4
5 public class GridLayoutDemo
6 {
```

**Fig. 26.44** | Testing `GridLayoutFrame`. (Part 1 of 2.)

```
7       public static void main(String[] args)
8       {
9          GridLayoutFrame gridLayoutFrame = new GridLayoutFrame();
10         gridLayoutFrame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
11         gridLayoutFrame.setSize(300, 200);
12         gridLayoutFrame.setVisible(true);
13      }
14   }
```

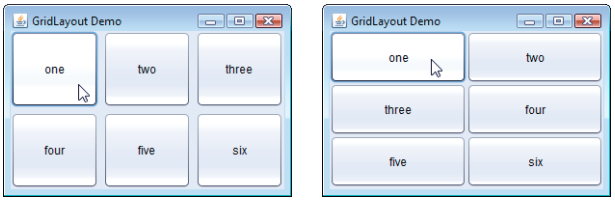



**Fig. 26.44** | Testing `GridLayoutFrame`. (Part 2 of 2.)

Lines 24–25 (Fig. 26.43) create two `GridLayout` objects. The `GridLayout` constructor used at line 24 specifies a `GridLayout` with `2` rows, `3` columns, `5` pixels of horizontal-gap space between `Components` in the grid and `5` pixels of vertical-gap space between `Components` in the grid. The `GridLayout` constructor used at line 25 specifies a `GridLayout` with `3` rows and `2` columns that uses the default gap space (1 pixel).

The `JButton` objects in this example initially are arranged using `gridLayout1` (set for the content pane at line 27 with method `setLayout`). The first component is added to the first column of the first row. The next component is added to the second column of the first row, and so on. When a `JButton` is pressed, method `actionPerformed` (lines 39–49) is called. Every call to `actionPerformed` toggles the layout between `gridLayout2` and `gridLayout1`, using `boolean` variable `toggle` to determine the next layout to set.

Line 48 shows another way to reformat a container for which the layout has changed. `Container` method **`validate`** recomputes the container's layout based on the current layout manager for the `Container` and the current set of displayed GUI components.

## 26.19 Using Panels to Manage More Complex Layouts

Complex GUIs (like Fig. 26.1) often require that each component be placed in an exact location. They often consist of multiple panels, with each panel's components arranged in a specific layout. Class `JPanel` extends `JComponent` and `JComponent` extends class `Container`, so every `JPanel` is a `Container`. Thus, every `JPanel` may have components, including other panels, attached to it with `Container` method `add`. The application of Figs. 26.45–26.46 demonstrates how a `JPanel` can be used to create a more complex layout in which several `JButtons` are placed in the `SOUTH` region of a `BorderLayout`.

```
1  // Fig. 26.45: PanelFrame.java
2  // Using a JPanel to help lay out components.
3  import java.awt.GridLayout;
4  import java.awt.BorderLayout;
5  import javax.swing.JFrame;
6  import javax.swing.JPanel;
7  import javax.swing.JButton;
8
9  public class PanelFrame extends JFrame
10 {
11    private final JPanel buttonJPanel; // panel to hold buttons
12    private final JButton[] buttons;
13
14    // no-argument constructor
15    public PanelFrame()
16    {
17       super("Panel Demo");
18       buttons = new JButton[5];
19       buttonJPanel = new JPanel();
20       buttonJPanel.setLayout(new GridLayout(1, buttons.length));
21
22       // create and add buttons
23       for (int count = 0; count < buttons.length; count++)
24       {
25          buttons[count] = new JButton("Button " + (count + 1));
26          buttonJPanel.add(buttons[count]); // add button to panel
27       }
28
29       add(buttonJPanel, BorderLayout.SOUTH); // add panel to JFrame
30    }
31 }
```

**Fig. 26.45** | `JPanel` with five `JButtons` in a `GridLayout` attached to the `SOUTH` region of a `BorderLayout`.

```
1  // Fig. 26.46: PanelDemo.java
2  // Testing PanelFrame.
3  import javax.swing.JFrame;
4
5  public class PanelDemo extends JFrame
6  {
7     public static void main(String[] args)
8     {
9        PanelFrame panelFrame = new PanelFrame();
10       panelFrame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
11       panelFrame.setSize(450, 200);
12       panelFrame.setVisible(true);
13    }
14 }
```

**Fig. 26.46** | Testing `PanelFrame`. (Part 1 of 2.)

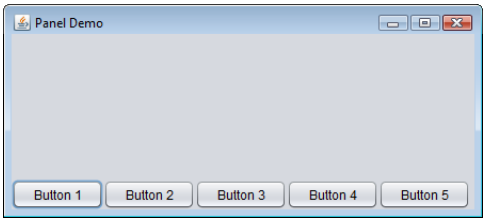



**Fig. 26.46** | Testing `PanelFrame`. (Part 2 of 2.)

After `JPanel buttonJPanel` is declared (line 11 of Fig. 26.45) and created (line 19), line 20 sets `buttonJPanel`'s layout to a `GridLayout` of one row and five columns (there are five `JButtons` in array `buttons`). Lines 23–27 add the `JButtons` in the array to the `JPanel`. Line 26 adds the buttons directly to the `JPanel`—class `JPanel` does not have a content pane, unlike a `JFrame`. Line 29 uses the `JFrame`'s default `BorderLayout` to add `buttonJPanel` to the `SOUTH` region. The `SOUTH` region is as tall as the buttons on `buttonJPanel`. A `JPanel` is sized to the components it contains. As more components are added, the `JPanel` *grows* (according to the restrictions of its layout manager) to accommodate the components. Resize the window to see how the layout manager affects the size of the `JButtons`.

## 26.20 JTextArea

A **`JTextArea`** provides an area for *manipulating multiple lines of text*. Like class `JTextField`, `JTextArea` is a subclass of `JTextComponent`, which declares common methods for `JTextFields`, `JTextAreas` and several other text-based GUI components.

The application in Figs. 26.47–26.48 demonstrates `JTextAreas`. One `JTextArea` displays text that the user can select. The other is uneditable by the user and is used to display the text the user selected in the first `JTextArea`. Unlike `JTextFields`, `JTextAreas` do not have action events—when you press *Enter* while typing in a `JTextArea`, the cursor simply moves to the next line. As with multiple-selection `JLists` (Section 26.13), an external event from another GUI component indicates when to process the text in a `JTextArea`. For example, when typing an e-mail message, you normally click a **Send** button to send the text of the message to the recipient. Similarly, when editing a document in a word processor, you normally save the file by selecting a **Save** or **Save As...** menu item. In this program, the button **Copy >>>** generates the external event that copies the selected text in the left `JTextArea` and displays it in the right `JTextArea`.

