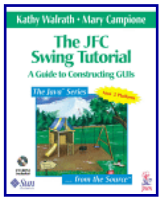
Trail: Creating a GUI with JFC/Swing

The **Creating a GUI with JFC/Swing** trail tells you how to create graphical user interfaces (GUIs) for applications and applets, using the Swing components. The Swing components, which are part of the Java^{TM} Foundation Classes (JFC), can be used with either JDK^{TM} 1.1 or the Java^{TM} 2 platform.

Note: This trail does not tell you how to use the AWT components. If you need to write a JDK 1.0 program or a 1.1 program that doesn't use Swing components, please download the old UI trail, **Creating a User Interface (AWT Only)**.



This trail is available as a book, *The JFC Swing Tutorial*. Besides having the usual advantages of a book (such as portability and readability) this 950-page tome contains a CD that has API documentation, the JFC 1.1 and JDK 1.1 releases, the latest available releases of the Java 2 SDK, and lots of other goodies.

A shorter, simpler introduction to using the Swing components is published in the book *The Java Tutorial, 3rd Edition*. You can find it online here: **User Interfaces that Swing: A Quick Start Guide**.

Getting Started with Swing is a quick start lesson. First it gives you a bit of background about the JFC and Swing. Then it tells you how to compile and run programs -- both applications and applets -- that use Swing components. Finally, it walks you through the code for a simple program.

Swing Features and Concepts gives you the information you need to be able to use Swing components effectively. For example, it tells you how Swing programs display their GUIs, how they handle events such as mouse clicks, and how they can use features such as borders to help with layout. It ends with a discussion of how the features and concepts are used by a real program.

Using Swing Components tells you how to use each of the Swing components -- buttons, tables, text components, and all the rest.

Using Other Swing Features tells you how to use actions, borders, icons, and timers. It also helps you to create multithreaded programs.

Laying Out Components Within a Container tells you how to choose a layout manager, how to use each of the layout manager classes the Java™ platform provides, how to use absolute positioning instead of a layout manager, and how to create your own layout manager.

Writing Event Listeners tells you how to handle events in your programs.

Working with Graphics tells you how to do everything from drawing lines and text to loading, displaying, and manipulating images. It includes information on performing animation and on improving graphics performance.

Converting to Swing tells you how to convert programs that use the 1.1 AWT API to use the Swing components.

Although this is the main trail for learning about GUIs, it isn't the only trail with UI-related information. Here are some other trails that discuss UI topics:

- 2D Graphics◆, which describes the 2D graphics features available in the Java 2 platform.
- Sound◆, which discusses the sound capabilities available in the Java 2 platform.
- Writing Applets◆, which describes API available only to applets, such as sound capabilities in JDK 1.0 and 1.1.
- Essential Java Classes◆, which covers many topics, including properties and the standard I/O streams.
- The Bonus trail contains Full-Screen Exclusive Mode API◆, a lesson that describes how to use API introduced in v1.4 to render graphics directly to the screen.

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Trail: Creating a GUI with JFC/Swing
Lesson: Getting Started with Swing

Getting Started with Swing: Examples

Note: Examples are applets unless noted otherwise.

Source Files	Image & Other Files	Where Described
AppletDemo.java◆	right.gif, middle.gif, left.gif To run the applet: AppletDemo.html To view the <APPLET> tag: AppletDemo.atag	Running Swing Applets
HelloSwingApplet.java◆	To run the applet: HelloSwingApplet.html To view the <APPLET> tag: HelloSwingApplet.atag	Running Swing Applets
SwingApplication.java◆ *(an application)*		Compiling and Running Swing Programs

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Trail: Creating a GUI with JFC/Swing
Lesson: Swing Features and Concepts

Swing Features and Concepts: Examples

Note: Examples are applications unless noted otherwise.

Source Files	Image & Other Files	Where Described
`Converter.java`◆ `ConversionPanel.java`◆ `ConverterRangeModel.java`◆ `DecimalField.java`◆ `FollowerRangeModel.java`◆ `FormattedDocument.java`◆ `Unit.java`◆		The Anatomy of a Swing-Based Program

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Trail: Creating a GUI with JFC/Swing
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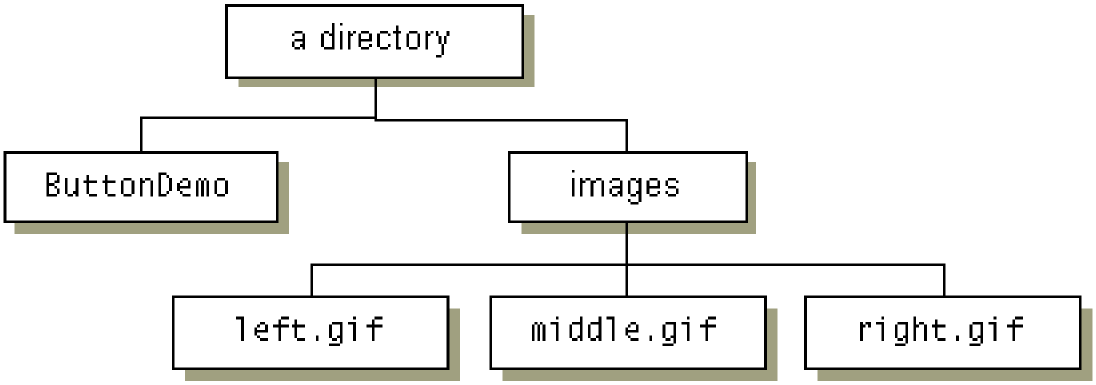
Using Swing Components: Examples

Note: Examples are applications unless noted otherwise.

For most examples, place the image files in a directory named `images` in the same directory as the source and class files for the example. For example, here's the setup for `ButtonDemo`:



Some examples, such as `CheckBoxDemo` and `SliderDemo`, require the image files to be in a sub-directory of the `images` directory.

Source Files	Image & Other Files	Where Described
`ButtonDemo.java`	`right.gif`, `middle.gif`, `left.gif`	How to Use Buttons, ...
`CheckBoxDemo.java`	All of the images in the `images/geek` directory.	How to Use Buttons, ...
`ColorChooserDemo.java`		How to Use Color Choosers

ColorChooserDemo2.java◆ CrayonPanel.java◆	red.gif, yellow.gif, green.gif, blue.gif	How to Use Color Choosers
ComboBoxDemo.java◆	Bird.gif, Cat.gif, Dog.gif, Rabbit.gif, Pig.gif	How to Use Combo Boxes
ComboBoxDemo2.java◆		How to Use Combo Boxes
CustomComboBoxDemo.java◆	Bird.gif, Cat.gif, Dog.gif, Rabbit.gif, Pig.gif	How to Use Combo Boxes
DialogDemo.java◆ CustomDialog.java◆	middle.gif	How to Use Dialogs
DynamicTreeDemo.java◆ DynamicTree.java◆		How to Use Trees
FileChooserDemo.java◆	open.gif, save.gif	How to Use File Choosers
FileChooserDemo2.java◆ ImageFileView.java◆ ImageFilter.java◆ ImagePreview.java◆ Utils.java◆	jpgIcon.gif, gifIcon.gif, tiffIcon.gif	How to Use File Choosers
FrameDemo.java◆		How to Make Frames
Framework.java◆		Nowhere
GenealogyExample.java◆ GenealogyModel.java◆ GenealogyTree.java◆ Person.java◆		How to Use Trees
GlassPaneDemo.java◆		How to Use Root Panes

HtmlDemo.java◆		How to Use Labels
InternalFrameDemo.java◆ MyInternalFrame.java◆		How to Use Internal Frames
LabelDemo.java◆	middle.gif	How to Use Labels
LayeredPaneDemo.java◆	dukeWaveRed.gif	How to Use Layered Panes
LayeredPaneDemo2.java◆	dukeWaveRed.gif	How to Use Layered Panes
ListDemo.java◆		How to Use Lists
ListDialog.java◆		How to Use Buttons, ...
MenuLookDemo.java◆	middle.gif	How to Use Menus
MenuDemo.java◆	middle.gif	How to Use Menus
MenuGlueDemo.java◆		How to Use Menus
MenuLayoutDemo.java◆		How to Use Menus
PasswordDemo.java◆		How to Use Text Fields
PopupMenuDemo.java◆	middle.gif	How to Use Menus
ProgressBarDemo.java◆ LongTask.java◆ SwingWorker.java◆		How to Monitor Progress

ProgressMonitorDemo.java LongTask.java SwingWorker.java		How to Monitor Progress
RadioButtonDemo.java	Bird.gif, Cat.gif, Dog.gif, Rabbit.gif, Pig.gif	How to Use Buttons, ...
ScrollDemo.java Rule.java Corner.java ScrollablePicture.java	youngdad.jpeg	How to Use Scroll Panes
ScrollDemo2.java		How to Use Scroll Panes
SharedModelDemo.java		Nowhere
SimpleTableDemo.java		How to Use Tables
SimpleTableSelectionDemo.java		How to Use Tables
SliderDemo.java	All of the images in the images/doggy directory.	How to Use Sliders
SliderDemo2.java	All of the images in the images/doggy directory.	How to Use Sliders
SplitPaneDemo.java	imagenames.properties and all of the image files listed in it.	How to Use Split Panes
SplitPaneDemo2.java	imagenames.properties and all of the image files listed in it.	How to Use Split Panes
TabbedPaneDemo.java	middle.gif	How to Use Tabbed Panes
TableDemo.java		How to Use Tables
TableEditDemo.java WholeNumberField.java		How to Use Tables
TableDialogEditDemo.java WholeNumberField.java		How to Use Tables

TableRenderDemo.java◆		How to Use Tables
TableSorterDemo.java◆ TableMap.java◆ TableSorter.java◆		How to Use Tables
TextComponentDemo.java◆ LimitedStyledDocument.java◆		General Rules for Using Text Components
TextDemo.java◆ *(an applet)*	To run the applet: TextDemo.html To view the <APPLET> tag: TextDemo.atag	How to Use Text Fields
TextFieldDemo.java◆ DecimalField.java◆ FormattedDocument.java◆ WholeNumberField.java◆		How to Use Text Fields
TextSamplerDemo.java◆	Pig.gif, sound.gif, dukeWaveRed.gif, TextSamplerDemoHelp.html	An Example of Using Each Text Component
ToolBarDemo.java◆	right.gif, middle.gif, left.gif	How to Use Tool Bars
ToolBarDemo2.java◆	right.gif, middle.gif, left.gif	How to Use Tool Bars
TopLevelDemo.java◆		Using Top-Level Containers
TreeDemo.java◆	Several html files.	How to Use Trees
TreeIconDemo.java◆	middle.gif and several html files.	How to Use Trees
TreeIconDemo2.java◆	middle.gif and several html files.	How to Use Trees

TumbleItem.java *(an applet)* SwingWorker.java	All of the images in the images/tumble directory. To run the applet: TumbleItem.html To view the <APPLET> tag: TumbleItem.atag	How to Make Applets

Geek Images

geek-----.gif, geek-c---.gif, geek--g--.gif, geek---h-.gif, geek----g.gif, geek-cg--.gif, geek-c-h-.gif, geek-c--t.gif, geek--gh-.gif, geek--g-t.gif, geek---h-.gif, geek-cg-t.gif, geek-cgh-.gif, geek-c-ht.gif, geek--ght.gif, geek-cght.gif

Doggy Images

T0.gif, T1.gif, T2.gif, T3.gif, T4.gif, T5.gif, T6.gif, T7.gif, T8.gif, T9.gif, T10.gif, T11.gif, T12.gif, T13.gif

Tumble Images

T1.gif, T2.gif, T3.gif, T4.gif, T5.gif, T6.gif, T7.gif, T8.gif, T9.gif, T10.gif, T11.gif, T12.gif, T13.gif, T14.gif, T15.gif, T16.gif, T17.gif

Images listed in imagenames.properties

Bird.gif, Cat.gif, Dog.gif, Rabbit.gif, Pig.gif, all.gif, blue.gif, doggy/T1.gif, dukeWaveRed.gif, geek/geek-cght.gif, green.gif, kathyCosmo.gif, lainesTongue.gif, left.gif, middle.gif, red.gif, right.gif, smallbabies.jpeg, sophie.gif, stickerface.gif, tumble/T7.gif, yellow.gif, youngdad.jpeg,

HTML Files Required for Tree Demos

`TreeDemoHelp.html`
`tutorial.html`
`tutorialcont.html`
`swingtutorial.html`
`arnold.html`
`faq.html`
`chanlee.html`
`thread.html`
`vm.html`
`jls.html`

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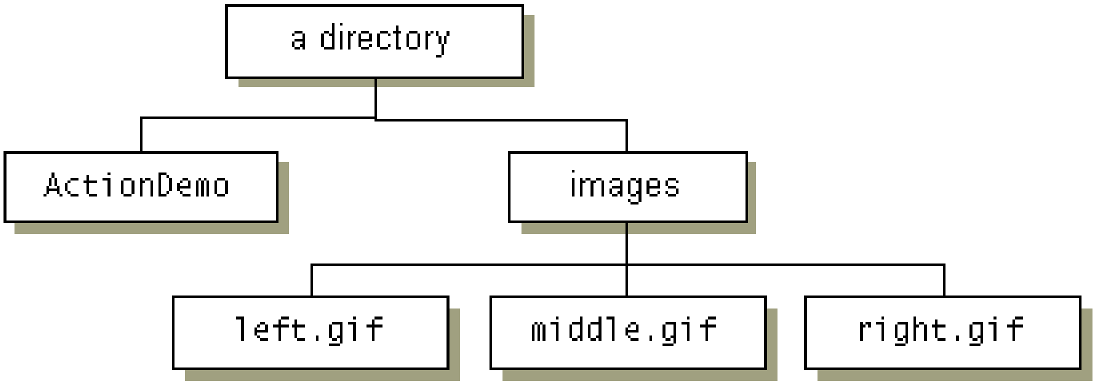
Trail: Creating a GUI with JFC/Swing
Lesson: Using Other Swing Features

Using Other Swing Features: Examples

Note: Examples are applications unless noted otherwise.

For all examples, place the image files in a directory named `images` in the same directory as the source and class files for the example. For example, here's the setup for `ActionDemo`:



Source Files	Image & Other Files	Where Described
AccessibleScrollDemo.java◆ Rule.java◆ Corner.java◆ ScrollablePicture.java◆	youngdad.jpeg	How to Support Assistive Technologies
ActionDemo.java◆	right.gif, middle.gif, left.gif	How to Use Actions
BorderDemo.java◆	left.gif	How to Use Borders
CustomIconDemo.java◆ ArrowIcon.java◆	middle.gif	How to Use Icons

IconDemoApplet.java◆ *(an applet)* SwingWorker.java◆ Photo.java◆	right.gif, left.gif, dimmedRight.gif, dimmedLeft.gif, stickerface.gif, lainesTongue.gif, kathyCosmo.gif, ewanPumpkin.gif, To run the applet: IconDemoApplet.html To view the <APPLET> tag: IconDemoApplet.atag	How to Use Icons

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Trail: Creating a GUI with JFC/Swing
Lesson: Laying Out Components

Laying Out Components: Examples

Note: The examples listed here can run either as an application or as an applet unless noted otherwise.

Source Files	Image & Other Files	Where Described
`AlignmentDemo.java`◆ *(application only)*	`geek-cght.gif` `middle.gif`	How to Use BoxLayout

`BorderWindow.java`◆
`AppletButton.java`◆
	To run the applet:
	`BorderDemo.html`
	To view the <APPLET> tag:
	`BorderDemo.atag`
		How to Use BorderLayout

`BoxLayoutDemo.java`◆ *(application only)* `BLDComponent.java`◆		How to Use BoxLayout

`BoxWindow.java`◆
`AppletButton.java`◆
	To run the applet:
	`BoxDemo.html`
	To view the <APPLET> tag:
	`BoxDemo.atag`
		How to Use BoxLayout

`CardWindow.java`◆
`AppletButton.java`◆
	To run the applet:
	`CardDemo.html`
	To view the <APPLET> tag:
	`CardDemo.atag`
		How to Use CardLayout

`CustomWindow.java`◆
`DiagonalLayout.java`◆
`AppletButton.java`◆
	To run the applet:
	`CustomDemo.html`
	To view the <APPLET> tag:
	`CustomDemo.atag`
		How to Use CustomLayout

FlowWindow.java◆ AppletButton.java◆	To run the applet: FlowDemo.html To view the <APPLET> tag: FlowDemo.atag	How to Use FlowLayout
GridBagWindow.java◆ AppletButton.java◆	To run the applet: GridBagDemo.html To view the <APPLET> tag: GridBagDemo.atag	How to Use GridBagLayout
GridWindow.java◆ AppletButton.java◆	To run the applet: GridDemo.html To view the <APPLET> tag: GridDemo.atag	How to Use GridLayout
NoneWindow.java◆ AppletButton.java◆	To run the applet: NoneDemo.html To view the <APPLET> tag: NoneDemo.atag	Doing Without a Layout Manager (Absolute Positioning)
TabWindow.java◆ AppletButton.java◆	To run the applet: TabDemo.html To view the <APPLET> tag: TabDemo.atag	How to Use CardLayout

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Trail: Creating a GUI with JFC/Swing
Lesson: Writing Event Listeners

Writing Event Listeners: Examples

Note: Examples are applets unless noted otherwise.