```
1  // Fig. 26.47: TextAreaFrame.java
2  // Copying selected text from one JText area to another.
3  import java.awt.event.ActionListener;
4  import java.awt.event.ActionEvent;
5  import javax.swing.Box;
6  import javax.swing.JFrame;
7  import javax.swing.JTextArea;
```

**Fig. 26.47** | Copying selected text from one `JTextArea` to another. (Part 1 of 2.)

```
import javax.swing.JButton;
import javax.swing.JScrollPane;

public class TextAreaFrame extends JFrame
{
   private final JTextArea textArea1; // displays demo string
   private final JTextArea textArea2; // highlighted text is copied here
   private final JButton copyJButton; // initiates copying of text

   // no-argument constructor
   public TextAreaFrame()
   {
      super("TextArea Demo");
      Box box = Box.createHorizontalBox(); // create box
      String demo = "This is a demo string to\n" +
         "illustrate copying text\nfrom one textarea to \n" +
         "another textarea using an\nexternal event\n";

      textArea1 = new JTextArea(demo, 10, 15);
      box.add(new JScrollPane(textArea1)); // add scrollpane

      copyJButton = new JButton("Copy >>>"); // create copy button
      box.add(copyJButton); // add copy button to box
      copyJButton.addActionListener(
         new ActionListener() // anonymous inner class
         {
            // set text in textArea2 to selected text from textArea1
            @Override
            public void actionPerformed(ActionEvent event)
            {
               textArea2.setText(textArea1.getSelectedText());
            }
         }
      );

      textArea2 = new JTextArea(10, 15);
      textArea2.setEditable(false);
      box.add(new JScrollPane(textArea2)); // add scrollpane

      add(box); // add box to frame
   }
}
```

**Fig. 26.47** | Copying selected text from one `JTextArea` to another. (Part 2 of 2.)

```
// Fig. 26.48: TextAreaDemo.java
// Testing TextAreaFrame.
import javax.swing.JFrame;

public class TextAreaDemo
{
```

**Fig. 26.48** | Testing `TextAreaFrame`. (Part 1 of 2.)

```
7       public static void main(String[] args)
8       {
9          TextAreaFrame textAreaFrame = new TextAreaFrame();
10         textAreaFrame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
11         textAreaFrame.setSize(425, 200);
12         textAreaFrame.setVisible(true);
13      }
14   }
```

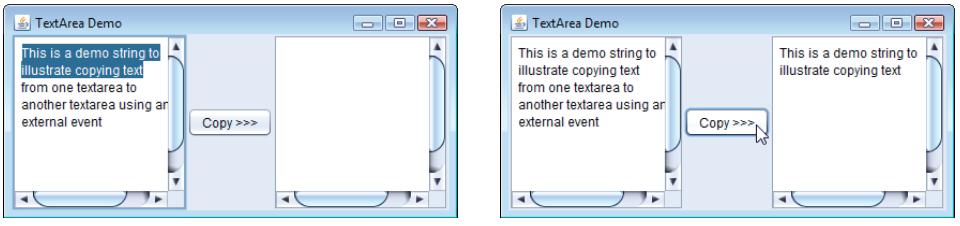



**Fig. 26.48** | Testing `TextAreaFrame`. (Part 2 of 2.)

In the constructor (lines 18–48), line 21 creates a **`Box`** container (package `javax.swing`) to organize the GUI components. `Box` is a subclass of `Container` that uses a **`BoxLayout`** layout manager (discussed in detail in Section 35.9) to arrange the GUI components either horizontally or vertically. `Box`'s `static` method **`createHorizontalBox`** creates a `Box` that arranges components from left to right in the order that they're attached.

Lines 26 and 43 create `JTextAreas` `textArea1` and `textArea2`. Line 26 uses `JTextArea`'s three-argument constructor, which takes a `String` representing the initial text and two `int`s specifying that the `JTextArea` has `10` rows and `15` columns. Line 43 uses `JTextArea`'s two-argument constructor, specifying that the `JTextArea` has `10` rows and `15` columns. Line 26 specifies that `demo` should be displayed as the default `JTextArea` content. A `JTextArea` does not provide scrollbars if it cannot display its complete contents. So, line 27 creates a `JScrollPane` object, initializes it with `textArea1` and attaches it to container `box`. By default, horizontal and vertical scrollbars appear as necessary in a `JScrollPane`.

Lines 29–41 create `JButton` object `copyJButton` with the label `"Copy >>>"`, add `copyJButton` to container `box` and register the event handler for `copyJButton`'s `ActionEvent`. This button provides the external event that determines when the program should copy the selected text in `textArea1` to `textArea2`. When the user clicks `copyJButton`, line 38 in `actionPerformed` indicates that method **`getSelectedText`** (inherited into `JTextArea` from `JTextComponent`) should return the selected text from `textArea1`. The user selects text by dragging the mouse over the desired text to highlight it. Method `setText` changes the text in `textArea2` to the string returned by `getSelectedText`.

Lines 43–45 create `textArea2`, set its editable property to `false` and add it to container `box`. Line 47 adds `box` to the `JFrame`. Recall from Section 26.18.2 that the default layout of a `JFrame` is a `BorderLayout` and that the `add` method by default attaches its argument to the `CENTER` of the `BorderLayout`.

When text reaches the right edge of a `JTextArea` the text can wrap to the next line. This is referred to as **line wrapping**. By default, `JTextArea` does *not* wrap lines.


**Look-and-Feel Observation 26.19**

*To provide line wrapping functionality for a* `JTextArea`*, invoke* `JTextArea` *method* **`setLineWrap`** *with a* `true` *argument.*

### *`JScrollPane` Scrollbar Policies*

This example uses a `JScrollPane` to provide scrolling for a `JTextArea`. By default, `JScrollPane` displays scrollbars *only* if they're required. You can set the horizontal and vertical **scrollbar policies** of a `JScrollPane` when it's constructed. If a program has a reference to a `JScrollPane`, the program can use `JScrollPane` methods **`setHorizontalScrollBarPolicy`** and **`setVerticalScrollBarPolicy`** to change the scrollbar policies at any time. Class `JScrollPane` declares the constants