Source Files	**Image & Other Files**	**Where Described**
`Beeper.java`	To run the applet: `Beeper.html` To view the <APPLET> tag: `Beeper.atag`	Some Simple Event-Handling Examples
`ComponentEventDemo.java`	To run the applet: `ComponentEventDemo.html` To view the <APPLET> tag: `ComponentEventDemo.atag`	How to Write a Component Listener
`ContainerEventDemo.java`	To run the applet: `ContainerEventDemo.html` To view the <APPLET> tag: `ContainerEventDemo.atag`	How to Write a Container Listener
`DocumentEventDemo.java`	To run the applet: `DocumentEventDemo.html` To view the <APPLET> tag: `DocumentEventDemo.atag`	How to Write a Document Listener
`FocusEventDemo.java`	To run the applet: `FocusEventDemo.html` To view the <APPLET> tag: `FocusEventDemo.atag`	How to Write a Focus Listener

KeyEventDemo.java	To run the applet: KeyEventDemo.html To view the <APPLET> tag: KeyEventDemo.atag	How to Write a Key Listener
ListDataEventDemo.java	up.gif, down.gif To run the applet: ListDataEventDemo.html To view the <APPLET> tag: ListDataEventDemo.atag	How to Write a List Data Listener
ListSelectionDemo.java *(an application)*		How to Write a List Selection Listener
InternalFrameEventDemo.java *(an application)*		How to Write a Internal Frame Listener
MouseEventDemo.java BlankArea.java	To run the applet: MouseEventDemo.html To view the <APPLET> tag: MouseEventDemo.atag	How to Write a Mouse Listener
MouseMotionEventDemo.java BlankArea.java	To run the applet: MouseMotionEventDemo.html To view the <APPLET> tag: MouseMotionEventDemo.atag	How to Write a Mouse-Motion Listener
MultiListener.java	To run the applet: MultiListener.html To view the <APPLET> tag: MultiListener.atag	Some Simple Event-Handling Examples

TreeExpandEventDemo.java	To run the applet: TreeExpandEventDemo.html To view the <APPLET> tag: TreeExpandEventDemo.atag	How to Write a Tree Expansion Listener
TreeExpandEventDemo2.java	To run the applet: TreeExpandEventDemo2.html To view the <APPLET> tag: TreeExpandEventDemo2.atag	How to Write a Tree Will Expand Listener
WindowEventDemo.java	To run the applet: WindowEventDemo.html To view the <APPLET> tag: WindowEventDemo.atag	How to Write a Window Listener

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Trail: Creating a GUI with JFC/Swing
Lesson: Working with Graphics

Working with Graphics: Examples

Note: Examples are applets unless noted otherwise.

Source Files	Image & Other Files	Where Described
AnimatorAppletTimer.java◆	To run the applet: AnimatorAppletTimer.html To view the <APPLET> tag: AnimatorAppletTimer.atag	Creating an Animation Loop with Timer
AnimatorApplicationTimer.java◆ *(an application)*		Creating an Animation Loop with Timer
CoordinatesDemo.java◆	To run the applet: CoordinatesDemo.html To view the <APPLET> tag: CoordinatesDemo.atag	Overview of Custom Painting
FontDemo.java◆	To run the applet: FontDemo.html To view the <APPLET> tag: FontDemo.atag	Working with Text
ImageDisplayer.java◆	rocketship.gif To run the applet: ImageDisplayer.html To view the <APPLET> tag: ImageDisplayer.atag	Overview of Custom Painting

ImageSequenceTimer.java	Several images. To run the applet: ImageSequenceTimer.html To view the <APPLET> tag: ImageSequenceTimer.atag	Displaying a Sequence of Images
MTImageSequenceTimer.java	Several images. To run the applet: MTImageSequenceTimer.html To view the <APPLET> tag: MTImageSequenceTimer.atag	Improving the Appearance and Performance of Image Animation
MovingImageTimer.java	rocketship.gif, starfield.gif To run the applet: MovingImageTimer.html To view the <APPLET> tag: MovingImageTimer.atag	Moving an Image Across the Screen
MovingLabels.java	rocketship.gif, starfield.gif To run the applet: MovingLabels.html To view the <APPLET> tag: MovingLabels.atag	Moving an Image Across the Screen
RectangleDemo.java	To run the applet: RectangleDemo.html To view the <APPLET> tag: RectangleDemo.atag	Painting Shapes
SelectionDemo.java	starfield.gif To run the applet: SelectionDemo.html To view the <APPLET> tag: SelectionDemo.atag	Overview of Custom Painting
ShapesDemo.java	To run the applet: ShapesDemo.html To view the <APPLET> tag: ShapesDemo.atag	Painting Shapes

TextXY.java◆	To run the applet: TextXY.html To view the <APPLET> tag: TextXY.atag	Working with Text

Animation Images

T1.gif, T2.gif, T3.gif, T4.gif, T5.gif, T6.gif, T7.gif, T8.gif, T9.gif, T10.gif

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Trail: Creating a GUI with JFC/Swing
Lesson: Converting to Swing

Converting to Swing: Examples

Note: Examples are applications unless noted otherwise. Refer to Converting to Swing: AWT-Based Examples for the AWT-based equivalents of these examples.

Source Files	Image & Other Files	Where Described
`AnimatorApplication.java`◆		Some Conversion Examples
`AnimatorApplicationTimer.java`◆		Some Conversion Examples
`ButtonDemoApplet.java`◆ *(an applet)*	`right.gif`, `middle.gif`, `left.gif` To run the applet: `ButtonDemoApplet.html` To view the <APPLET> tag: `ButtonDemoApplet.atag`	Some Conversion Examples
`Converter.java`◆ `ConversionPanel.java`◆ `ConverterRangeModel.java`◆ `DecimalField.java`◆ `FollowerRangeModel.java`◆ `FormattedDocument.java`◆ `Unit.java`◆		Some Conversion Examples

`ListSelectionDemo.java`		Some Conversion Examples

`TextEventDemo.java` *(an applet)*	To run the applet:
	`TextEventDemo.html`
	To view the <APPLET> tag:
	`TextEventDemo.atag`
		Some Conversion Examples

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Trail: Creating a GUI with JFC/Swing

Lesson: Converting to Swing

This lesson tells you how to convert your AWT-based programs to use the Swing components. If a program was written for JDK 1.0 -- meaning that instead of using the event listening system introduced in JDK 1.1, it uses methods such as `handleEvent` and `action` -- you should convert the program to the newer event system first. Refer to Migrating to 1.1◆ for information and instructions on updating 1.0 programs.

Why to Convert

Swing components provide many benefits to programmers and end users. For a list of Swing features, see Swing Features and Concepts◆. Another good resource is the How Are Swing Components Different from AWT Components?◆ section. Unless you have a good reason not to convert, we urge you to convert to Swing components as soon as possible.

How to Convert

This section outlines a procedure for converting your programs to Swing. The good news is that converting 1.1 AWT-based programs to Swing can be pretty straightforward. The bad news is that we don't know of any automatic tools for doing so. If you find one, please tell us. Click the Creating a GUI with JFC/Swing radio button in Step 2.

Conversion Resources

This section provides several resources to help you with your conversion, including examples.

Solving Common Conversion Problems

Like the name says, this section lists some common gotchas, along with their solutions.

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Trail: Creating a GUI with JFC/Swing
Lesson: Converting to Swing

Converting to Swing: AWT-Based Examples

Note: These are JDK 1.1 AWT examples and do not require Swing. Refer to Converting to Swing: Examples for the Swing equivalents of these examples.

Source Files	Image & Other Files	Where Described
`AnimatorApplication.java`◆		Some Conversion Examples
`ButtonDemoApplet.java`◆ *(an applet)*	To run the applet and to view the <APPLET> tag: `ButtonDemoApplet.html`	Some Conversion Examples
`Converter.java`◆ `ConversionPanel.java`◆ `Unit.java`◆		Some Conversion Examples
`ListDemo.java`◆ *(an applet)*	To run the applet and to view the <APPLET> tag: `ListDemo.html`	Some Conversion Examples
`TextEventDemo.java`◆ *(an applet)*	To run the applet and to view the <APPLET> tag: `TextEventDemo.html`	Some Conversion Examples

```
/*
 * Swing 1.1 version (compatible with both JDK 1.1 and Java 2).
 */

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

/*
 * Based on Arthur van Hoff's animation examples, this application
 * can serve as a template for all animation applications.
 */
public class AnimatorApplication extends JFrame
                                 implements Runnable {
    AnimappPanel animappPanel;
    int frameNumber = -1;
    int delay;
    Thread animatorThread;
    boolean frozen = false;

    AnimatorApplication(int fps, String windowTitle) {
        super(windowTitle);
        delay = (fps > 0) ? (1000 / fps) : 100;

        animappPanel = new AnimappPanel();
        getContentPane().add(animappPanel);

        addMouseListener(new MouseAdapter() {
            public void mousePressed(MouseEvent e) {
                if (frozen) {
                    frozen = false;
                    startAnimation();
                } else {
                    frozen = true;
                    stopAnimation();
                }
            }
        });

        addWindowListener(new WindowAdapter() {
            public void windowIconified(WindowEvent e) {
                stopAnimation();
            }
            public void windowDeiconified(WindowEvent e) {
                startAnimation();
            }
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });
    }

    public void startAnimation() {
        if (frozen) {
            //Do nothing.  The user has requested that we
            //stop changing the image.
        } else {
            //Start animating!
            if (animatorThread == null) {
                animatorThread = new Thread(this);
            }
            animatorThread.start();
        }
    }

    public void stopAnimation() {
        //Stop the animating thread.
        animatorThread = null;
    }

    public void run() {
        //Just to be nice, lower this thread's priority
        //so it can't interfere with other processing going on.
        Thread.currentThread().setPriority(Thread.MIN_PRIORITY);

        //Remember the starting time.
        long startTime = System.currentTimeMillis();

        //Remember which thread we are.
        Thread currentThread = Thread.currentThread();

        //This is the animation loop.
        while (currentThread == animatorThread) {
            //Advance the animation frame.
            frameNumber++;

            //Display it.
            repaint();

            //Delay depending on how far we are behind.
            try {
                startTime += delay;
                Thread.sleep(Math.max(0,
                             startTime-System.currentTimeMillis()));
            } catch (InterruptedException e) {
                break;
            }
        }
    }

class AnimappPanel extends JPanel {

    public AnimappPanel() {}

    //Draw the current frame of animation.
    public void paintComponent(Graphics g) {
        super.paintComponent(g);
        g.drawString("Frame " + frameNumber, 5, 50);
    }
}

    public static void main(String args[]) {
        AnimatorApplication animator = null;
        int fps = 10;

        // Get frames per second from the command line argument
        if (args.length > 0) {
            try {
                fps = Integer.parseInt(args[0]);
            } catch (Exception e) {}
        }
        animator = new AnimatorApplication(fps, "Animator");
        animator.setSize(200, 60);
        animator.setVisible(true);
        animator.startAnimation();
    }
}
```

Trail: Creating a GUI with JFC/Swing
Lesson: Converting to Swing

Some Conversion Examples

This section provides the AWT and Swing versions of several example programs and talks about the interesting aspects of the conversion. Here is an overview of each program:

`ButtonDemoApplet`
: A simple applet that uses three buttons. In our conversion, we added mnemonics and icons.

`AnimatorApplication`
: An application that uses custom painting to perform a simple animation. Our first conversion just made the application work. The second pass made the application use Swing features such as the `JLabel` and `Timer` classes.

`TextEventDemo`
: An applet that illustrates using listeners on text components. We added no new features during this conversion.

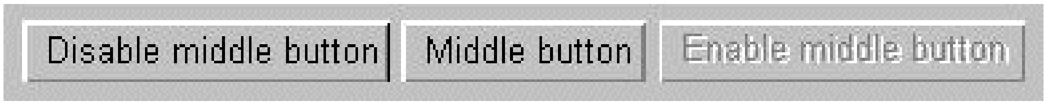
`Converter`
: An application that converts distance measurements between U.S. and metric. We made many changes in this program, taking advantage of Swing features such as data models, borders, and `BoxLayout`.

`ListDemo`
: An application to demonstrate the use of lists. The conversion was fairly straightforward, but again we did more than necessary. We took advantage of some new Swing features, including tables, split panes, and models.

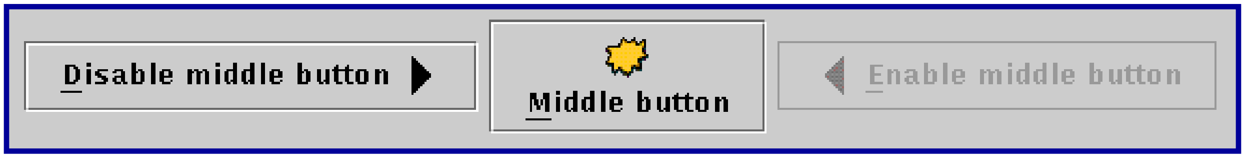
The discussions don't analyze the conversions line-by-line. However, you can see the differences between the AWT and Swing versions of each program by using a program such as UNIX's `diff` utility to compare both versions of the source code.

Converting ButtonDemoApplet

The first AWT-to-Swing conversion example we'll look at is a simple applet that contains three buttons. The first snapshot shows the AWT version of the applet running. The second shows the Swing version.



AWT version (Win32 platform)



This is a picture of the applet's GUI. To run the applet, click the picture. The applet will appear in a new browser window.

Swing version (any platform; Java Look & Feel)

You'll notice that the programs look different:

1. The button edges are different. In the AWT version, running on Win32, the buttons appear raised. In the Swing version, which uses the Java Look & Feel, the button edges appear etched.
2. The button font is different.
3. The buttons in the Swing applet have icons as well as text.
4. The buttons in the Swing applet have underlined letters, which lets the user know the mnemonic for each button.
5. The Swing applet is bigger.

The first two differences exist simply because the Win32 AWT implementation and the Java Look & Feel used by the Swing program draw buttons differently and have different default fonts. The Java Look & Feel is the default look and feel, which works on all platforms. However, your program or the user can specify another preference.

Differences 3 and 4 exist because we chose to take advantage of two Swing button features not supported by AWT buttons: images and mnemonics.

The final difference -- increased applet size -- is a side effect of the previous four differences. To allow space for the Swing applet, we had to modify the <APPLET> tag. We used Applet Viewer to test the results, making sure that the applet displayed and worked properly. After we were satisfied with the <APPLET> tag, we ran an HTML converter to generate the corresponding <OBJECT> and <EMBED> tags required by Java Plug-in.

Although the programs look somewhat different, they behave the same. When you click the left button, it disables the middle button and itself, and enables the right button. When you click the right button, it disables itself, and enables the middle and left buttons.

The following table links to the complete source code and an HTML file containing a sample <APPLET> tag for each version of the program. Compare the code and the <APPLET> tags to see the differences between the two programs.

	Source Code	**<APPLET> Tag** *
AWT	ButtonDemoApplet.java◆	ButtonDemoApplet.html
Swing	ButtonDemoApplet.java◆ left.gif middle.gif right.gif	ButtonDemoApplet.atag

* Note that if your browser isn't configured to run 1.1 or Swing programs, visiting the `.html` files listed in the table will produce errors. We provide the files so that you can look at the applet tags. Use shift-click to download the files.

For a slightly more sophisticated Swing version of `ButtonDemoApplet` that works as either an applet or an application, see AppletDemo.java◆.

Converting AnimatorApplication

`AnimatorApplication` is a template for animation programs. This particular implementation "animates" a string by changing the string periodically. The program can be easily modified to animate images in the same manner.

This section discusses two different solutions to converting the animator program. The first solution takes a minimalistic approach--the code is changed only as necessary to get the program to run with Swing. The second solution is more complete--it changes the code to adjust for differences in the way the AWT and Swing programs paint and to take advantage of the Swing timer support.

The AWT `AnimatorApplication` class extends `Frame`. Its `paint` method uses `drawString` to paint a string in the frame. A thread periodically wakes up, changes the string to the next value, and repaints the frame.

Both Swing versions of the `AnimatorApplication` class extend `JFrame`.

The minimalist version of the program paints the same way the AWT version paints--by calling the `drawString` method. However in Swing the painting code belongs in a method named `paintComponent`. Furthermore, because a `JFrame` has a content pane, the painting done in its `paintComponent` method has no effect (the content pane just paints right over it). So the painting code must move out of the frame. Instead, the program defines a `JPanel` subclass, `AnimappPanel`, to do the painting, and uses an instance of `AnimappPanel` as the `JFrame`'s content pane.