```
JScrollPane.VERTICAL_SCROLLBAR_ALWAYS
JScrollPane.HORIZONTAL_SCROLLBAR_ALWAYS
```

to indicate that *a scrollbar should always appear*, constants

```
JScrollPane.VERTICAL_SCROLLBAR_AS_NEEDED
JScrollPane.HORIZONTAL_SCROLLBAR_AS_NEEDED
```

to indicate that *a scrollbar should appear only if necessary* (the defaults) and constants

```
JScrollPane.VERTICAL_SCROLLBAR_NEVER
JScrollPane.HORIZONTAL_SCROLLBAR_NEVER
```

to indicate that *a scrollbar should never appear*. If the horizontal scrollbar policy is set to `JScrollPane.HORIZONTAL_SCROLLBAR_NEVER`, a `JTextArea` attached to the `JScrollPane` will automatically wrap lines.

## 26.21 Wrap-Up

In this chapter, you learned many GUI components and how to handle their events. You also learned about nested classes, inner classes and anonymous inner classes. You saw the special relationship between an inner-class object and an object of its top-level class. You learned how to use `JOptionPane` dialogs to obtain text input from the user and how to display messages to the user. You also learned how to create applications that execute in their own windows. We discussed class `JFrame` and components that enable a user to interact with an application. We also showed you how to display text and images to the user. You learned how to customize `JPanel`s to create custom drawing areas, which you'll use extensively in the next chapter. You saw how to organize components on a window using layout managers and how to creating more complex GUIs by using `JPanel`s to organize components. Finally, you learned about the `JTextArea` component in which a user can enter text and an application can display text. In Chapter 35, you'll learn about more advanced GUI components, such as sliders, menus and more complex layout managers. In the next chapter, you'll learn how to add graphics to your GUI application. Graphics allow you to draw shapes and text with colors and styles.

## Summary

### *Section 26.1 Introduction*

- A graphical user interface (GUI; p. 2) presents a user-friendly mechanism for interacting with an application. A GUI gives an application a distinctive look-and-feel (p. 2).
- Providing different applications with consistent, intuitive user-interface components gives users a sense of familarity with a new application, so that they can learn it more quickly.
- GUIs are built from GUI components (p. 2)—sometimes called controls or widgets.

### *Section 26.2 Java's Nimbus Look-and-Feel*

- As of Java SE 6 update 10, Java comes bundled with a new, elegant, cross-platform look-and-feel known as Nimbus (p. 4).
- To set Nimbus as the default for all Java applications, create a `swing.properties` text file in the `lib` folder of your JDK and JRE installation folders. Place the following line of code in the file:

```
swing.defaultlaf=com.sun.java.swing.plaf.nimbus.NimbusLookAndFeel
```

- To select Nimbus on an application-by-application basis, place the following command-line argument after the java command and before the application's name when you run the application:

```
-Dswing.defaultlaf=com.sun.java.swing.plaf.nimbus.NimbusLookAndFeel
```

### *Section 26.3 Simple GUI-Based Input/Output with `JOptionPane`*

- Most applications use windows or dialog boxes (p. 4) to interact with the user.
- Class `JOptionPane` (p. 4) of package `javax.swing` provides prebuilt dialog boxes for both input and output. `JOptionPane` `static` method `showInputDialog` (p. 5) displays an input dialog (p. 4).
- A prompt typically uses sentence-style capitalization—capitalizing only the first letter of the first word in the text unless the word is a proper noun.
- An input dialog can input only input `String`s. This is typical of most GUI components.
- `JOptionPane` `static` method `showMessageDialog` (p. 6) displays a message dialog (p. 4).

### *Section 26.4 Overview of Swing Components*

- Most Swing GUI components (p. 2) are located in package `javax.swing`.
- Together, the appearance and the way in which the user interacts with the application are known as that application's look-and-feel. Swing GUI components allow you to specify a uniform look-and-feel for your application across all platforms or to use each platform's custom look-and-feel.
- Lightweight Swing components are not tied to actual GUI components supported by the underlying platform on which an application executes.
- Several Swing components are heavyweight components (p. 8) that require direct interaction with the local windowing system (p. 8), which may restrict their appearance and functionality.
- Class `Component` (p. 8) of package `java.awt` declares many of the attributes and behaviors common to the GUI components in packages `java.awt` (p. 7) and `javax.swing`.
- Class `Container` (p. 8) of package `java.awt` is a subclass of `Component`. `Component`s are attached to `Container`s so the `Component`s can be organized and displayed on the screen.
- Class `JComponent` (p. 8) of package `javax.swing` is a subclass of `Container`. `JComponent` is the superclass of all lightweight Swing components and declares their common attributes and behaviors.

- Some common `JComponent` features include a pluggable look-and-feel (p. 8), shortcut keys called mnemonics (p. 8), tool tips (p. 9), support for assistive technologies and support for user-interface localization (p. 9).

### *Section 26.5 Displaying Text and Images in a Window*

- Class `JFrame` provides the basic attributes and behaviors of a window.
- A `JLabel` (p. 9) displays read-only text, an image, or both text and an image. Text in a `JLabel` normally uses sentence-style capitalization.
- Each GUI component must be attached to a container, such as a window created with a `JFrame`.
- Many IDEs provide GUI design tools in which you can specify the exact size and location of a component by using the mouse; then the IDE will generate the GUI code for you.
- `JComponent` method `setToolTipText` (p. 11) specifies the tool tip that's displayed when the user positions the mouse cursor over a lightweight component (p. 8).
- `Container` method `add` attaches a GUI component to a `Container`.
- Class `ImageIcon` (p. 12) supports several image formats, including GIF, PNG and JPEG.
- Method `getClass` of class `Object` (p. 12) retrieves a reference to the `Class` object that represents the the class declaration for the object on which the method is called.
- `Class` method `getResource` (p. 12) returns the location of its argument as a URL. The method `getResource` uses the `Class` object's class loader to determine the location of the resource.
- The horizontal and vertical alignments of a `JLabel` can be set with methods `setHorizontalAlignment` (p. 13) and `setVerticalAlignment` (p. 13), respectively.
- `JLabel` methods `setText` (p. 13) and `getText` (p. 13) set and get the text displayed on a label.
- `JLabel` methods `setIcon` (p. 13) and `getIcon` (p. 13) set and get the `Icon` (p. 12) on a label.
- `JLabel` methods `setHorizontalTextPosition` (p. 13) and `setVerticalTextPosition` (p. 13) specify the text position in the label.
- `JFrame` method `setDefaultCloseOperation` (p. 13) with constant `JFrame.EXIT_ON_CLOSE` as the argument indicates that the program should terminate when the window is closed by the user.
- `Component` method `setSize` (p. 13) specifies the width and height of a component.
- `Component` method `setVisible` (p. 13) with the argument `true` displays a `JFrame` on the screen.

### *Section 26.6 Text Fields and an Introduction to Event Handling with Nested Classes*

- GUIs are event driven—when the user interacts with a GUI component, events (p. 13) drive the program to perform tasks.
- An event handler (p. 14) performs a task in response to an event.
- Class `JTextField` (p. 14) extends `JTextComponent` (p. 14) of package `javax.swing.text`, which provides common text-based component features. Class `JPasswordField` (p. 14) extends `JTextField` and adds several methods that are specific to processing passwords.
- A `JPasswordField` shows that characters are being typed as the user enters them, but hides the actual characters with echo characters (p. 14).
- A component receives the focus (p. 14) when the user clicks the component.
- `JTextComponent` method `setEditable` (p. 16) can be used to make a text field uneditable.
- To respond to an event for a particular GUI component, you must create a class that represents the event handler and implements an appropriate event-listener interface (p. 16), then register an object of the event-handling class as the event handler (p. 16).

- Non-`static` nested classes (p. 17) are called inner classes and are frequently used for event handling.
- An object of a non-`static` inner class (p. 17) must be created by an object of the top-level class (p. 17) that contains the inner class.
- An inner-class object can directly access the instance variables and methods of its top-level class.
- A nested class that's `static` does not require an object of its top-level class and does not implicitly have a reference to an object of the top-level class.
- Pressing *Enter* in a `JTextField` or `JPasswordField` generates an `ActionEvent` (p. 17) that can be handled by an `ActionListener` (p. 17) of package `java.awt.event`.
- `JTextField` method `addActionListener` (p. 17) registers an event handler for a text field's `ActionEvent`.
- The GUI component with which the user interacts is the event source (p. 18).
- An `ActionEvent` object contains information about the event that just occurred, such as the event source and the text in the text field.
- `ActionEvent` method `getSource` returns a reference to the event source. `ActionEvent` method `getActionCommand` (p. 18) returns the text the user typed in a text field or the label on a `JButton`.
- `JPasswordField` method `getPassword` (p. 18) returns the password the user typed.

### *Section 26.7 Common GUI Event Types and Listener Interfaces*

- Each event-object type typically has a corresponding event-listener interface that specifies one or more event-handling methods, which must be declared in the class that implements the interface.