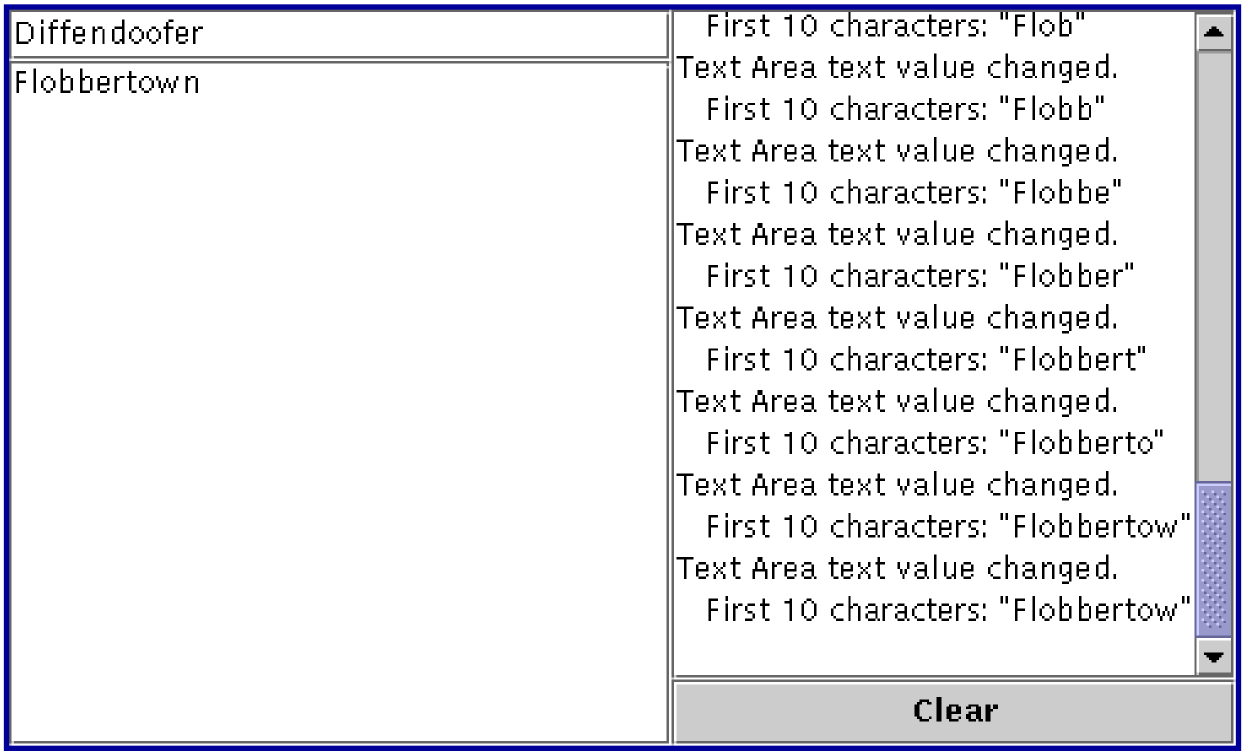
The second solution is a more complete Swing solution. Instead of using a `Thread` that sleeps periodically, the second solution uses Swing's `Timer` class. Additionally, this solution uses a `JLabel` instead of creating a `JPanel` subclass to draw a string. Replacing the custom component with a label isn't essential for this program, but it is something you might well do in your own programs.

Here are the three different versions to compare:

	Source Code
AWT	`AnimatorApplication.java`
Minimalist Swing Solution	`AnimatorApplication.java`
More Complete Swing Solution	`AnimatorApplicationTimer.java`

Converting TextEventDemo

Here's the Swing version of the `TextEventDemo` applet. The AWT version looks similar.



```
Diffendoofer
Flobbertown
```

```
  First 10 characters: "Flob"
Text Area text value changed.
  First 10 characters: "Flobb"
Text Area text value changed.
  First 10 characters: "Flobbe"
Text Area text value changed.
  First 10 characters: "Flobber"
Text Area text value changed.
  First 10 characters: "Flobbert"
Text Area text value changed.
  First 10 characters: "Flobberto"
Text Area text value changed.
  First 10 characters: "Flobbertow"
Text Area text value changed.
  First 10 characters: "Flobbertow"
```

This is a picture of the applet's GUI. To run the applet, click the picture. The applet will appear in a new browser window.

This program has a text field and a text area on the left, both of which are editable. The program listens for changes to the text on the text field and the text area and logs changes in the uneditable text area on the right.

AWT text areas support scrolling directly. Swing text areas don't. So the Swing version of this example creates a `JScrollPane` for each text area. The program uses a `GridBagLayout` to position the components. During the first pass of the conversion, we forgot to change the `setConstraints` call to set the constraints on the scroll pane instead of the text area and ended up with a tiny little scroll pane.

The AWT version of this program registers a text listener with `addTextListener` to listen for changes on the text components. The text listener implements a single method called `textValueChanged`.

Swing text components do not have an `addTextListener` method. Instead, the Swing version of this program has to register a document listener on each text component's document. A document listener implements three methods: `insertUpdate`, `removeUpdate`, and `changedUpdate`. These methods allow a program to listen for specific types of changes.

Here's the code and <APPLET> tags to compare:

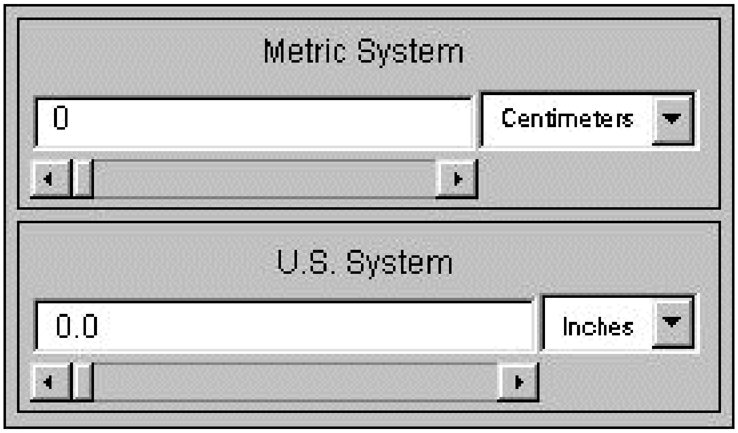
	Source Code	<APPLET> Tag *
AWT	`TextEventDemo.java`	`TextEventDemo.html`
Swing	`TextEventDemo.java`	`TextEventDemo.atag`

* Note that if your browser isn't configured to run 1.1 or Swing programs, visiting the `.html` files listed in the table will produce errors. We provide the files so that you can look at the applet tags. Use shift-click to download the files.

Converting Converter

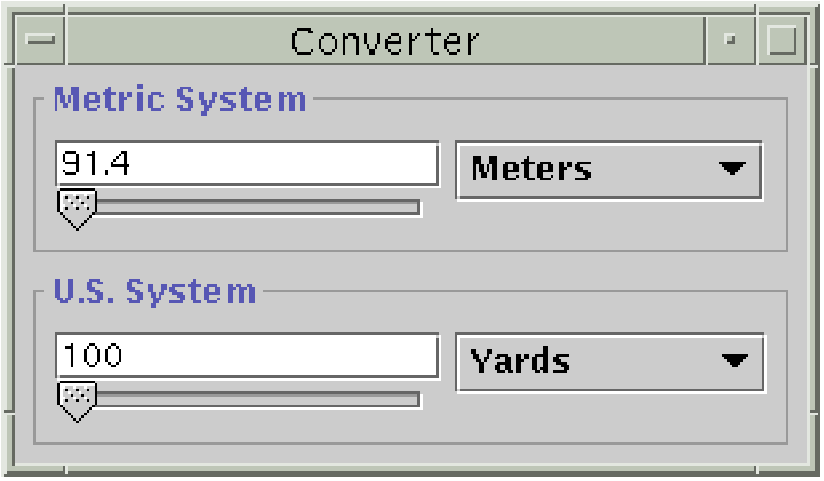
The `Converter` is an application that converts distance measurements between metric and U.S. units. Here are snapshots of the AWT and Swing versions of the program:

AWT Converter



0
Centimeters
0.0
Inches

Swing Converter



91.4
Meters
100
Yards

Here's the source code for both versions:

AWT Converter Source	Swing Converter Source
Converter.java ConversionPanel.java Unit.java	Converter.java ConversionPanel.java Unit.java ConverterRangeModel.java FollowerRangeModel.java DecimalField.java FormattedDocument.java

The `main` method for both versions is in the `Converter` class. Both versions use two instances of `ConversionPanel`--one for the metric system controls and one for the U.S. system controls. The `Converter` program keeps several instances of `Unit`, each of which contains a multiplier for a particular conversion.

The Swing version of the program has four additional classes. These provide custom data models for the text fields and the sliders.

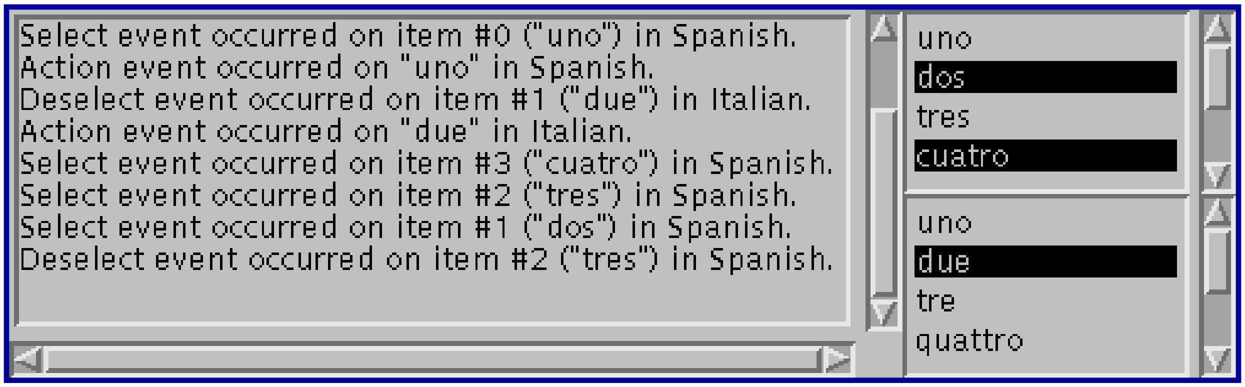
The Anatomy of a Swing-Based Program dissects the Swing version of the `Converter` program. Read that section to familiarize yourself with the program before proceeding.

The Swing version of this program takes advantage of the Swing API and improves upon the AWT version in these ways:

- Draws a line border around and provides a text label for each `ConversionPanel` with a titled border. In the AWT version, the `ConversionPanel` has to draw its own line border and uses an AWT `Label` for the panel's label.
- Uses a custom document for the text fields that ensures that the user enters only valid data. In the AWT version, the user can enter invalid data, such as characters, into the text fields.
- Provides a custom data model to contain the current value. This ensures that the current value for the program is kept in only one place.
- Uses Swing's `BoxLayout` class to lay out the components within each `ConversionPanel`. This makes the layout code simpler, compared to the code for the layout manager previously used (`GridBagLayout`).

Converting ListDemo

Let's look at our final conversion example, converting a program that uses lists. The AWT version of this example is fairly simple. Here's its GUI:

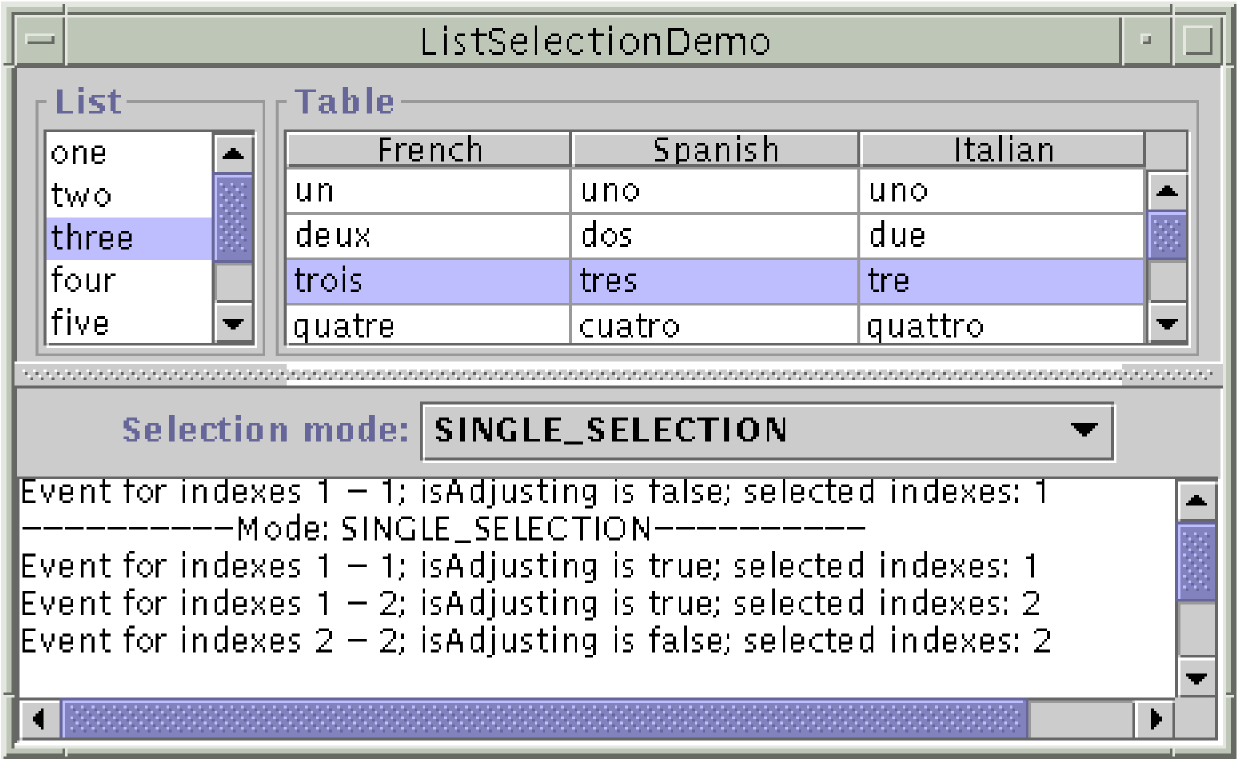


```
Select event occurred on item #0 ("uno") in Spanish.
Action event occurred on "uno" in Spanish.
Deselect event occurred on item #1 ("due") in Italian.
Action event occurred on "due" in Italian.
Select event occurred on item #3 ("cuatro") in Spanish.
Select event occurred on item #2 ("tres") in Spanish.
Select event occurred on item #1 ("dos") in Spanish.
Deselect event occurred on item #2 ("tres") in Spanish.
```

This figure has been reduced to fit on the page.
Click the image to view it at its natural size.

This applet contains two lists, one that allows single selection and one that allows multiple, discontiguous selections.

When converting this program, we got a little carried away. Rather than doing a basic conversion, we decided to show off the power of Swing's model-view split. The Swing version of the program can be run as an application and is shown here:



French	Spanish	Italian
un	uno	uno
deux	dos	due
trois	tres	tre
quatre	cuatro	quattro

Selection mode: SINGLE_SELECTION

```
Event for indexes 1 - 1; isAdjusting is false; selected indexes: 1
----------Mode: SINGLE_SELECTION----------
Event for indexes 1 - 1; isAdjusting is true; selected indexes: 1
Event for indexes 1 - 2; isAdjusting is true; selected indexes: 2
Event for indexes 2 - 2; isAdjusting is false; selected indexes: 2
```

This program contains a single list alongside a table. The list and the table share a list selection model. Thus, selecting an item in the list selects the corresponding row in the table, and vice versa. Furthermore, this program lets the user change the selection mode dynamically.

	Source Code	HTML Code *
AWT	ListDemo.java◆	ListDemo.html
Swing	ListSelectionDemo.java◆	*None (implemented as an application)*

* Note that if your browser isn't configured to run 1.1 or Swing programs, visiting the .html files listed in the table will produce errors. We provide the files so that you can look at the applet tags. Use shift-click to download the files.

Not leaving well enough alone, we modified ListSelectionDemo so that, in addition to sharing the selection model, the list and table share the same data model. This new example is called SharedModelDemo. You can find its code in SharedModelDemo.java◆.

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```java
/*
 * Swing version.
 */

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

/*
 * A template for animation applications.
 */
public class AnimatorApplicationTimer extends JFrame
                                      implements ActionListener {
    int frameNumber = -1;
    Timer timer;
    boolean frozen = false;
    JLabel label;

    AnimatorApplicationTimer(int fps, String windowTitle) {
        super(windowTitle);
        int delay = (fps > 0) ? (1000 / fps) : 100;

        //Set up a timer that calls this object's action handler.
        timer = new Timer(delay, this);
        timer.setInitialDelay(0);
        timer.setCoalesce(true);

        addWindowListener(new WindowAdapter() {
            public void windowIconified(WindowEvent e) {
                stopAnimation();
            }
            public void windowDeiconified(WindowEvent e) {
                startAnimation();
            }
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });

        label = new JLabel("Frame     ", JLabel.CENTER);
        label.addMouseListener(new MouseAdapter() {
            public void mousePressed(MouseEvent e) {
                if (frozen) {
                    frozen = false;
                    startAnimation();
                } else {
                    frozen = true;
                    stopAnimation();
                }
            }
        });

        getContentPane().add(label, BorderLayout.CENTER);
    }

    //Can be invoked by any thread (since timer is thread-safe).
    public void startAnimation() {
        if (frozen) {
            //Do nothing.  The user has requested that we
            //stop changing the image.
        } else {
            //Start animating!
            if (!timer.isRunning()) {
                timer.start();
            }
        }
    }

    //Can be invoked by any thread (since timer is thread-safe).
    public void stopAnimation() {
        //Stop the animating thread.
        if (timer.isRunning()) {
            timer.stop();
        }
    }

    public void actionPerformed(ActionEvent e) {
        //Advance the animation frame.
        frameNumber++;
        label.setText("Frame " + frameNumber);
    }

    public static void main(String args[]) {
        AnimatorApplicationTimer animator = null;
        int fps = 10;

        //Get frames per second from the command line argument.
        if (args.length > 0) {
            try {
                fps = Integer.parseInt(args[0]);
            } catch (Exception e) {}
        }
        animator = new AnimatorApplicationTimer(fps, "Animator with Timer");
        animator.pack();
        animator.setVisible(true);

        //It's OK to start the animation here because
        //startAnimation can be invoked by any thread.
        animator.startAnimation();
    }
}
```

```
/*
 * Swing 1.1 version (compatible with both JDK 1.1 and Java 2).
 */

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

public class ButtonDemoApplet extends JApplet
                              implements ActionListener {

    protected JButton b1, b2, b3;

    protected static final String DISABLE = "disable";
    protected static final String ENABLE = "enable";

    protected String leftButtonFilename = "images/right.gif";
    protected String middleButtonFilename = "images/middle.gif";
    protected String rightButtonFilename = "images/left.gif";

    public void init() {
        ImageIcon leftButtonIcon = new ImageIcon(
                                        getURL(leftButtonFilename));
        ImageIcon middleButtonIcon = new ImageIcon(
                                        getURL(middleButtonFilename));
        ImageIcon rightButtonIcon = new ImageIcon(
                                        getURL(rightButtonFilename));

        b1 = new JButton("Disable middle button", leftButtonIcon);
        b1.setVerticalTextPosition(AbstractButton.CENTER);
        b1.setHorizontalTextPosition(AbstractButton.LEFT);
        b1.setMnemonic(KeyEvent.VK_D);
        b1.setActionCommand(DISABLE);

        b2 = new JButton("Middle button", middleButtonIcon);
        b2.setVerticalTextPosition(AbstractButton.BOTTOM);
        b2.setHorizontalTextPosition(AbstractButton.CENTER);
        b2.setMnemonic(KeyEvent.VK_M);

        b3 = new JButton("Enable middle button", rightButtonIcon);
        //Use the default text position of CENTER, RIGHT.
        b3.setMnemonic(KeyEvent.VK_E);
        b3.setActionCommand(ENABLE);
        b3.setEnabled(false);

        //Listen for actions on buttons 1 and 3.
        b1.addActionListener(this);
        b3.addActionListener(this);

        //Add Components to a JPanel, using the default FlowLayout.
        JPanel pane = new JPanel();
        pane.add(b1);
        pane.add(b2);
        pane.add(b3);

        //Make the JPanel this applet's content pane.
        setContentPane(pane);
    }

    public void actionPerformed(ActionEvent e) {
        if (e.getActionCommand().equals(DISABLE)) {
            b2.setEnabled(false);
            b1.setEnabled(false);
            b3.setEnabled(true);
        } else {
            b2.setEnabled(true);
            b1.setEnabled(true);
            b3.setEnabled(false);
        }
    }

    protected URL getURL(String filename) {
        URL codeBase = getCodeBase();
        URL url = null;

        try {
            url = new URL(codeBase, filename);
        } catch (java.net.MalformedURLException e) {
            System.out.println("Couldn't create image: badly specified URL");
            return null;
        }

        return url;
    }
}
```

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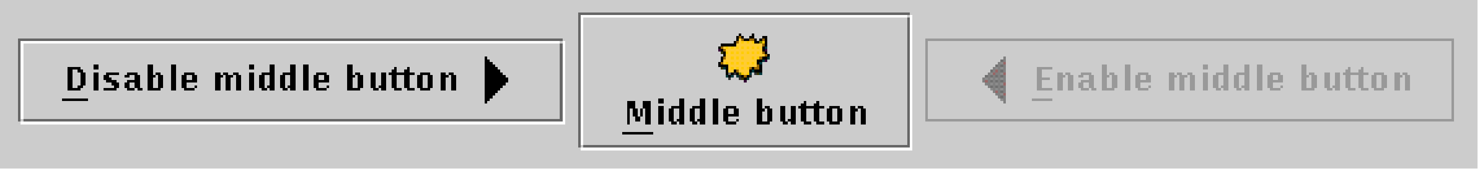
Run ButtonDemoApplet

Since you can't run the applet, here's a picture of it:



Note: Because the preceding applet uses the Swing 1.1 API, it requires Java Plug-in 1.1.2 or Java Plug-in 1.2. It won't work with Java Plug-in 1.1.1 or uncustomized 1.1 browsers. For more information about running applets in the tutorial, refer to About Our Examples. That page includes a section about Downloading Java Plug-in.

```
<applet code="ButtonDemoApplet.class"
        codebase="example-swing"
        archive="buttondemo.jar"
        width="570" height="65">

Since you can't run the applet,
here's a picture of it:

#usemacro UI_FIGURE (
    NAME ButtonDemoApplet.gif
    W 570
    H 65
    ALT A snapshot of ButtonDemoApplet.
)

</applet>
```

```
/*
 * 1.1+Swing version.
 */

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

public class Converter {
    ConversionPanel metricPanel, usaPanel;
    Unit[] metricDistances = new Unit[3];
    Unit[] usaDistances = new Unit[4];
    final static boolean COLORS = false;
    final static boolean DEBUG = false;
    final static String LOOKANDFEEL = null;
    ConverterRangeModel dataModel = new ConverterRangeModel();
    JPanel mainPane;

    /**
     * Create the ConversionPanels (one for metric, another for U.S.).
     * I used "U.S." because although Imperial and U.S. distance
     * measurements are the same, this program could be extended to
     * include volume measurements, which aren't the same.
     *
     * Put the ConversionPanels into a frame, and bring up the frame.
     */
    public Converter() {
        //Create Unit objects for metric distances, and then
        //instantiate a ConversionPanel with these Units.
        metricDistances[0] = new Unit("Centimeters", 0.01);
        metricDistances[1] = new Unit("Meters", 1.0);
        metricDistances[2] = new Unit("Kilometers", 1000.0);
        metricPanel = new ConversionPanel(this, "Metric System",
                                          metricDistances,
                                          dataModel);

        //Create Unit objects for U.S. distances, and then
        //instantiate a ConversionPanel with these Units.
        usaDistances[0] = new Unit("Inches", 0.0254);
        usaDistances[1] = new Unit("Feet", 0.305);
        usaDistances[2] = new Unit("Yards", 0.914);
        usaDistances[3] = new Unit("Miles", 1613.0);
        usaPanel = new ConversionPanel(this, "U.S. System",
                                       usaDistances,
                                       new FollowerRangeModel(dataModel));

        //Create a JPanel, and add the ConversionPanels to it.
        mainPane = new JPanel();
        if (COLORS) {
            mainPane.setBackground(Color.red);
        }
        mainPane.setLayout(new GridLayout(2,1,5,5));
        mainPane.setBorder(BorderFactory.createEmptyBorder(5,5,5,5));
        mainPane.add(metricPanel);
        mainPane.add(usaPanel);
        resetMaxValues(true);
    }

    public void resetMaxValues(boolean resetCurrentValues) {
        double metricMultiplier = metricPanel.getMultiplier();
        double usaMultiplier = usaPanel.getMultiplier();
        int maximum = ConversionPanel.MAX;

        if (metricMultiplier > usaMultiplier) {
            maximum = (int)(ConversionPanel.MAX *
                      (usaMultiplier/metricMultiplier));
        }

        if (DEBUG) {
            System.out.println("in Converter resetMaxValues");
            System.out.println("  metricMultiplier = "
                                + metricMultiplier
                             + "; usaMultiplier = "
                                + usaMultiplier
                             + "; maximum = "
                                + maximum);
        }

        dataModel.setMaximum(maximum);

        if (resetCurrentValues) {
            dataModel.setDoubleValue(maximum);
        }
    }

    private static void initLookAndFeel() {
        String lookAndFeel = null;

        if (LOOKANDFEEL != null) {
            if (LOOKANDFEEL.equals("Metal")) {
                lookAndFeel = UIManager.getCrossPlatformLookAndFeelClassName();
            } else if (LOOKANDFEEL.equals("System")) {
                lookAndFeel = UIManager.getSystemLookAndFeelClassName();
            } else if (LOOKANDFEEL.equals("Mac")) {
                lookAndFeel = "com.sun.java.swing.plaf.mac.MacLookAndFeel";
                //PENDING: check!
            } else if (LOOKANDFEEL.equals("Windows")) {
                lookAndFeel = "com.sun.java.swing.plaf.windows.WindowsLookAndFeel";
            } else if (LOOKANDFEEL.equals("Motif")) {
                lookAndFeel = "com.sun.java.swing.plaf.motif.MotifLookAndFeel";
            }

            if (DEBUG) {
                System.out.println("About to request look and feel: "
                                   + lookAndFeel);
            }

            try {
                UIManager.setLookAndFeel(lookAndFeel);
            } catch (ClassNotFoundException e) {
                System.err.println("Couldn't find class for specified look and feel:"
                                   + lookAndFeel);
                System.err.println("Did you include the L&F library in the class path?");
                System.err.println("Using the default look and feel.");
            } catch (UnsupportedLookAndFeelException e) {
                System.err.println("Can't use the specified look and feel ("
                                   + lookAndFeel
                                   + ") on this platform.");
                System.err.println("Using the default look and feel.");
            } catch (Exception e) {
                System.err.println("Couldn't get specified look and feel ("
                                   + lookAndFeel
                                   + "), for some reason.");
                System.err.println("Using the default look and feel.");
                e.printStackTrace();
            }
        }
    }

    public static void main(String[] args) {
        initLookAndFeel();
        Converter converter = new Converter();

        //Create a new window.
        JFrame f = new JFrame("Converter");
        f.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });

        //Add the JPanel to the window and display the window.
        //We can use a JPanel for the content pane because
        //JPanel is opaque.
        f.setContentPane(converter.mainPane);
        if (COLORS) {
           //This has no effect, since the JPanel completely
           //covers the content pane.
           f.getContentPane().setBackground(Color.green);
        }

        f.pack();        //Resizes the window to its natural size.
        f.setVisible(true);
    }
}
```

```
/*
 * 1.1+Swing version.
 */

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

public class ConversionPanel extends JPanel {
    DecimalField textField;
    JComboBox unitChooser;
    JSlider slider;
    ConverterRangeModel sliderModel;
    Converter controller;
    Unit[] units;
    String title;
    final static boolean DEBUG = false;
    final static boolean COLORS = false;
    final static int MAX = 10000;

    ConversionPanel(Converter myController, String myTitle,
                    Unit[] myUnits,
                    ConverterRangeModel myModel) {
        if (COLORS) {
            setBackground(Color.cyan);
        }
        setBorder(BorderFactory.createCompoundBorder(
                        BorderFactory.createTitledBorder(myTitle),
                        BorderFactory.createEmptyBorder(5,5,5,5)));

        //Save arguments in instance variables.
        controller = myController;
        units = myUnits;
        title = myTitle;
        sliderModel = myModel;

        //Add the text field.  It initially displays "0" and needs
        //to be at least 10 columns wide.
        NumberFormat numberFormat = NumberFormat.getNumberInstance();
        numberFormat.setMaximumFractionDigits(2);
        textField = new DecimalField(0, 10, numberFormat);
        textField.setValue(sliderModel.getDoubleValue());
        textField.addActionListener(new ActionListener() {
            public void actionPerformed(ActionEvent e) {
                sliderModel.setDoubleValue(textField.getValue());
            }
        });

        //Add the combo box.
        unitChooser = new JComboBox();
        for (int i = 0; i < units.length; i++) { //Populate it.
            unitChooser.addItem(units[i].description);
        }
        unitChooser.setSelectedIndex(0);
        sliderModel.setMultiplier(units[0].multiplier);
        unitChooser.addActionListener(new ActionListener() {
            public void actionPerformed(ActionEvent e) {
                //Set new maximums for the sliders.
                int i = unitChooser.getSelectedIndex();
                sliderModel.setMultiplier(units[i].multiplier);
                controller.resetMaxValues(false);
            }
        });

        //Add the slider.
        slider = new JSlider(sliderModel);
        sliderModel.addChangeListener(new ChangeListener() {
            public void stateChanged(ChangeEvent e) {
                textField.setValue(sliderModel.getDoubleValue());
            }
        });

        //Make the textfield/slider group a fixed size.
        JPanel unitGroup = new JPanel() {
            public Dimension getMinimumSize() {
                return getPreferredSize();
            }
            public Dimension getPreferredSize() {
                return new Dimension(150,
                                     super.getPreferredSize().height);
            }
            public Dimension getMaximumSize() {
                return getPreferredSize();
            }
        };
        if (COLORS) {
            unitGroup.setBackground(Color.blue);
        }
        unitGroup.setBorder(BorderFactory.createEmptyBorder(
                                                0,0,0,5));
        unitGroup.setLayout(new BoxLayout(unitGroup,
                                          BoxLayout.Y_AXIS));
        unitGroup.add(textField);
        unitGroup.add(slider);

        setLayout(new BoxLayout(this, BoxLayout.X_AXIS));
        add(unitGroup);
        add(unitChooser);
        unitGroup.setAlignmentY(TOP_ALIGNMENT);
        unitChooser.setAlignmentY(TOP_ALIGNMENT);
    }

    /**
     * Returns the multiplier (units/meter) for the currently
     * selected unit of measurement.
     */
    public double getMultiplier() {
        return sliderModel.getMultiplier();
    }

    public double getValue() {
        return sliderModel.getDoubleValue();
    }
}
```

```
/*
 * 1.1+Swing version.
 */

import javax.swing.*;
import javax.swing.event.*;

/**
 * Based on the source code for DefaultBoundedRangeModel,
 * this class stores its value as a double, rather than
 * an int.  The minimum value and extent are always 0.
 **/
public class ConverterRangeModel implements BoundedRangeModel {
    protected ChangeEvent changeEvent = null;
    protected EventListenerList listenerList = new EventListenerList();

    protected int maximum = 10000;
    protected int minimum = 0;
    protected int extent = 0;
    protected double value = 0.0;
    protected double multiplier = 1.0;
    protected boolean isAdjusting = false;
    final static boolean DEBUG = false;

    public ConverterRangeModel() {
    }

    public double getMultiplier() {
        if (DEBUG) {
            System.out.println("In ConverterRangeModel getMultiplier");
        }
        return multiplier;
    }

    public void setMultiplier(double multiplier) {
        if (DEBUG) {
            System.out.println("In ConverterRangeModel setMultiplier");
        }
        this.multiplier = multiplier;
        fireStateChanged();
    }

    public int getMaximum() {
        if (DEBUG) {
            System.out.println("In ConverterRangeModel getMaximum");
        }
        return maximum;
    }

    public void setMaximum(int newMaximum) {
        if (DEBUG) {
            System.out.println("In ConverterRangeModel setMaximum");
        }
        setRangeProperties(value, extent, minimum, newMaximum, isAdjusting);
    }

    public int getMinimum() {
        return (int)minimum;
    }

    public void setMinimum(int newMinimum) {
        System.out.println("In ConverterRangeModel setMinimum");
        //Do nothing.
    }

    public int getValue() {
        if (DEBUG) {
            System.out.println("In ConverterRangeModel getValue");
        }
        return (int)getDoubleValue();
    }

    public void setValue(int newValue) {
        if (DEBUG) {
            System.out.println("In ConverterRangeModel setValue");
        }
        setDoubleValue((double)newValue);
    }

    public double getDoubleValue() {
        if (DEBUG) {
            System.out.println("In ConverterRangeModel getDoubleValue");
        }
        return value;
    }

    public void setDoubleValue(double newValue) {
        if (DEBUG) {
            System.out.println("In ConverterRangeModel setDoubleValue");
        }
        setRangeProperties(newValue, extent, minimum, maximum, isAdjusting);
    }

    public int getExtent() {
        return (int)extent;
    }

    public void setExtent(int newExtent) {
        //Do nothing.
    }

    public boolean getValueIsAdjusting() {
        return isAdjusting;
    }

    public void setValueIsAdjusting(boolean b) {
        setRangeProperties(value, extent, minimum, maximum, b);
    }

    public void setRangeProperties(int newValue,
                                   int newExtent,
                                   int newMin,
                                   int newMax,
                                   boolean newAdjusting) {
        System.out.println("In ConverterRangeModel setRangeProperties");
        setRangeProperties((double)newValue,
                           newExtent,
                           newMin,
                           newMax,
                           newAdjusting);
    }

    public void setRangeProperties(double newValue,
                                   int unusedExtent,
                                  int unusedMin,
                                  int newMax,
                                  boolean newAdjusting) {
        if (DEBUG) {
            System.out.println("setRangeProperties(): "
                               + "newValue = " + newValue
                               + "; newMax = " + newMax);
        }
        if (newMax <= minimum) {
            newMax = minimum + 1;
            if (DEBUG) {
                System.out.println("maximum raised by 1 to " + newMax);
            }
        }
        if (Math.round(newValue) > newMax) { //allow some rounding error
            newValue = newMax;
            if (DEBUG) {
                System.out.println("value lowered to " + newMax);
            }
        }

        boolean changeOccurred = false;
        if (newValue != value) {
            if (DEBUG) {
                System.out.println("value set to " + newValue);
            }
            value = newValue;
            changeOccurred = true;
        }
        if (newMax != maximum) {
            if (DEBUG) {
                System.out.println("maximum set to " + newMax);
            }
            maximum = newMax;
            changeOccurred = true;
        }
        if (newAdjusting != isAdjusting) {
            maximum = newMax;
            isAdjusting = newAdjusting;
            changeOccurred = true;
        }

        if (changeOccurred) {
            fireStateChanged();
        }
    }

    /*
     * The rest of this is event handling code copied from
     * DefaultBoundedRangeModel.
     */
    public void addChangeListener(ChangeListener l) {
        listenerList.add(ChangeListener.class, l);
    }

    public void removeChangeListener(ChangeListener l) {
        listenerList.remove(ChangeListener.class, l);
    }

    protected void fireStateChanged() {
        Object[] listeners = listenerList.getListenerList();
        for (int i = listeners.length - 2; i >= 0; i -=2 ) {
            if (listeners[i] == ChangeListener.class) {
                if (changeEvent == null) {
                    changeEvent = new ChangeEvent(this);
                }
                ((ChangeListener)listeners[i+1]).stateChanged(changeEvent);
            }
        }
    }
}
```