### *Section 26.8 How Event Handling Works*

- When an event occurs, the GUI component with which the user interacted notifies its registered listeners by calling each listener's appropriate event-handling method.
- Every GUI component supports several event types. When an event occurs, the event is dispatched (p. 23) only to the event listeners of the appropriate type.

### *Section 26.9* `JButton`

- A button is a component the user clicks to trigger an action. All the button types are subclasses of `AbstractButton` (p. 23; package `javax.swing`). Button labels (p. 24) typically use book-title capitalization.
- Command buttons (p. 23) are created with class `JButton`.
- A `JButton` can display an `Icon`. A `JButton` can also have a rollover `Icon` (p. 25)—an `Icon` that's displayed when the user positions the mouse over the button.
- Method `setRolloverIcon` (p. 25) of class `AbstractButton` specifies the image displayed on a button when the user positions the mouse over it.

### *Section 26.10 Buttons That Maintain State*

- There are three Swing state button types—`JToggleButton` (p. 27), `JCheckBox` (p. 27) and `JRadioButton` (p. 27).
- Classes `JCheckBox` and `JRadioButton` are subclasses of `JToggleButton`.
- `Component` method `setFont` (p. 29) sets the component's font to a new `Font` object (p. 29) of package `java.awt`.

- Clicking a `JCheckBox` causes an `ItemEvent` (p. 29) that can be handled by an `ItemListener` (p. 29) which defines method `itemStateChanged` (p. 29). Method `addItemListener` registers the listener for the `ItemEvent` of a `JCheckBox` or `JRadioButton` object.
- `JCheckBox` method `isSelected` determines whether a `JCheckBox` is selected.
- `JRadioButtons` have two states—selected and not selected. Radio buttons (p. 23) normally appear as a group (p. 30) in which only one button can be selected at a time.
- `JRadioButtons` are used to represent mutually exclusive options (p. 30).
- The logical relationship between `JRadioButtons` is maintained by a `ButtonGroup` object (p. 30).
- `ButtonGroup` method `add` (p. 32) associates each `JRadioButton` with a `ButtonGroup`. If more than one selected `JRadioButton` object is added to a group, the selected one that was added first will be selected when the GUI is displayed.
- `JRadioButtons` generate `ItemEvents` when they're clicked.

### *Section 26.11 `JComboBox`; Using an Anonymous Inner Class for Event Handling*

- A `JComboBox` (p. 33) provides a list of items from which the user can make a single selection. `JComboBoxes` generate `ItemEvents`.
- Each item in a `JComboBox` has an index (p. 35). The first item added to a `JComboBox` appears as the currently selected item when the `JComboBox` is displayed.
- `JComboBox` method `setMaximumRowCount` (p. 35) sets the maximum number of elements that are displayed when the user clicks the `JComboBox`.
- An anonymous inner class (p. 35) is a class without a name and typically appears inside a method declaration. One object of the anonymous inner class must be created when the class is declared.
- `JComboBox` method `getSelectedIndex` (p. 36) returns the index of the selected item.

### *Section 26.12 `JList`*

- A `JList` displays a series of items from which the user may select one or more items. Class `JList` supports single-selection lists (p. 36) and multiple-selection lists.
- When the user clicks an item in a `JList`, a `ListSelectionEvent` (p. 37) occurs. `JList` method `addListSelectionListener` (p. 38) registers a `ListSelectionListener` (p. 38) for a `JList`'s selection events. A `ListSelectionListener` of package `javax.swing.event` must implement method `valueChanged`.
- `JList` method `setVisibleRowCount` (p. 37) specifies the number of visible items in the list.
- `JList` method `setSelectionMode` (p. 37) specifies a list's selection mode.
- A `JList` can be attached to a `JScrollPane` (p. 38) to provide a scrollbar for the `JList`.
- `JFrame` method `getContentPane` (p. 39) returns a reference to the `JFrame`'s content pane where GUI components are displayed.
- `JList` method `getSelectedIndex` (p. 39) returns the selected item's index.

### *Section 26.13 Multiple-Selection Lists*

- A multiple-selection list enables the user to select many items from a `JList`.
- `JList` method `setFixedCellWidth` (p. 41) sets a `JList`'s width. Method `setFixedCellHeight` (p. 41) sets the height of each item in a `JList`.
- Normally, an external event (p. 41) generated by another GUI component (such as a `JButton`) specifies when the multiple selections in a `JList` should be processed.

- `JList` method `setListData` (p. 41) sets the items displayed in a `JList`. `JList` method `getSelectedValues` (p. 41) returns an array of `Objects` representing the selected items in a `JList`.

### *Section 26.14 Mouse Event Handling*

- The `MouseListener` (p. 23) and `MouseMotionListener` event-listener interfaces are used to handle mouse events. Mouse events can be trapped for any GUI component that extends `Component`.
- Interface `MouseInputListener` of package `javax.swing.event` extends interfaces `MouseListener` and `MouseMotionListener` to create a single interface containing all their methods.
- Each mouse event-handling method receives a `MouseEvent` object (p. 23) that contains information about the event, including the *x*- and *y*-coordinates where the event occurred. Coordinates are measured from the upper-left corner of the GUI component on which the event occurred.
- The methods and constants of class `InputEvent` (`MouseEvent`'s superclass) enable an application to determine which mouse button the user clicked.
- Interface `MouseWheelListener` enables applications to respond to mouse-wheel events.

### *Section 26.15 Adapter Classes*

- An adapter class (p. 46) implements an interface and provides default implementations of its methods. When you extend an adapter class, you can override just the method(s) you need.
- `MouseEvent` method `getClickCount` (p. 50) returns the number of consecutive mouse-button clicks. Methods `isMetaDown` (p. 50) and `isAltDown` (p. 50) determine which button was clicked.

### *Section 26.16* `JPanel` *Subclass for Drawing with the Mouse*

- `JComponents` method `paintComponent` (p. 50) is called when a lightweight Swing component is displayed. Override this method to specify how to draw shapes using Java's graphics capabilities.
- When overriding `paintComponent`, call the superclass version as the first statement in the body.
- Subclasses of `JComponent` support transparency. When a component is opaque (p. 50), `paintComponent` clears its background before the component is displayed.
- The transparency of a Swing lightweight component can be set with method `setOpaque` (p. 50; a `false` argument indicates that the component is transparent).
- Class `Point` (p. 52) package `java.awt` represents an *x*-*y* coordinate.
- Class `Graphics` (p. 52) is used to draw.
- `MouseEvent` method `getPoint` (p. 52) obtains the `Point` where a mouse event occurred.
- Method `repaint` (p. 52), inherited indirectly from class `Component`, indicates that a component should be refreshed on the screen as soon as possible.