```
import javax.swing.*;
import javax.swing.text.*;

import java.awt.Toolkit;
import java.text.*;

public class DecimalField extends JTextField {
    private NumberFormat format;

    public DecimalField(double value, int columns, NumberFormat f) {
        super(columns);
        setDocument(new FormattedDocument(f));
        format = f;
        setValue(value);
    }

    public double getValue() {
        double retVal = 0.0;

        try {
            retVal = format.parse(getText()).doubleValue();
        } catch (ParseException e) {
            // This should never happen because insertString allows
            // only properly formatted data to get in the field.
            Toolkit.getDefaultToolkit().beep();
            System.err.println("getValue: could not parse: " + getText());
        }
        return retVal;
    }

    public void setValue(double value) {
        setText(format.format(value));
    }
}
```

```
/*
 * 1.1+Swing version.
 */

import javax.swing.*;
import javax.swing.event.*;

public class FollowerRangeModel extends ConverterRangeModel
                                implements ChangeListener {
    ConverterRangeModel dataModel;

    public FollowerRangeModel(ConverterRangeModel dataModel) {
        this.dataModel = dataModel;
        dataModel.addChangeListener(this);
    }

    public void stateChanged(ChangeEvent e) {
        fireStateChanged();
    }

    public int getMaximum() {
        int modelMax = dataModel.getMaximum();
        double multiplyBy = dataModel.getMultiplier()/multiplier;
        if (DEBUG) {
            System.out.println("In FollowerRangeModel getMaximum");
            System.out.println("  dataModel.getMaximum = " + modelMax
                                + "; multiply by " + multiplyBy
                                + "; result: " + modelMax*multiplyBy);
        }
        return (int)(modelMax * multiplyBy);
    }

    public void setMaximum(int newMaximum) {
        dataModel.setMaximum((int)(newMaximum *
                     (multiplier/dataModel.getMultiplier())));
    }

    public int getValue() {
        return (int)getDoubleValue();
    }

    public void setValue(int newValue) {
        setDoubleValue((double)newValue);
    }

    public double getDoubleValue() {
        return dataModel.getDoubleValue()
               * dataModel.getMultiplier()
               / multiplier;
    }

    public void setDoubleValue(double newValue) {
        dataModel.setDoubleValue(
                     newValue * multiplier
                     / dataModel.getMultiplier());
    }

    public int getExtent() {
        return super.getExtent();
    }

    public void setExtent(int newExtent) {
        super.setExtent(newExtent);
    }

    public void setRangeProperties(int value,
                                   int extent,
                                   int min,
                                   int max,
                                   boolean adjusting) {
        double multiplyBy = multiplier/dataModel.getMultiplier();
        dataModel.setRangeProperties(value*multiplyBy,
                                     extent, min,
                                     (int)(max*multiplyBy),
                                     adjusting);
    }
}
```

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

import java.awt.Toolkit;
import java.text.*;
import java.util.Locale;

public class FormattedDocument extends PlainDocument {
    private Format format;

    public FormattedDocument(Format f) {
        format = f;
    }

    public Format getFormat() {
        return format;
    }

    public void insertString(int offs, String str, AttributeSet a)
        throws BadLocationException {

        String currentText = getText(0, getLength());
        String beforeOffset = currentText.substring(0, offs);
        String afterOffset = currentText.substring(offs, currentText.length());
        String proposedResult = beforeOffset + str + afterOffset;

        try {
            format.parseObject(proposedResult);
            super.insertString(offs, str, a);
        } catch (ParseException e) {
            Toolkit.getDefaultToolkit().beep();
            System.err.println("insertString: could not parse: "
                               + proposedResult);
        }
    }

    public void remove(int offs, int len) throws BadLocationException {
        String currentText = getText(0, getLength());
        String beforeOffset = currentText.substring(0, offs);
        String afterOffset = currentText.substring(len + offs,
                                                   currentText.length());
        String proposedResult = beforeOffset + afterOffset;

        try {
            if (proposedResult.length() != 0)
                format.parseObject(proposedResult);
            super.remove(offs, len);
        } catch (ParseException e) {
            Toolkit.getDefaultToolkit().beep();
            System.err.println("remove: could not parse: " + proposedResult);
        }
    }
}
```

```
public class Unit {
    String description;
    double multiplier;

    Unit(String description, double multiplier) {
        super();
        this.description = description;
        this.multiplier = multiplier;
    }

    public String toString() {
        String s = "Meters/" + description + " = " + multiplier;
        return s;
    }
}
```

```
import javax.swing.*;
import javax.swing.event.*;
import javax.swing.table.*;

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

public class ListSelectionDemo extends JPanel {
    JTextArea output;
    JList list;
    JTable table;
    String newline = "\n";
    ListSelectionModel listSelectionModel;

    public ListSelectionDemo() {
        super(new BorderLayout());

        String[] listData = { "one", "two", "three", "four",
                              "five", "six", "seven" };
        String[] columnNames = { "French", "Spanish", "Italian" };
        String[][] tableData = {{"un",     "uno",     "uno"     },
                                {"deux",   "dos",     "due"     },
                                {"trois",  "tres",    "tre"     },
                                { "quatre", "cuatro",  "quattro"},
                                { "cinq",   "cinco",   "cinque" },
                                { "six",    "seis",    "sei"    },
                                { "sept",   "siete",   "sette"  } };

        list = new JList(listData);

        listSelectionModel = list.getSelectionModel();
        listSelectionModel.addListSelectionListener(
                new SharedListSelectionHandler());
        JScrollPane listPane = new JScrollPane(list);

        table = new JTable(tableData, columnNames);
        table.setSelectionModel(listSelectionModel);
        JScrollPane tablePane = new JScrollPane(table);

        //Build control area (use default FlowLayout).
        JPanel controlPane = new JPanel();
        String[] modes = { "SINGLE_SELECTION",
                           "SINGLE_INTERVAL_SELECTION",
                           "MULTIPLE_INTERVAL_SELECTION" };

        final JComboBox comboBox = new JComboBox(modes);
        comboBox.setSelectedIndex(2);
        comboBox.addActionListener(new ActionListener() {
            public void actionPerformed(ActionEvent e) {
                String newMode = (String)comboBox.getSelectedItem();
                if (newMode.equals("SINGLE_SELECTION")) {
                    listSelectionModel.setSelectionMode(
                        ListSelectionModel.SINGLE_SELECTION);
                } else if (newMode.equals("SINGLE_INTERVAL_SELECTION")) {
                    listSelectionModel.setSelectionMode(
                        ListSelectionModel.SINGLE_INTERVAL_SELECTION);
                } else {
                    listSelectionModel.setSelectionMode(
                        ListSelectionModel.MULTIPLE_INTERVAL_SELECTION);
                }
                output.append("----------"
                                + "Mode: " + newMode
                                + "----------" + newline);
            }
        });
        controlPane.add(new JLabel("Selection mode:"));
        controlPane.add(comboBox);

        //Build output area.
        output = new JTextArea(1, 10);
        output.setEditable(false);
        JScrollPane outputPane = new JScrollPane(output,
                         ScrollPaneConstants.VERTICAL_SCROLLBAR_ALWAYS,
                         ScrollPaneConstants.HORIZONTAL_SCROLLBAR_AS_NEEDED);

        //Do the layout.
        JSplitPane splitPane = new JSplitPane(JSplitPane.VERTICAL_SPLIT);
        add(splitPane, BorderLayout.CENTER);

        JPanel topHalf = new JPanel();
        topHalf.setLayout(new BoxLayout(topHalf, BoxLayout.X_AXIS));
        JPanel listContainer = new JPanel(new GridLayout(1,1));
        listContainer.setBorder(BorderFactory.createTitledBorder(
                                                "List"));
        listContainer.add(listPane);
        JPanel tableContainer = new JPanel(new GridLayout(1,1));
        tableContainer.setBorder(BorderFactory.createTitledBorder(
                                                "Table"));
        tableContainer.add(tablePane);
        tablePane.setPreferredSize(new Dimension(300, 100));
        topHalf.setBorder(BorderFactory.createEmptyBorder(5,5,0,5));
        topHalf.add(listContainer);
        topHalf.add(tableContainer);

        topHalf.setMinimumSize(new Dimension(400, 50));
        topHalf.setPreferredSize(new Dimension(400, 110));
        splitPane.add(topHalf);

        JPanel bottomHalf = new JPanel(new BorderLayout());
        bottomHalf.add(controlPane, BorderLayout.NORTH);
        bottomHalf.add(outputPane, BorderLayout.CENTER);
        //XXX: next line needed if bottomHalf is a scroll pane:
        //bottomHalf.setMinimumSize(new Dimension(400, 50));
        bottomHalf.setPreferredSize(new Dimension(450, 135));
        splitPane.add(bottomHalf);
    }

    public static void main(String[] args) {
        JFrame frame = new JFrame("ListSelectionDemo");
        frame.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });

        frame.setContentPane(new ListSelectionDemo());
        frame.pack();
        frame.setVisible(true);
    }

    class SharedListSelectionHandler implements ListSelectionListener {
        public void valueChanged(ListSelectionEvent e) {
            ListSelectionModel lsm = (ListSelectionModel)e.getSource();
            int firstIndex = e.getFirstIndex();
            int lastIndex = e.getLastIndex();
            boolean isAdjusting = e.getValueIsAdjusting();
            output.append("Event for indexes "
                          + firstIndex + " - " + lastIndex
                          + "; isAdjusting is " + isAdjusting
                          + "; selected indexes:");

            if (lsm.isSelectionEmpty()) {
                output.append(" <none>");
            } else {
                // Find out which indexes are selected.
                int minIndex = lsm.getMinSelectionIndex();
                int maxIndex = lsm.getMaxSelectionIndex();
                for (int i = minIndex; i <= maxIndex; i++) {
                    if (lsm.isSelectedIndex(i)) {
                        output.append(" " + i);
                    }
                }
            }
            output.append(newline);
        }
    }
}
```

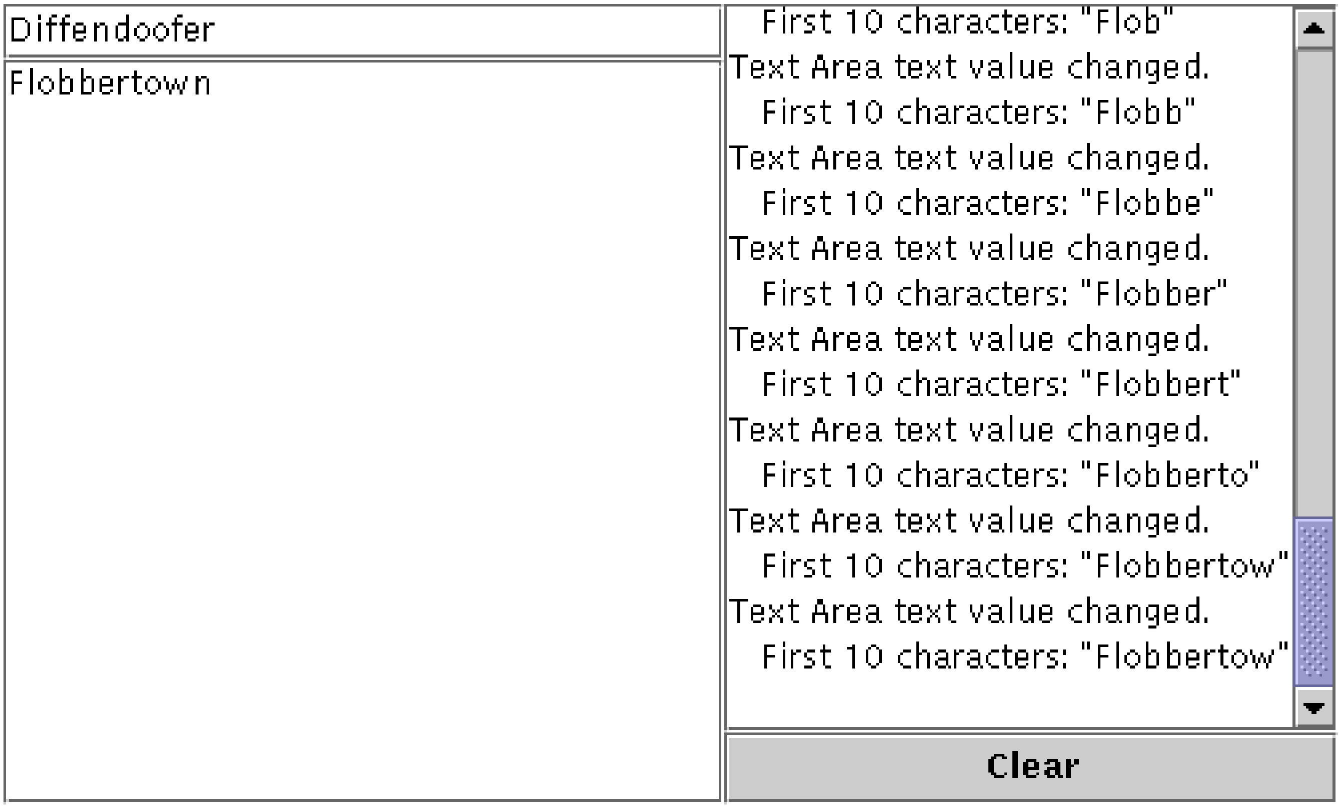
```
/*
 * Swing 1.1 version (compatible with both JDK 1.1 and Java 2).
 */

import javax.swing.*;
import javax.swing.text.*;
import javax.swing.event.*;

import java.awt.Dimension;
import java.awt.BorderLayout;
import java.awt.GridBagLayout;
import java.awt.GridBagConstraints;

import java.awt.event.*;

public class TextEventDemo extends JApplet
                           implements ActionListener {
    JTextField textField;
    JTextArea textArea;
    JTextArea displayArea;

    public void init() {
        JButton button = new JButton("Clear");
        button.addActionListener(this);

        textField = new JTextField(20);
        textField.addActionListener(new MyTextActionListener());
        textField.getDocument().addDocumentListener(
            new MyDocumentListener("Text Field"));

        textArea = new JTextArea();
        textArea.getDocument().addDocumentListener(
            new MyDocumentListener("Text Area"));
        JScrollPane scrollPane = new JScrollPane(textArea);
        scrollPane.setPreferredSize(new Dimension(200, 75));

        displayArea = new JTextArea();
        displayArea.setEditable(false);
        JScrollPane displayScrollPane = new JScrollPane(displayArea);
        displayScrollPane.setPreferredSize(new Dimension(200, 75));

        JPanel contentPane = new JPanel();
        GridBagLayout gridbag = new GridBagLayout();
        GridBagConstraints c = new GridBagConstraints();
        contentPane.setLayout(gridbag);
        c.fill = GridBagConstraints.BOTH;
        c.weightx = 1.0;

        /*
         * Hack to get around gridbag's refusal to allow
         * multi-row components in anything but the left column.
         */
        JPanel leftPanel = new JPanel();
        leftPanel.setLayout(new BorderLayout());
        leftPanel.add(textField, BorderLayout.NORTH);
        leftPanel.add(scrollPane, BorderLayout.CENTER);

        c.gridheight = 2;
        gridbag.setConstraints(leftPanel, c);
        contentPane.add(leftPanel);

        c.weighty = 1.0;
        c.gridwidth = GridBagConstraints.REMAINDER;
        c.gridheight = 1;
        gridbag.setConstraints(displayScrollPane, c);
        contentPane.add(displayScrollPane);

        c.weighty = 0.0;
        gridbag.setConstraints(button, c);
        contentPane.add(button);

        textField.requestFocus();

        setContentPane(contentPane);
    }

    class MyDocumentListener implements DocumentListener {
        String preface;
        String newline;

        public MyDocumentListener(String source) {
            newline = System.getProperty("line.separator");
            preface = source
                      + " text value changed."
                      + newline
                      + "   First 10 characters: \"";
        }

        public void insertUpdate(DocumentEvent e) {
            update(e);
        }

        public void removeUpdate(DocumentEvent e) {
            update(e);
        }
        public void changedUpdate(DocumentEvent e) {
            //You don't get these with a plain text component.
        }
        public void update(DocumentEvent e) {
            Document doc = (Document)e.getDocument();
            int length = doc.getLength();
            String s = null;
            try {
                s = doc.getText(0, (length > 10) ? 10 : length);
            } catch (BadLocationException ex) {
            }
            displayArea.append(preface + s + "\"" + newline);
        }
    }

    class MyTextActionListener implements ActionListener {
        /** Handle the text field Return. */
        public void actionPerformed(ActionEvent e) {
            int selStart = textArea.getSelectionStart();
            int selEnd = textArea.getSelectionEnd();

            textArea.replaceRange(textField.getText(),
                                  selStart, selEnd);
            textField.selectAll();
        }
    }

    /** Handle button click. */
    public void actionPerformed(ActionEvent e) {
        displayArea.setText("");
        textField.requestFocus();
    }
}
```

The Java^{TM} Tutorial

Trail: Creating a GUI with JFC/Swing
Lesson: Converting to Swing

Run TextEventDemo

Since you can't run the applet, here's a picture of it:



Diffendoofer

Flobbertown

```
  First 10 characters: "Flob"
Text Area text value changed.
  First 10 characters: "Flobb"
Text Area text value changed.
  First 10 characters: "Flobbe"
Text Area text value changed.
  First 10 characters: "Flobber"
Text Area text value changed.
  First 10 characters: "Flobbert"
Text Area text value changed.
  First 10 characters: "Flobberto"
Text Area text value changed.
  First 10 characters: "Flobbertow"
Text Area text value changed.
  First 10 characters: "Flobbertow"
```

Note: Because the preceding applet uses the Swing 1.1 API, it requires Java Plug-in 1.1.2 or Java Plug-in 1.2. It won't work with Java Plug-in 1.1.1 or uncustomized 1.1 browsers. For more information about running applets in the tutorial, refer to About Our Examples. That page includes a section about Downloading Java Plug-in.

```
<applet code="TextEventDemo.class"
        codebase="example-swing"
        archive="textdemo.jar"
        width="500" height="300">

Since you can't run the applet,
here's a picture of it:

#usemacro UI_FIGURE (
    NAME TextEventDemo.gif
    W 500
    H 300
    ALT A snapshot of TextEventDemo, which demonstrates handling document events on text
components.
)

</applet>
```

Trail: Creating a GUI with JFC/Swing

Lesson: Working with Graphics

You might not need to read this lesson at all. Many programs get by with no custom graphics. If they display images, they do so using icons◆ in standard Swing components such as labels◆ and buttons◆. To display styled text, perhaps with embedded images and components, they use text components◆. To customize the edges of components, they use borders◆.

If you can't find a component that paints what you need onscreen, then read on. This lesson teaches you how to display text, simple shapes, and images, using API that works in both JDK 1.1 and 1.2. Our examples create custom components, but you might also use this API when creating a custom border or icon implementation. This lesson finishes with information about animation.

Note: If you're using only Java 2 (JDK 1.2, and not JDK 1.1) then in addition to reading the relevant pages in this lesson, you should read the 2D Graphics◆ trail. That trail describes the Java™ 2D Graphics API, which provides much more functionality than the graphics primitives described in this lesson.

Overview of Custom Painting

This section gives you the information you need to start implementing custom painting in components.

Using Graphics Primitives

This section teaches you how to paint simple shapes and display text effectively. It includes examples of using the `Graphics`, `Font`, and `FontMetrics` classes.

Using Images

This section discusses how the Java platform supports images and tells you how to load and display images.

Performing Animation

Many programs perform animation, whether it's the classic, cartoon-style animation of Duke waving or simply moving static images across the screen. This section tells you how to perform animation, using a `Timer` object to implement an animation loop.

Solving Common Graphics Problems

This section describes some common problems of graphics programs, along with possible solutions to these problems.

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Trail: Creating a GUI with JFC/Swing

Lesson: Writing Event Listeners

This lesson gives you details about writing event listeners. It assumes you've already read and understood Event Handling◆, which gives an overview of the event model.

You might not need to read this section, at all. Your first source of information for event information should be the how-to section for the component in question. You can find the appropriate section using the A Visual Index to the Swing Components◆. Each component's section shows code for handling the events most commonly needed when implementing the component. For example, How to Use Check Boxes◆ shows you how to handle mouse clicks on check boxes using an item listener.

Some Simple Event-Handling Examples

The applets in this section illustrate events and event handling.

General Information about Writing Event Listeners

This section provides information that's useful for handling all types of events. One of the topics is how to reduce unnecessary code by using adapters and inner classes to implement event handlers.

Listeners Supported by Swing Components

This is *the* place to find out which Swing components can fire which kinds of events. You might want to bookmark this section so you can easily find its quick-reference table.

Implementing Listeners for Commonly Handled Events

This section has detailed information and examples of writing each common kind of event listener.

Summary of Listener API

This section features a quick-reference table that shows each listener, its adapter class (if any), and its methods.

Solving Common Event-Handling Problems

If you're having some hard-to-debug problems related to handling events, you might find the solution here.

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Trail: Creating a GUI with JFC/Swing
Lesson: Working with Graphics

Overview of Custom Painting

If you haven't read the Painting◆ section, please do so right now. That section describes how Swing components are painted -- essential information if you're going to write custom painting code.

Before you implement a component that performs custom painting, first make sure that you really need to do so. You might be able to use the text and image capabilities of labels◆, buttons◆, or text components◆ instead. And remember, you can use borders◆ to customize the outside edges of a component.

If you really need to perform custom painting, then you need to decide which superclass to use. We recommend that you extend either `JPanel` or a more specialized Swing component class. For example, if you're creating a custom button class, you should probably implement it by extending a button class such as `JButton` or `JToggleButton`. That way you'll inherit the state management provided by those classes. If you're creating a component that paints on top of an image, you might want to create a `JLabel` subclass. On the other hand, if you're implementing a component that generates and displays a graph on top of a blank or transparent background, then you might want to use a `JPanel` subclass.

When implementing custom painting code, keep two things in mind:

- Your custom painting code belongs in a method named `paintComponent`.
- You can -- and probably should -- use a border to paint the outside edges of your component.

An Example of Custom Painting

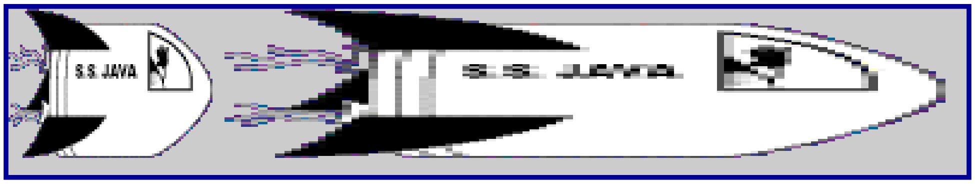
The following code gives an example of custom painting. It shows an image twice, once at its natural size and once very wide.

```
class ImagePanel extends JPanel {
    ...
    public void paintComponent(Graphics g) {
        super.paintComponent(g); //paint background

        //Draw image at its natural size first.
        g.drawImage(image, 0, 0, this); //85x62 image

        //Now draw the image scaled.
        g.drawImage(image, 90, 0, 300, 62, this);
        }
    }
```

Here is the result:



This is a picture of the applet's GUI. To run the applet, click the picture. The applet will appear in a new browser window.

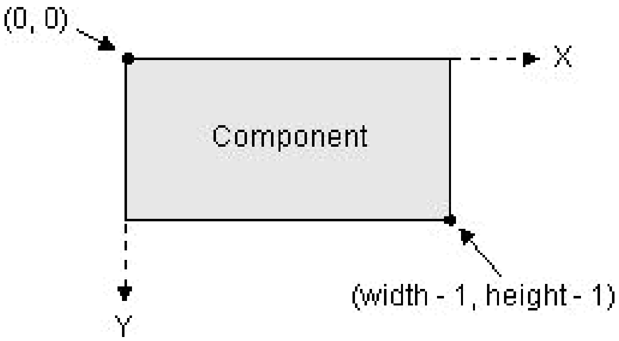
The example code is from `ImageDisplayer.java`, which is further discussed in Displaying Images. The example demonstrates a few rules that apply to all components that perform custom painting:

- The painting code does something that no standard Swing component does. If we just wanted to display the figure once, at its natural size, we would have used a `JLabel` object instead of the custom component.
- The custom component is a `JPanel` subclass. This is a common superclass for custom components.
- All the custom painting code is in a method called `paintComponent`.
- Before performing any custom painting, the component paints its background by invoking `super.paintComponent`. If we remove that call, either our custom painting code must paint the component's background or we must invoke `setOpaque(false)` on the component. Doing the latter would inform the Swing painting system that the components behind the non-opaque component might be visible, and thus should be painted.

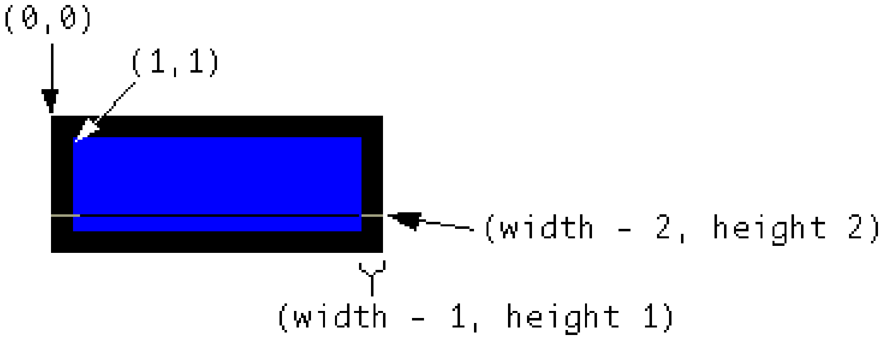
One thing this component does *not* do is take borders into account. Not only does it not use a border, but it also doesn't adjust its painting coordinates to take a border into account. A production-quality component would adjust to borders as described in the next subsection.

The Coordinate System

Each component has its own integer coordinate system, ranging from (0, 0) to (*width* - 1, *height* - 1), with each unit representing the size of one pixel. As the following figure shows, the upper left corner of a component's painting area is (0, 0). The X coordinate increases to the right, and the Y coordinate increases downward.



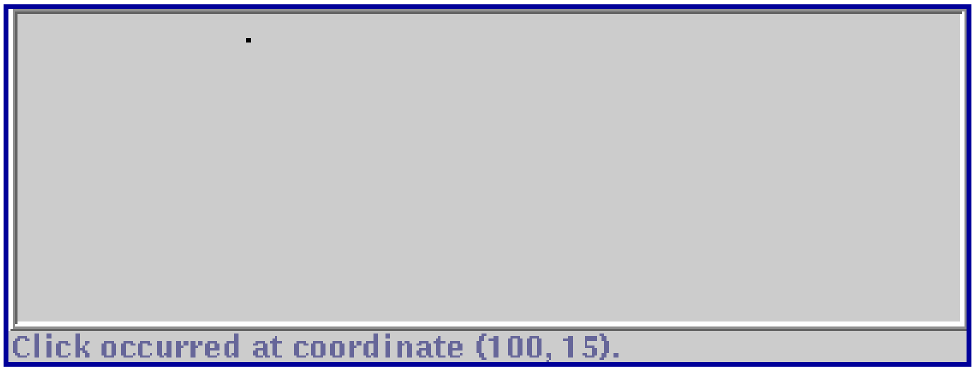
When painting a component, you must take into account not only the component's size but also the size of the component's border, if any. For example, a border that paints a one-pixel line around a component changes the top leftmost corner from (0,0) to (1,1) and reduces the width and the height of the painting area by two pixels each (one pixel per side). The following figure demonstrates this:



You get the width and height of a component using its `getWidth` and `getHeight` methods. To determine the border size, use the `getInsets` method. Here is some code that a component might use to determine the width and height available for custom painting:

```
public void paintComponent(Graphics g) {
    ...
    Insets insets = getInsets();
    int currentWidth = getWidth() - insets.left - insets.right;
    int currentHeight = getHeight() - insets.top - insets.bottom;
    ...
    .../* First painting occurs at (x,y), where x is at least
      insets.left, and y is at least insets.height. */...
}
```

To familiarize yourself with the coordinate system, you can play with the following applet. Wherever you click on or inside the framed area, a dot is painted, and the label below lists the click's coordinates. The dot is obscured if you click on the border because the component's border is painted after the component performs its custom painting. If we didn't want this effect, an easy solution would be to move the border from the component into a new `JPanel` object that contains the component.



This is a picture of the applet's GUI. To run the applet, click the picture. The applet will appear in a new browser window.

The program is implemented in `CoordinatesDemo.java`. Although we don't discuss this example's code anywhere, it's very similar to the code in the `RectangleDemo` program, which is discussed a little later in Painting Shapes.

Arguments to the repaint Method

Remember that calling a component's `repaint` method requests that the component be scheduled to paint itself. When the painting system is unable to keep up with the pace of repaint requests, it might combine multiple requests into a single paint request to the component.

The `repaint` method has two useful forms:

`void repaint()`
: Requests that the entire component be repainted.

`void repaint(int, int, int, int)`
: Requests that only the specified part of the component be repainted. The arguments specify first the X and Y coordinates at the upper left of the area to be repainted, and then the area's width and height.

Although using the four-argument form of `repaint` method often isn't practical, it can help painting performance significantly. The program in the following picture uses the four-argument `repaint` method when requesting frequent repaints to display the user's current selection area. Doing so avoids repainting the parts of the component that haven't changed since the last painting operation.

This is a picture of the applet's GUI. To run the applet, click the picture. The applet will appear in a new browser window.

The program is implemented in `SelectionDemo.java`. Here is the code that calculates the area to be repainted and then paints it:

```
class SelectionArea extends JLabel {
    ...
    public SelectionArea(ImageIcon image, ...) {
        super(image); //Makes this component display an image.
        ...
    }

    ...//In a mouse-dragged event handler:
        Rectangle totalRepaint = rectToDraw.union(previousRectDrawn);
        repaint(totalRepaint.x, totalRepaint.y,
                totalRepaint.width, totalRepaint.height);
    ...
    public void paintComponent(Graphics g) {
        super.paintComponent(g); //paints the background and image
        ...
        //Paint a rectangle on top of the image.
        g.setColor(Color.white);
        g.drawRect(rectToDraw.x, rectToDraw.y,
                   rectToDraw.width - 1, rectToDraw.height - 1);
        ...
    }
    ...
}
```

As you can see, the custom component extends `JLabel` so that it inherits the ability to display an image. The user can select a rectangular area by dragging the mouse. The component continuously displays a rectangle indicating the size of the current selection. To improve rendering speed, the component's mouse-dragged event handler specifies a painting area to the `repaint` method.

By limiting the area to be repainted, the event handlers avoid unnecessarily repainting the image outside of that area. For this small image there's no noticeable performance benefit to this strategy. However, for a large image there might be a real benefit. And if instead of painting an image from a file, you had to compute what to paint under the rectangle -- for example, computing shapes in a draw program -- then using knowledge of the paint area to limit the computation you perform might improve performance significantly.

The area specified to `repaint` must include not only the area to be painted, but also any area that needs to be erased. Otherwise, old painting remains visible until it happens to be erased by other painting. The preceding code calculates the total area to be repainted by taking the union of the rectangle to be painted with the rectangle that was previously painted.

The painting area specified to `repaint` is reflected in the `Graphics` object passed into the `paintComponent` method. You can use the `getClipBounds` method to determine which rectangular area to paint. Here is an example of using the clip bounds:

```
public void paintComponent(Graphics g) {
    Rectangle clipRect = g.getClipBounds();
    if (clipRect != null) {
        //If it's more efficient, draw only the area
        //specified by clipRect.
        //Top-leftmost point = (clipRect.x, clipRect.y)
        //Width, height = clipRect.width, clipRect.height
    } else {
        //Paint the entire component.
    }
}
```

The Graphics Object

The `Graphics` object passed into the `paintComponent` method provides both a context for painting and methods for performing the painting. The methods, which we discuss in detail a little later, have names such as `drawImage`, `drawString`, `drawRect`, and `fillRect`.

The graphics context consists of state such as the current painting color, the current font, and (as you've already seen) the current painting area, The color and font are initialized to the foreground color and font of the component just before the invocation of `paintComponent`. You can get them using the `getColor` and `getFont` methods, and set them using the `setColor` and `setFont` methods.

You can safely ignore the current painting area, if you like. It has no effect on the component's coordinate system, and any painting outside the area is ignored. However, if your painting code involves complex operations that can be simplified if the painting area is reduced, then you should use your knowledge of the painting area to help you improve painting performance. As shown by the previous code example, you get the painting area's rectangular bounds from the `Graphics` object by invoking the `getClipBounds` method.

You can reduce the painting area in two ways. The first is to specify `repaint` with arguments whenever possible. The other is to implement `paintComponent` so that it invokes the `Graphics` object's `setClip` method. If you use `setClip`, be sure to restore the original painting area before returning. Otherwise, the component could be painted improperly. Here's an example of reducing and then restoring the painting area:

```
Rectangle oldClipBounds = g.getClipBounds();
Rectangle clipBounds = new Rectangle(...);
g.setClip(clipBounds);

...//Perform custom painting...

g.setClip(oldClipBounds);
```

When writing your painting code, keep in mind that you can't depend on any graphics context except what's provided by the `Graphics` object. For example, you can't rely on the painting area you specify with `repaint` being exactly the same as the painting area used in the subsequent call to paintComponent. For one thing, multiple repaint requests can be coalesced into a single paintComponent call, with the painting area adjusted accordingly. For another, the painting system occasionally calls paintComponent on its own, without any repaint request from your program. As an example, the painting system invokes a component's paintComponent method when it first shows the component's GUI. Also, when the GUI is covered by another window and then becomes uncovered, the painting system invokes the paintComponent method with the painting area equal to the newly uncovered area.

The Swing Painting Methods

The paintComponent method is one of three methods that JComponent objects use to paint themselves. The three methods are invoked in this order:

1. paintComponent -- The main method for painting. By default, it first paints the background if the component is opaque. Then it performs any custom painting.
2. paintBorder -- Tells the component's border (if any) to paint. *Do not invoke or override this method.*
3. paintChildren -- Tells any components contained by this component to paint themselves. *Do not invoke or override this method.*

Note: Don't override or invoke the method that calls the paint*Xxx* methods: the paint method. Although overriding paint was legitimate in pre-Swing components, it's generally not a good thing to do in components that descend from JComponent. Unless you're careful, overriding paint would likely confuse the painting system, which relies on the JComponent implementation of the paint method for correct painting, performance enhancements, and features such as double buffering.