- Method `paintComponent` receives a `Graphics` parameter and is called automatically whenever a lightweight component needs to be displayed on the screen.
- `Graphics` method `fillOval` (p. 52) draws a solid oval. The first two arguments are the upper-left *x*-*y* coordinate of the bounding box, and the last two are the bounding box's width and height.

### *Section 26.17 Key Event Handling*

- Interface `KeyListener` is used to handle key events that are generated when keys on the keyboard are pressed and released. Method `addKeyListener` of class `Component` (p. 53) registers a `KeyListener`.
- `KeyEvent` method `getKeyCode` (p. 56) gets the virtual key code (p. 56) of the pressed key. Class `KeyEvent` contains virtual key-code constants that represent every key on the keyboard.
- `KeyEvent` method `getKeyText` (p. 56) returns a string containing the name of the pressed key.
- `KeyEvent` method `getKeyChar` (p. 56) gets the Unicode value of the character typed.

- `KeyEvent` method `isActionKey` (p. 56) determines whether the key in an event was an action key (p. 53).
- `InputEvent` method `getModifiers` (p. 56) determines whether any modifier keys (such as *Shift*, *Alt* and *Ctrl*) were pressed when the key event occurred.
- `KeyEvent` method `getKeyModifiersText` (p. 56) returns a string containing the pressed modifier keys.

### *Section 26.18 Introduction to Layout Managers*

- Layout managers (p. 11) arrange GUI components in a container for presentation purposes.
- All layout managers implement the interface `LayoutManager` of package `java.awt`.
- `Container` method `setLayout` specifies the layout of a container.
- `FlowLayout` places components left to right in the order in which they're added to the container. When the container's edge is reached, components continue to display on the next line. `FlowLayout` allows GUI components to be left aligned, centered (the default) and right aligned.
- `FlowLayout` method `setAlignment` changes the alignment for a `FlowLayout`.
- `BorderLayout` (the default for a `JFrame`) arranges components into five regions: `NORTH`, `SOUTH`, `EAST`, `WEST` and `CENTER`. `NORTH` corresponds to the top of the container.
- A `BorderLayout` limits a `Container` to containing at most five components—one in each region.
- `GridLayout` (p. 64) divides a container into a grid of rows and columns.
- `Container` method `validate` (p. 66) recomputes a container's layout based on the current layout manager for the `Container` and the current set of displayed GUI components.

### *Section 26.19 Using Panels to Manage More Complex Layouts*

- Complex GUIs often consist of multiple panels with different layouts. Every `JPanel` may have components, including other panels, attached to it with `Container` method `add`.

### *Section 26.20* `JTextArea`

- A `JTextArea` (p. 68)—a subclass of `JTextComponent`—may contain multiple lines of text.
- Class `Box` (p. 70) is a subclass of `Container` that uses a `BoxLayout` layout manager (p. 70) to arrange the GUI components either horizontally or vertically.
- `Box` `static` method `createHorizontalBox` (p. 70) creates a `Box` that arranges components from left to right in the order that they're attached.
- Method `getSelectedText` (p. 70) returns the selected text from a `JTextArea`.
- You can set the horizontal and vertical scrollbar policies (p. 71) of a `JScrollPane` when it's constructed. `JScrollPane` methods `setHorizontalScrollBarPolicy` (p. 71) and `setVerticalScrollBarPolicy` (p. 71) can be used to change the scrollbar policies at any time.

## Self-Review Exercises

**26.1** Fill in the blanks in each of the following statements:

a) Method _____ is called when the mouse is moved with no buttons pressed and an event listener is registered to handle the event.
b) Text that cannot be modified by the user is called _____ text.
c) A(n) _____ arranges GUI components in a `Container`.
d) The `add` method for attaching GUI components is a method of class _____.
e) GUI is an acronym for _____.
f) Method _____ is used to specify the layout manager for a container.

g) A `mouseDragged` method call is preceded by a(n) _____ method call and followed by a(n) _____ method call.
h) Class _____ contains methods that display message dialogs and input dialogs.
i) An input dialog capable of receiving input from the user is displayed with method _____ of class _____.
j) A dialog capable of displaying a message to the user is displayed with method _____ of class _____.
k) Both `JTextFields` and `JTextAreas` directly extend class _____.

**26.2** Determine whether each statement is *true* or *false*. If *false*, explain why.
a) `BorderLayout` is the default layout manager for a `JFrame`'s content pane.
b) When the mouse cursor is moved into the bounds of a GUI component, method `mouseOver` is called.
c) A `JPanel` cannot be added to another `JPanel`.
d) In a `BorderLayout`, two buttons added to the `NORTH` region will be placed side by side.
e) A maximum of five components can be added to a `BorderLayout`.
f) Inner classes are not allowed to access the members of the enclosing class.
g) A `JTextArea`'s text is always read-only.
h) Class `JTextArea` is a direct subclass of class `Component`.

**26.3** Find the error(s) in each of the following statements, and explain how to correct it (them):
a)
```
buttonName = JButton("Caption");
```
b)
```
JLabel aLabel, JLabel;
```
c)
```
txtField = new JTextField(50, "Default Text");
```
d)
```
setLayout(new BorderLayout());
button1 = new JButton("North Star");
button2 = new JButton("South Pole");
add(button1);
add(button2);
```

## Answers to Self-Review Exercises

**26.1** a) `mouseMoved`. b) uneditable (read-only). c) layout manager. d) `Container`. e) graphical user interface. f) `setLayout`. g) `mousePressed`, `mouseReleased`. h) `JOptionPane`. i) `showInputDialog`, `JOptionPane`. j) `showMessageDialog`, `JOptionPane`. k) `JTextComponent`.

**26.2** Answers for a) through h):
a) True.
b) False. Method `mouseEntered` is called.
c) False. A `JPanel` can be added to another `JPanel`, because `JPanel` is an indirect subclass of `Component`. So, a `JPanel` is a `Component`. Any `Component` can be added to a `Container`.
d) False. Only the last button added will be displayed. Remember that only one component should be added to each region in a `BorderLayout`.
e) True. [*Note:* Panels containing multiple components can be added to each region.]
f) False. Inner classes have access to all members of the enclosing class declaration.
g) False. `JTextAreas` are editable by default.
h) False. `JTextArea` derives from class `JTextComponent`.

**26.3** Answers for a) through d):
a) `new` is needed to create an object.
b) `JLabel` is a class name and cannot be used as a variable name.
c) The arguments passed to the constructor are reversed. The `String` must be passed first.

d) `BorderLayout` has been set, and components are being added without specifying the region, so both are added to the center region. Proper `add` statements might be