The standard Swing components delegate their look-and-feel-specific painting to an object called a *UI delegate*. When such a component's paintComponent method is called, the method asks the UI delegate to paint the component. Generally, the UI delegate first checks whether the component is opaque and, if so, paints the entire background of the component. Then the UI delegate performs any look-and-feel-specific painting.

The reason that we recommend extending JPanel instead of JComponent is that the JComponent class doesn't currently set up a UI delegate -- only its subclasses do. This means that if you extend JComponent, your component's background won't be painted unless you paint it yourself. When you extend JPanel and invoke super.paintComponent at the top of your paintComponent method, however, then the panel's UI delegate paints the component's background if the component is opaque.

If you need more information about painting, see Painting in AWT and Swing. It's an article in The Swing Connection that discusses in depth the intricacies of painting.

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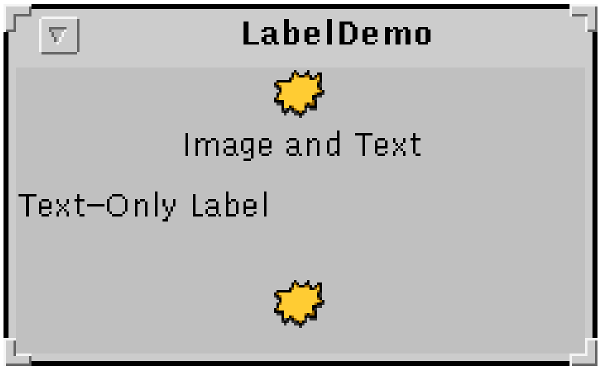
Trail: Creating a GUI with JFC/Swing
Lesson: Using Other Swing Features

How to Use Icons

Some Swing components, such as `JLabel` and `JButton`, can be decorated with an *icon* -- a fixed-sized picture. An icon is an object that adheres to the `Icon` interface. Swing provides a particularly useful implementation of the `Icon` interface: `ImageIcon`, which paints an icon from a GIF or JPEG image.

Here's a snapshot of an application that decorates two labels with an icon:



The program uses one image icon to contain and paint the yellow splat. One statement creates the image icon and two more statements include the image icon on each of the two labels:

```
ImageIcon icon = new ImageIcon("images/middle.gif",
                               "a pretty but meaningless splat");
...
label1 = new JLabel("Image and Text", icon, JLabel.CENTER);
...
label3 = new JLabel(icon);
```

The first argument to the `ImageIcon` constructor specifies the file to load, relative to the directory containing the application's class file. The second argument provides a description of the icon, to be used by assistive technologies. This description might be used, for example, to help a visually impaired user understand what information the icon conveys.

Applets generally load image data from the computer that served up the applet. There are two reasons for this. First, untrusted applets can't read from the file system on which they're running. Second, it just makes sense to put an applet's class and data files together on the server. To load image data from the server, an applet uses a URL as shown in the following example:

```
public class SomeClass extends JApplet ... {
    protected String leftButtonFilename = "images/left.gif";
    ...
    public void init() {
        ...
        URL leftButtonURL = getURL(leftButtonFilename);
        ...
        leftButtonIcon = new ImageIcon(leftButtonURL,
                                       "an arrow pointing left");
        ...
    }
    ...
    protected URL getURL(String filename) {
        URL codeBase = getCodeBase();
        URL url = null;

        try {
            url = new URL(codeBase, filename);
        } catch (java.net.MalformedURLException e) {
            System.err.println("Couldn't create image: " +
                               "badly specified URL");
            return null;
        }

        return url;
    }
    ...
}
```

If you're writing an applet, you might want to copy the `getURL` method for use in your applet. For more information on specifying the source of image data, see Specifying the Image Source.

When you specify a filename or URL to an `ImageIcon` constructor, the constructor returns only after the image data is completely loaded. Thus, you can be sure that the image icon is usable following the call to the constructor. If you want more information while the image is loading, you can register an observer on an image icon by calling its `setImageObserver` method.

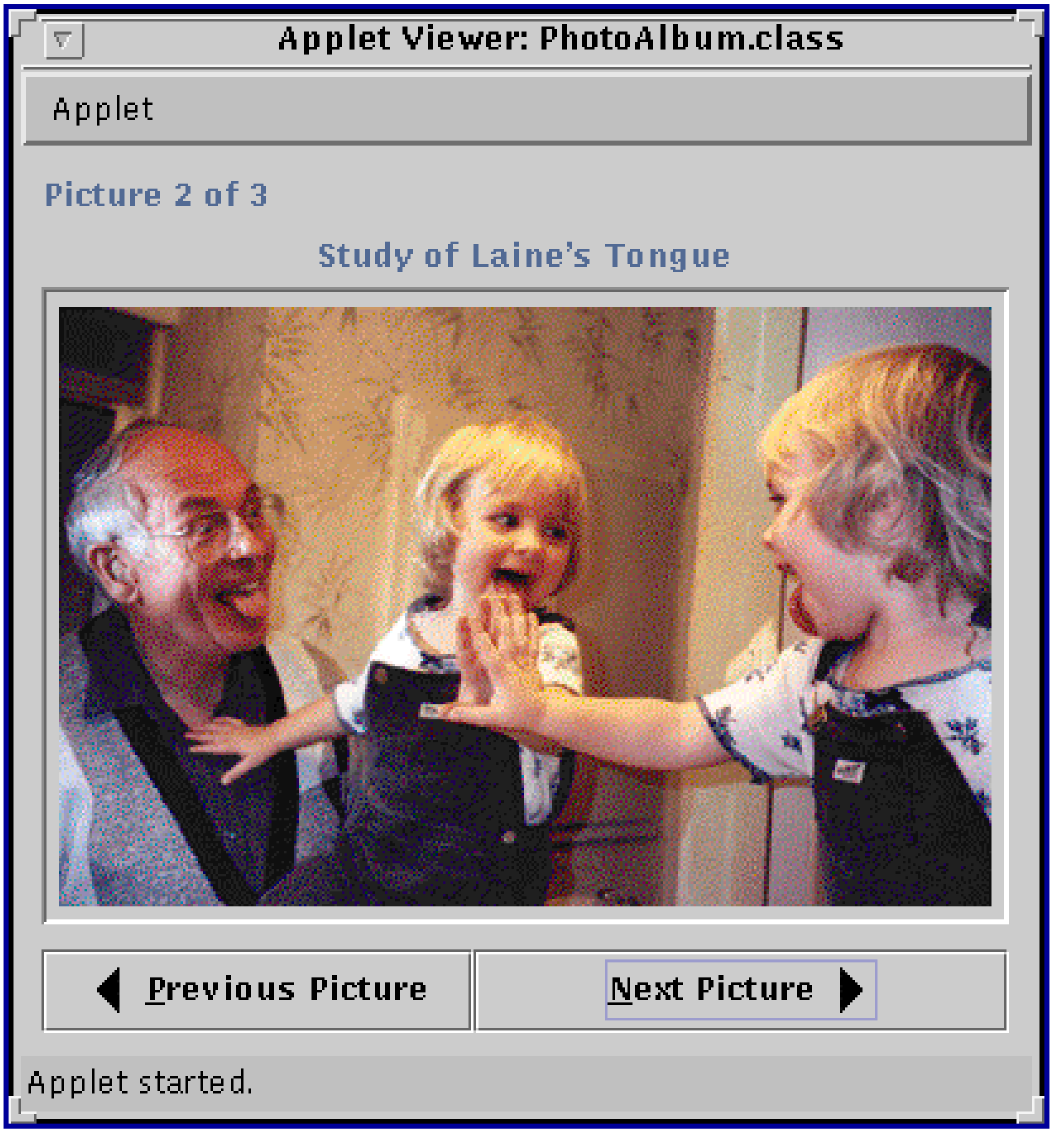
Under the covers, each image icon uses an `Image` object to hold the image data and a `MediaTracker` object, which is shared by all image icons in the same program, to keep track of the image's loading status. If you're curious about `Image` objects, image observers, media trackers, and other image topics, see Using Images.

The rest of this section covers the following topics:

- A More Complex Image Icon Example
- Specifying the Image Source
- Improving Perceived Performance When Loading Image Icons
- Creating a Custom Icon Implementation
- The Image Icon API
- Examples that Use Icons

A More Complex Image Icon Example

Here's an applet that uses eight image icons. In the snapshot, you can see three of them: one displays the photograph and two decorate the buttons at the bottom of the applet window with small arrows.



This is a picture of the applet's GUI. To run the applet, click the picture. The applet will appear in a new browser window.

Try this:

1. Run the applet. For information on running applets, see Running Swing Applets.
   The main source code for the program is `IconDemoApplet.java`.
   You will also need a few other source files and several image files. See the examples index for links to all the files required by this example.
2. Click the **Previous Picture** and **Next Picture** buttons to view the photographs.
3. Hold the mouse over a photograph. A tool tip appears that indicates the filename of the current photograph and its width and height.
4. To view your own photographs, modify the applet parameters. Here's the applet tag used for the applet running above:

```
<applet code="IconDemoApplet.class"
        codebase="example-swing/"
        archive="icon.jar"
        width="400" height="360">
    <param NAME="IMAGEDIR" VALUE="images">

    <param NAME="IMAGE0" VALUE="stickerface.gif">
    <param NAME="CAPTION0" VALUE="Sticker Face">
    <param NAME="WIDTH0" VALUE="230">
    <param NAME="HEIGHT0" VALUE="238">
    ...
<applet>
```

   The `IMAGEDIR` parameter indicates that the image files should be in a directory named `images` relative to the applet's codebase. Four parameters are required for each photograph and the applet uses four photographs. The tag shown above shows the parameters for only the first photograph.

Specifying the Image Source

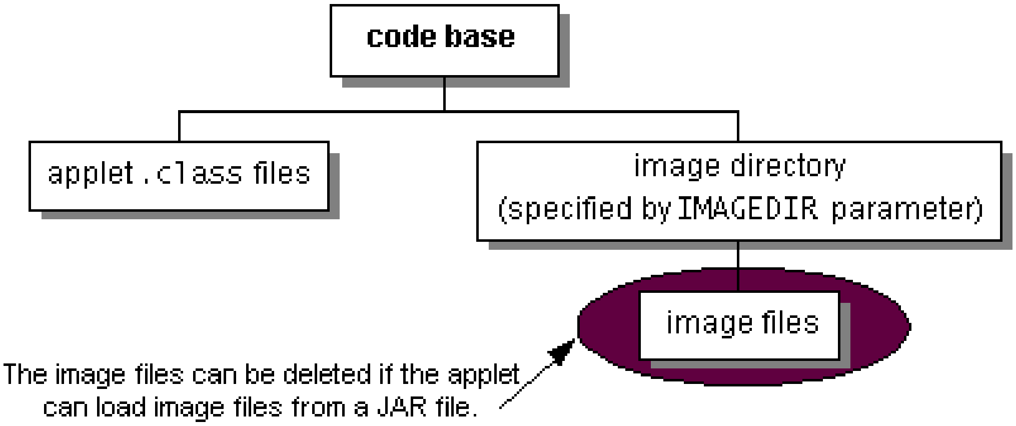
Most often, an image icon's data comes from an image file. You can specify the location of the file with either a filename or a `URL` object. For applications, the filename or URL is generally relative either to the directory containing the application's class files, or to the class path. Applets generally use a URL that is constructed relative to the applet's code base (the directory containing the applet's class files).

You've already seen how to specify a filename relative to the directory containing the application's class files. To specify a URL relative to an application's class path, you can use the ClassLoader getSystemResource method. Here is an example:

```
ImageIcon icon = null;
URL iconURL = ClassLoader.getSystemResource("images/middle.gif");
if (iconURL != null) {
    icon = new ImageIcon(iconURL,
                         "a beautiful yet meaningless icon");
}
```

The getSystemResource method looks through the directories and JAR files in the program's class path, returning a URL as soon as it finds the desired file. For example, assume that you put a JAR file named icons.jar in your program's class path. If the JAR file contains images/middle.gif, then the class loader will definitely return a URL for images/middle.gif. However, the URL might not be relative to icons.jar, if another JAR file or directory in the class path contains images/middle.gif. The URL will point to the *first* JAR file or directory in the class path that contains images/middle.gif.

The IconDemoApplet program initializes each of its image icons from GIF files whose locations are specified with URLs. Because IconDemoApplet is designed to be an untrusted applet, we must place the image files under the applet's code base. The following figure shows the locations of files for IconDemoApplet.


code base
applet .class files
image directory
(specified by IMAGEDIR parameter)
image files
The image files can be deleted if the applet can load image files from a JAR file.

Note: Applets are supposed to be able to load images from JAR files. Currently, however, some browsers can't read images from a JAR file, although they do successfully get classes from a JAR file. With our applets, we currently hedge our bets by both putting the image files in the applet's archive file (the JAR file containing the applet's class files) and by putting the image files in the file system on the server. The figure above depicts our setup.

Improving Perceived Performance When Loading Image Icons

Because the photograph images are large and because the applet uses multiple images, `IconDemoApplet` uses several techniques to improve the performance of the program as perceived by the user.

- **Providing dimmed icons --** The applet provides dimmed versions of the arrows for the buttons:

  ```
  imagedir = getParameter("IMAGEDIR");
  if (imagedir != null)
      imagedir = imagedir + "/";
  ...
  ImageIcon dimmedNextIcon = new ImageIcon(
      getURL(imagedir + "dimmedRight.gif"));
  ImageIcon dimmedPreviousIcon = new ImageIcon(
      getURL(imagedir + "dimmedLeft.gif"));
  ...
  nextButton.setDisabledIcon(dimmedNextIcon);
  ...
  previousButton.setDisabledIcon(dimmedPreviousIcon);
  ```

  Without this code, the dimmed versions of the arrows would be computed, which causes a slight delay the first time each button is dimmed. Basically, this technique trades a noticeable delay when the user clicks the buttons for a smaller, less noticeable delay in the `init`method.

  This applet uses four separate image files just to display arrows on two buttons. The performance impact of these little images can add up, especially if the browser in which the applet is running uses a separate HTTP connection to load each one. A better alternative is to implement a custom `Icon` that paints the arrows. See Creating a Custom Icon Implementation for an example.

- **Lazy image loading --** The applet's initialization code loads only the first photograph. Each other photograph gets loaded when the user first requests to see it. By loading images if and when needed, the applet avoids a long initialization. The downside is that the user has to wait to see each photograph. We try to make this wait less noticeable by providing feedback about the image loading and allowing the user to use the GUI while the image is loading.

  Not all programs can benefit from lazy loading. For example, the `TumbleItem.java`◆ applet performs an animation, so all of the images are needed up-front. That applet's initialization code causes the images to be loaded in a background thread, so that the applet can present a GUI (a "Loading Images..." label) before the images have loaded.

- **Background image loading --** The applet uses a `SwingWorker` to load each photograph image in a background thread. Because the image is loaded in a separate thread, the user can still click the buttons and otherwise interact with the applet while the image is loading.

Here's the code to load each image:

```
private void loadImage(final String imagePath,
                       final int index) {
    final SwingWorker worker = new SwingWorker() {
        ImageIcon icon = null;

        public Object construct() {
            icon = new ImageIcon(getURL(imagePath));
            return icon;
        }

        public void finished() {
            Photo pic = (Photo)pictures.elementAt(index);
            pic.setIcon(icon);
            if (index == current)
                updatePhotograph(index, pic);
        }
    };
    worker.start();
}
```

The `construct` method, which creates the image icon for the photograph, is invoked by the thread that's created by the `SwingWorker` constructor and started by the `start` method. After the image icon is fully loaded, the `finished` method is called. The `finished` method is guaranteed to execute on the event-dispatching thread, so it can safely update the GUI to display the photograph.

- **Status updates --** While the image is loading in the background, the applet displays a status message:

```
photographLabel.setIcon(null);
photographLabel.setText("Loading image...");
```

This lets the user know that the program is doing something. After the image is loaded, the applet displays the photograph in the viewing area.

- **Caching --** After each photograph is viewed for the first time, the applet caches the image icon for later use. Thus if the user revisits a photograph, the program can use the same image icon and display the photograph quickly.

> If you write a program without caching image icons, it may appear that some implicit image caching is going on within the Java platform. However, this is a side effect of the implementation and is not guaranteed. If your program uses one image many times, you can create the image icon once and use the same instance multiple times.

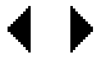
As with all performance-related issues, these techniques work in some situations and not others. These are not general recommendations for all programs, but some techniques you can try to improve the user's experience. Furthermore, the techniques described here are designed to improve the program's perceived performance, but don't necessarily impact its real performance.

Creating a Custom Icon Implementation

If you use a simple image repeatedly, consider implementing a custom `Icon` class to paint the image. The really nice thing about a custom icon is that you can easily change the icon's appearance to reflect its host component's state.

Look-and-feel implementations often use custom icons. For example, the Metal Look & Feel uses a single `MetalCheckBoxIcon` object to paint all of the check boxes in the GUI. The `MetalCheckBoxIcon` paints itself differently depending on whether its host component is enabled, pressed, or selected.