```
add(button1, BorderLayout.NORTH);
add(button2, BorderLayout.SOUTH);
```

## Exercises

**26.4** Fill in the blanks in each of the following statements:

a) The `JTextField` class directly extends class _____.
b) `Container` method _____ attaches a GUI component to a container.
c) Method _____ is called when a mouse button is released (without moving the mouse).
d) The _____ class is used to create a group of `JRadioButtons`.

**26.5** Determine whether each statement is *true* or *false*. If *false*, explain why.

a) Only one layout manager can be used per `Container`.
b) GUI components can be added to a `Container` in any order in a `BorderLayout`.
c) `JRadioButtons` provide a series of mutually exclusive options (i.e., only one can be `true` at a time).
d) `Graphics` method `setFont` is used to set the font for text fields.
e) A `JList` displays a scrollbar if there are more items in the list than can be displayed.
f) A `Mouse` object has a method called `mouseDragged`.

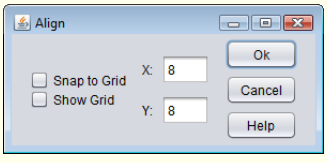
**26.6** Determine whether each statement is *true* or *false*. If *false*, explain why.

a) A `JPanel` is a `JComponent`.
b) A `JPanel` is a `Component`.
c) A `JLabel` is a `Container`.
d) A `JList` is a `JPanel`.
e) An `AbstractButton` is a `JButton`.
f) A `JTextField` is an `Object`.
g) `ButtonGroup` is a subclass of `JComponent`.

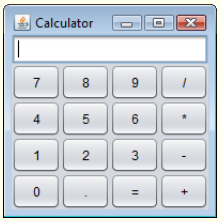
**26.7** Find any errors in each of the following lines of code, and explain how to correct them.

a) `import javax.swing.JFrame`
b) `panelObject.GridLayout(8, 8);`
c) `container.setLayout(new FlowLayout(FlowLayout.DEFAULT));`
d) `container.add(eastButton, EAST);`

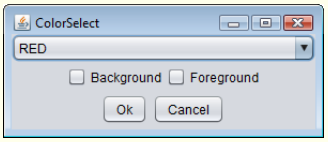
**26.8** Create the following GUI. You do not have to provide any functionality.



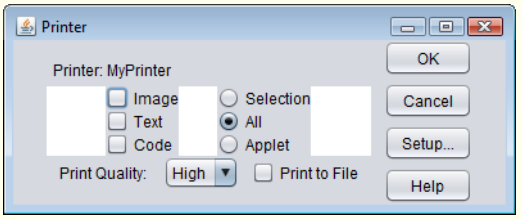

**26.9** Create the following GUI. You do not have to provide any functionality.



**26.10** Create the following GUI. You do not have to provide any functionality.




**26.11** Create the following GUI. You do not have to provide any functionality.




**26.12** ***(Temperature Conversion)*** Write a temperature-conversion application that converts from Fahrenheit to Celsius. The Fahrenheit temperature should be entered from the keyboard (via a `JTextField`). A `JLabel` should be used to display the converted temperature. Use the following formula for the conversion:

$$\text{Celsius} = \frac{5}{9} \times (\text{Fahrenheit} - 32)$$

**26.13** ***(Temperature-Conversion Modification)*** Enhance the temperature-conversion application of Exercise 26.12 by adding the Kelvin temperature scale. The application should also allow the user to make conversions between any two scales. Use the following formula for the conversion between Kelvin and Celsius (in addition to the formula in Exercise 26.12):

$$Kelvin = Celsius + 273.15$$

**26.14** ***(Guess-the-Number Game)*** Write an application that plays "guess the number" as follows: Your application chooses the number to be guessed by selecting an integer at random in the range 1–1000. The application then displays the following in a label:

```
I have a number between 1 and 1000. Can you guess my number?
Please enter your first guess.
```

A `JTextField` should be used to input the guess. As each guess is input, the background color should change to either red or blue. Red indicates that the user is getting "warmer," and blue, "colder." A `JLabel` should display either `"Too High"` or `"Too Low"` to help the user zero in. When the user gets the correct answer, `"Correct!"` should be displayed, and the `JTextField` used for input should be changed to be uneditable. A `JButton` should be provided to allow the user to play the game again. When the `JButton` is clicked, a new random number should be generated and the input `JTextField` changed to be editable.

**26.15** ***(Displaying Events)*** It's often useful to display the events that occur during the execution of an application. This can help you understand when the events occur and how they're generated. Write an application that enables the user to generate and process every event discussed in this chapter. The application should provide methods from the `ActionListener`, `ItemListener`, `ListSelectionListener`, `MouseListener`, `MouseMotionListener` and `KeyListener` interfaces to display messages when the events occur. Use method `toString` to convert the event objects received in each

event handler into Strings that can be displayed. Method toString creates a String containing all the information in the event object.

**26.16** *(GUI-Based Craps Game)* Modify the application of Section 6.10 to provide a GUI that enables the user to click a JButton to roll the dice. The application should also display four JLabels and four JTextFields, with one JLabel for each JTextField. The JTextFields should be used to display the values of each die and the sum of the dice after each roll. The point should be displayed in the fourth JTextField when the user does not win or lose on the first roll and should continue to be displayed until the game is lost.

## *(Optional) GUI and Graphics Case Study Exercise: Expanding the Interface*

**26.17** *(Interactive Drawing Application)* In this exercise, you'll implement a GUI application that uses the MyShape hierarchy from GUI and Graphics Case Study Exercise 10.2 to create an interactive drawing application. You'll create two classes for the GUI and provide a test class that launches the application. The classes of the MyShape hierarchy require no additional changes.

The first class to create is a subclass of JPanel called DrawPanel, which represents the area on which the user draws the shapes. Class DrawPanel should have the following instance variables:

a) An array shapes of type MyShape that will store all the shapes the user draws.
b) An integer shapeCount that counts the number of shapes in the array.
c) An integer shapeType that determines the type of shape to draw.
d) A MyShape currentShape that represents the current shape the user is drawing.
e) A Color currentColor that represents the current drawing color.
f) A boolean filledShape that determines whether to draw a filled shape.
g) A JLabel statusLabel that represents the status bar. The status bar will display the coordinates of the current mouse position.

Class DrawPanel should also declare the following methods:

a) Overridden method paintComponent that draws the shapes in the array. Use instance variable shapeCount to determine how many shapes to draw. Method paintComponent should also call currentShape's draw method, provided that currentShape is not null.
b) Set methods for the shapeType, currentColor and filledShape.
c) Method clearLastShape should clear the last shape drawn by decrementing instance variable shapeCount. Ensure that shapeCount is never less than zero.
d) Method clearDrawing should remove all the shapes in the current drawing by setting shapeCount to zero.

Methods clearLastShape and clearDrawing should call repaint (inherited from JPanel) to refresh the drawing on the DrawPanel by indicating that the system should call method paintComponent.

Class DrawPanel should also provide event handling to enable the user to draw with the mouse. Create a single inner class that both extends MouseAdapter and implements MouseMotionListener to handle all mouse events in one class.

In the inner class, override method mousePressed so that it assigns currentShape a new shape of the type specified by shapeType and initializes both points to the mouse position. Next, override method mouseReleased to finish drawing the current shape and place it in the array. Set the second point of currentShape to the current mouse position and add currentShape to the array. Instance variable shapeCount determines the insertion index. Set currentShape to null and call method repaint to update the drawing with the new shape.

Override method mouseMoved to set the text of the statusLabel so that it displays the mouse coordinates—this will update the label with the coordinates every time the user moves (but does not drag) the mouse within the DrawPanel. Next, override method mouseDragged so that it sets the second point of the currentShape to the current mouse position and calls method repaint. This will allow the user to see the shape while dragging the mouse. Also, update the JLabel in mouse-

`Dragged` with the current position of the mouse.

Create a constructor for `DrawPanel` that has a single `JLabel` parameter. In the constructor, initialize `statusLabel` with the value passed to the parameter. Also initialize array `shapes` with 100 entries, `shapeCount` to 0, `shapeType` to the value that represents a line, `currentShape` to `null` and `currentColor` to `Color.BLACK`. The constructor should then set the background color of the `DrawPanel` to `Color.WHITE` and register the `MouseListener` and `MouseMotionListener` so the `JPanel` properly handles mouse events.

Next, create a `JFrame` subclass called `DrawFrame` that provides a GUI that enables the user to control various aspects of drawing. For the layout of the `DrawFrame`, we recommend a `BorderLayout`, with the components in the `NORTH` region, the main drawing panel in the `CENTER` region, and a status bar in the `SOUTH` region, as in Fig. 26.49. In the top panel, create the components listed below. Each component's event handler should call the appropriate method in class `DrawPanel`.

a) A button to undo the last shape drawn.
b) A button to clear all shapes from the drawing.
c) A combo box for selecting the color from the 13 predefined colors.
d) A combo box for selecting the shape to draw.
e) A checkbox that specifies whether a shape should be filled or unfilled.

Declare and create the interface components in `DrawFrame`'s constructor. You'll need to create the status bar `JLabel` before you create the `DrawPanel`, so you can pass the `JLabel` as an argument to `DrawPanel`'s constructor. Finally, create a test class that initializes and displays the `DrawFrame` to execute the application.

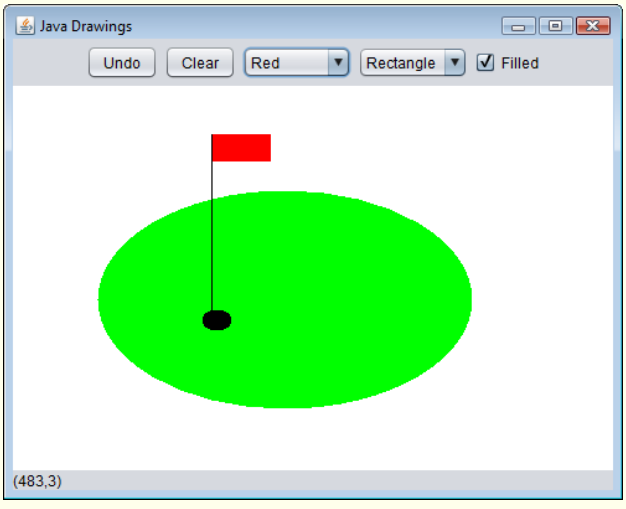



**Fig. 26.49** | Interface for drawing shapes.

**26.18** ***(GUI-Based Version of the ATM Case Study)*** Reimplement the Optional ATM Case Study of Chapters 33–34 as a GUI-based application. Use GUI components to approximate the ATM user interface shown in Fig. 33.1. For the cash dispenser and the deposit slot use `JButtons` labeled **Remove Cash** and **Insert Envelope**. This will enable the application to receive events indicating when the user takes the cash and inserts a deposit envelope, respectively.

## Making a Difference

**26.19** ***(Ecofont)*** Ecofont (`http://www.ecofont.com/en/products/green/font/download-the-ink-saving-font.html`)—developed by SPRANQ (a Netherlands-based company)—is a free, open-source computer font designed to reduce by as much as 20% the amount of ink used for printing, thus reducing also the number of ink cartridges used and the environmental impact of the manufacturing and shipping processes (using less energy, less fuel for shipping, and so on). The font, based on sans-serif Verdana, has small circular "holes" in the letters that are not visible in smaller sizes—such as the 9- or 10-point type frequently used. Download Ecofont, then install the font file `Spranq_eco_sans_regular.ttf` using the instructions from the Ecofont website. Next, develop a GUI-based program that allows you to type in a text string to be displayed in the Ecofont. Create **Increase Font Size** and **Decrease Font Size** buttons that allow you to scale up or down by one point at a time. Start with a default font size of 9 points. As you scale up, you'll be able to see the holes in the letters more clearly. As you scale down, the holes will be less apparent. What is the smallest font size at which you begin to notice the holes?

**26.20** ***(Typing Tutor: Tuning a Crucial Skill in the Computer Age)*** Typing quickly and correctly is an essential skill for working effectively with computers and the Internet. In this exercise, you'll build a GUI application that can help users learn to "touch type" (i.e., type correctly without looking at the keyboard). The application should display a *virtual keyboard* (Fig. 26.50) and should allow the user to watch what he or she is typing on the screen without looking at the *actual keyboard*. Use `JButton`s to represent the keys. As the user presses each key, the application highlights the corresponding `JButton` on the GUI and adds the character to a `JTextArea` that shows what the user has typed so far. [*Hint:* To highlight a `JButton`, use its `setBackground` method to change its background color. When the key is released, reset its original background color. You can obtain the `JButton`'s original background color with the `getBackground` method before you change its color.]

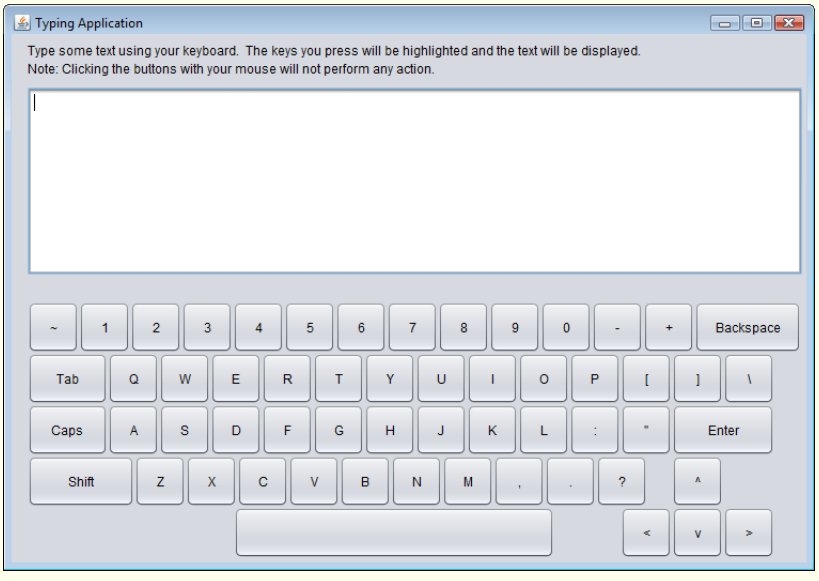



**Fig. 26.50** | Typing tutor.

You can test your program by typing a pangram—a phrase that contains every letter of the alphabet at least once—such as "The quick brown fox jumped over a lazy dog." You can find other pangrams on the web.

To make the program more interesting you could monitor the user's accuracy. You could have the user type specific phrases that you've prestored in your program and that you display on the screen above the virtual keyboard. You could keep track of how many keystrokes the user types correctly and how many are typed incorrectly. You could also keep track of which keys the user is having difficulty with and display a report showing those keys.