In this section, we'll convert a program called `ButtonDemo` so that it uses a custom icon to paint these two arrows:



You can see a picture of `ButtonDemo` in How to Use the Common Button API. Its source code is in `ButtonDemo.java`. `ButtonDemo` uses the following code to load the arrows from GIF files and put the arrows into buttons:

```
ImageIcon leftButtonIcon = new ImageIcon("images/right.gif");
...
ImageIcon rightButtonIcon = new ImageIcon("images/left.gif");

b1 = new JButton("Disable middle button", leftButtonIcon);
...
b3 = new JButton("Enable middle button", rightButtonIcon);
```

Here is the new code, which uses a custom icon class named `ArrowIcon`. Only the bold lines have changed. You can find the entire program in `CustomIconDemo.java`.

```
Icon leftButtonIcon = new ArrowIcon(SwingConstants.RIGHT);
...
```

```
Icon rightButtonIcon = new ArrowIcon(SwingConstants.LEFT);

b1 = new JButton("Disable middle button", leftButtonIcon);
...
b3 = new JButton("Enable middle button", rightButtonIcon);
```

You can find the implementation of the custom icon class in `ArrowIcon.java`. Here are the interesting parts of its code:

```
class ArrowIcon implements Icon, SwingConstants {
    ...
    public void paintIcon(Component c, Graphics g,
                          int x, int y) {
        int length = xPoints.length;
        int adjustedXPoints[] = new int[length];
        int adjustedYPoints[] = new int[length];

        for (int i = 0; i < length; i++) {
            adjustedXPoints[i] = xPoints[i] + x;
            adjustedYPoints[i] = yPoints[i] + y;
        }

        if (c.isEnabled()) {
            g.setColor(Color.black);
        } else {
            g.setColor(Color.gray);
        }

        g.fillPolygon(adjustedXPoints, adjustedYPoints,
                      length);
    }
}
```

Note that the icon sets the current color. If you don't do this, then the icon's painting might not be visible. For more information about performing custom painting, see Working with Graphics. The `fillPolygon` method is discussed in Painting Shapes.

Using a custom icon to paint the arrows has a few implications:

- Because the icon's appearance is determined dynamically, the icon painting code can use any information -- component and application state, for example -- to determine what to paint.
- Because we specified a non-`ImageIcon` icon for a button, the button doesn't bother to calculate the dimmed (disabled) version of the icon. Instead, the button lets the icon paint its disabled self. This can reduce computation time and save space that would otherwise

be used to hold the dimmed image.
- Depending on the platform, we might get a performance boost with custom icons, since painting polygons is often faster than painting images.
- Instead of loading all the GIF files for the arrows (left and right, and perhaps dimmed left and dimmed right), we load a single class file (`ArrowIcon`). The performance implications of this depend on factors such as the platform, the size of the files, and the overhead for loading each type of file.

The Image Icon API

The following tables list the commonly used `ImageIcon` constructors and methods. Note that `ImageIcon` is not a descendent of `JComponent` or even of `Component`.

The API for using image icons falls into these categories:

- Setting, Getting, and Painting the Image Icon's Image
- Setting or Getting Information about the Image Icon
- Watching the Image Icon's Image Load

Setting, Getting, and Painting the Image Icon's Image

Method or Constructor	**Purpose**

`ImageIcon()`
`ImageIcon(byte[])`
`ImageIcon(byte[], String)`
`ImageIcon(Image)`
`ImageIcon(Image, String)`
`ImageIcon(String)`
`ImageIcon(String, String)`
`ImageIcon(URL)`
`ImageIcon(URL, String)`
	Create a `ImageIcon` instance, initializing it to contain the specified image. The first argument indicates the source -- image, byte array, filename, or URL -- from which the image icon's image should be loaded. The source must be in a format supported by the `java.awt.Image` class: namely GIF or JPEG. The second argument, when present, provides a description for the image. The description is a short textual description of the image that could be used in a variety of ways, such as alternate text for the image.

`void setImage(Image)`
`Image getImage()`
	Set or get the image displayed by the image icon.

`void paintIcon(Component, Graphics, int, int)`	Paint the image icon's image in the specified graphics context. You would do this only if you're implementing a custom component that performs its own painting. The `Component` object is used as an image observer. You can rely on the default behavior provided by `Component` class and pass in any component. The two `int` argments specify the x and y coordinates, respectively.

Setting or Getting Information about the Image Icon

Method	**Purpose**

`void setDescription(String)`
`String getDescription()`
	Set or get a description of the image. This description is intended for use by assistive technologies.

`int getIconWidth()`
`int getIconHeight()`
	Get the width or height of the image icon in pixels.

Watching the Image Icon's Image Load

Method	**Purpose**

`void setImageObserver(ImageObserver)`
`ImageObserver getImageObserver()`
	Set or get an image observer for the image icon.

`int getImageLoadStatus()`	Get the loading status of the image icon's image. The set of values returned by this method are defined by `MediaTracker`.

Examples that Use Icons

The following table lists just a few of the many examples that use `ImageIcon`.

Example	**Where Described**	**Notes**
`LabelDemo`	This section and How to Use Labels	Demonstrates using icons in an application's label, with and without accompanying text.
`IconDemoApplet`	This section	An applet. Uses a label to show large images; uses buttons that have both images and text.
`CustomIconDemo`	This section	Uses a custom icon class implemented by `ArrowIcon.java`.
`TumbleItem`	How to Make Applets	Uses image icons in an animation. Shows how to use `ImageIcon`'s `paintIcon` method.

`ButtonDemo`	How to Use Buttons, Check Boxes, and Radio Buttons	Shows how to use icons in an application's buttons.
`CheckBoxDemo`	How to Use Check Boxes	Uses multiple GIF images.
`TabbedPaneDemo`	How to Use Tabbed Panes	Demonstrates adding icons to tabs in a tabbed pane.
`DialogDemo`	How to Make Dialogs	Shows how to use standard icons in dialogs.
`TreeIconDemo`	How to Use Trees	Shows how to change the icons displayed by a tree's nodes.
`ActionDemo`	How to Use Actions	Shows how to specify the icon in a tool-bar button or menu item using an `Action`.

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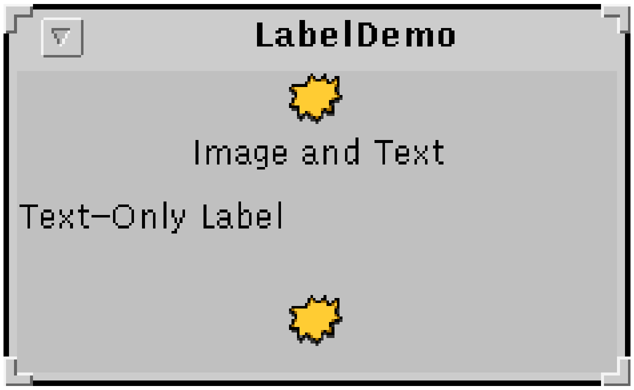
How to Use Labels

With the `JLabel` class, you can display unselectable text and images. If you need to create a component that displays a string or an image (or both), optionally reacting to user input, you can do so by using or extending `JLabel`. If the interactive component has state, then you should probably use a button instead of a label.

Here's a picture of an application that displays three labels. The window is divided into three rows of equal height; the label in each row is as wide as possible.



Try this:

1. Compile and run the application. The source code is in `LabelDemo.java`, and the image is `middle.gif`.
   See Getting Started with Swing if you need help compiling or running this application.
2. Resize the window so you can see how the labels' contents are placed with the labels' drawing area.
   All the label contents have the default vertical alignment -- the label contents are centered vertically in the label's drawing area. The top label, which contains both image and text, is specified to have horizontal center alignment. The second label, which contains just text, has the left alignment that is the default for text-only labels. The third label, which contains just an image, has horizontal center

alignment, which is the default for image-only labels.

Below is the code from `LabelDemo.java`◆ that creates the labels in the previous example.

```
ImageIcon icon = new ImageIcon("images/middle.gif");
. . .
label1 = new JLabel("Image and Text",
                    icon,
                    JLabel.CENTER);
//Set the position of the text, relative to the icon:
label1.setVerticalTextPosition(JLabel.BOTTOM);
label1.setHorizontalTextPosition(JLabel.CENTER);

label2 = new JLabel("Text-Only Label");

label3 = new JLabel(icon);

//Add labels to the JPanel.
add(label1);
add(label2);
add(label3);
```

Note that label alignment is different from X and Y alignment. X and Y alignment are used by layout managers and can affect the way any component -- not just a label -- is sized or positioned. Label alignment, on the other hand, has no effect on a label's size or position. It simply determines where, inside the label's painting area, the label's contents are positioned. In the usual case, the label's painting area is exactly the size needed to paint the label, and thus label alignment is irrelevant. For more information about X and Y alignment, see How to Use BoxLayout◆.

Often, a label describes another component. When this is true, you can improve your program's accessibility by using the `setLabelFor` method to identify the component the label describes. For example:

```
amountLabel.setLabelFor(amountField);
```

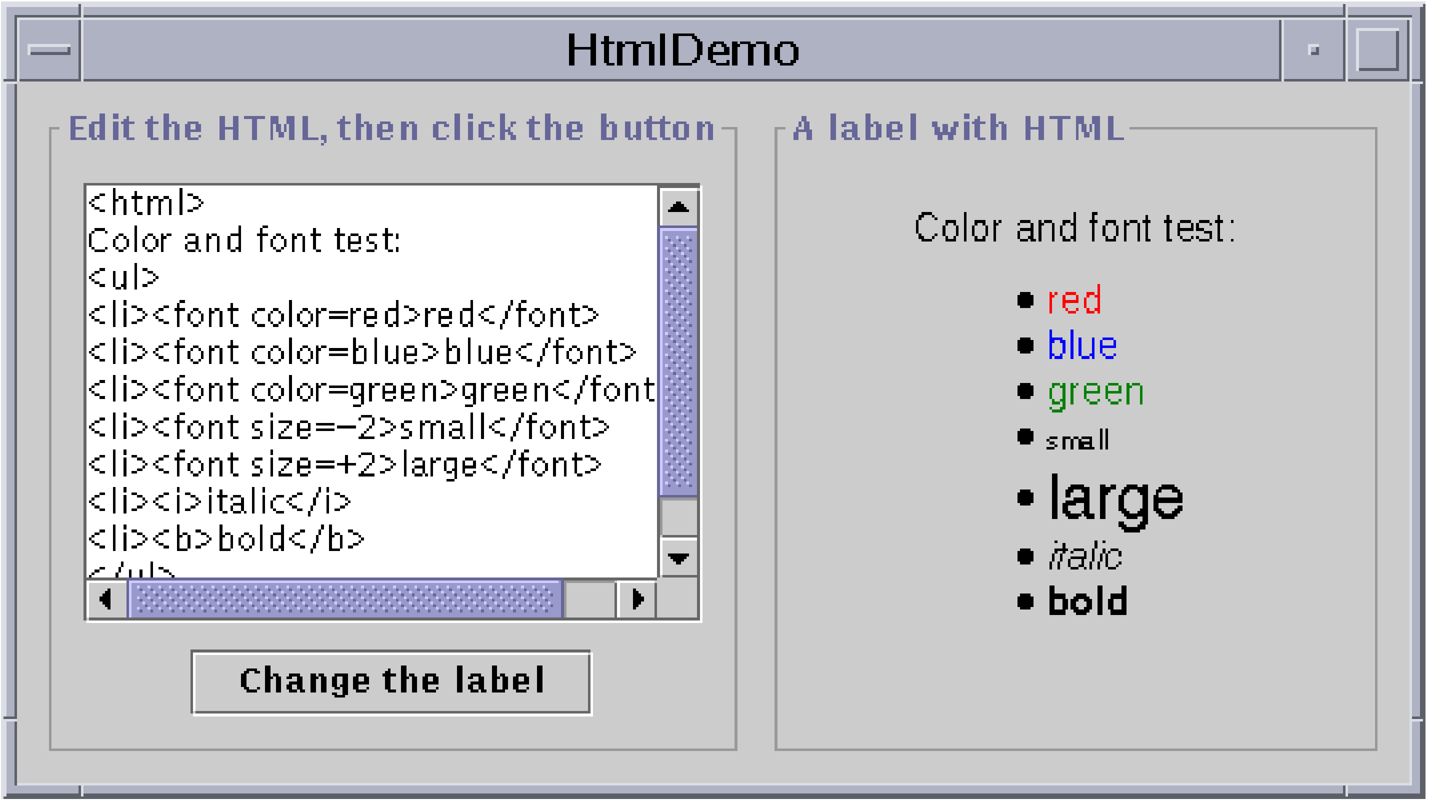
The preceding code, taken from the `TextFieldDemo` example discussed in How to Use Text Fields, lets assistive technologies know that the label (`amountLabel`) provides information about the text field (`amountField`). For more information about assistive technologies, see How to Support Assistive Technologies.

Using HTML on a Label

Note: The information in this section documents a feature available only in Swing 1.1.1 Beta 1 or compatible releases.

Have you ever wanted to put multiple lines on a label? Have you ever wanted to make part of a label bold or italic? Now you can. As of Swing 1.1.1 Beta 1, `JLabel` supports multiple lines, multiple fonts, and a whole lot more because you can specify a label's text using HTML.

Here's an application that dynamically sets the text on a label.



```
<html>
Color and font test:
<ul>
<li><font color=red>red</font>
<li><font color=blue>blue</font>
<li><font color=green>green</font
<li><font size=-2>small</font>
<li><font size=+2>large</font>
<li><i>italic</i>
<li><b>bold</b>
</ul>
```

Color and font test:

- red
- blue
- green
- small
- large
- *italic*
- **bold**

Try this:

1. Compile and run the application. The source code is in `HtmlDemo.java`.
   See Getting Started with Swing if you need help compiling or running this application. Make sure you compile this program and

run it using Swing 1.1.1 Beta 1 or a compatible release.
2. Edit the HTML in the text area at the left and click the **Change the label** button. The label at the right shows the result.
3. Remove `<html>` from the text area on the left. The label at the right shows the result.

The action listener for the button executes this single line of code:

```
theLabel.setText(htmlTextArea.getText());
```

If the string in the text area on the left begins with <html>, then the label parses it as HTML. Otherwise, the label assumes it's straight text.

Because this is an early release of this feature, there are some gotchas to be aware of:

- Don't use <br> in your HTML. The label's preferred size won't be computed correctly (it will be computed as if the <br> weren't there). Use a regular paragraph tag (<p>) instead .
- If you specify an invalid HTML tag, an exception is thrown deep in the text package. Fix your HTML and try again.

As of Swing 1.1.1 Beta 1, you can use HTML to set the text for labels and buttons. In the near future, many more Swing components -- tool tips, tabbed panes, and menu items, for example -- will support HTML.

Warning: There is no programmatic way to test whether a component supports HTML text. Do not specify HTML text unless you are absolutely sure that your program is running in a release that supports HTML text in the desired component.

The Label API

The following tables list the commonly used `JLabel` constructors and methods. Other methods you're likely to call are defined by the `Component` and `JComponent` classes. They include `setFont`, `setForeground`, `setBorder`, `setOpaque`, and `setBackground`. See The JComponent Class for details. The API for using labels falls into three categories:

- Setting or Getting the Label's Contents
- Fine Tuning the Label's Appearance
- Supporting Accessibility

Setting or Getting the Label's Contents

Method or Constructor	Purpose

`JLabel(Icon)`
`JLabel(Icon, int)`
`JLabel(String)`
`JLabel(String, Icon, int)`
`JLabel(String, int)`
`JLabel()`
	Create a `JLabel` instance, initializing it to have the specified text/image/alignment. The `int` argument specifies the horizontal alignment of the label's contents within its drawing area. The horizontal alignment must be one of the following constants defined in the `SwingConstants` interface (which `JLabel` implements): `LEFT`, `CENTER`, `RIGHT`, `LEADING`, or `TRAILING`.

`void setText(String)`
`String getText()`
	Set or get the text displayed by the label.

`void setIcon(Icon)`
`Icon getIcon()`
	Set or get the image displayed by the label.

`void setDisplayedMnemonic(char)`
`char getDisplayedMnemonic()`
	Set or get the letter that should look like a keyboard alternative. This is handy when a label describes a component (such as a text field) that has a keyboard alternative but can't display it.

`void setDisabledIcon(Icon)`
`Icon getDisabledIcon()`
	Set or get the image displayed by the label when it's disabled. If you don't specify a disabled image, then the look-and-feel creates one by manipulating the default image.

Fine Tuning the Label's Appearance

Method	Purpose

`void setHorizontalAlignment(int)`
`void setVerticalAlignment(int)`
`int getHorizontalAlignment()`
`int getVerticalAlignment()`
	Set or get where in the label its contents should be placed. The `SwingConstants` interface defines five possible values for horizontal alignment: `LEFT` (the default for text-only labels), `CENTER` (the default for image-only labels), `RIGHT`, `LEADING`, and `TRAILING`. For vertical alignment: `TOP`, `CENTER` (the default), and `BOTTOM`.

`void setHorizontalTextPosition(int)`
`void setVerticalTextPosition(int)`
`int getHorizontalTextPosition()`
`int getVerticalTextPosition()`
	Set or get where the button's text should be placed, relative to the button's image. The `SwingConstants` interface defines three possible values for horizontal position: `LEFT`, `CENTER`, and `RIGHT` (the default). For vertical position: `TOP`, `CENTER` (the default), and `BOTTOM`.

`void setIconTextGap(int)`
`int getIconTextGap()`
	Set or get the number of pixels between the label's text and its image.

Supporting Accessibility

Method	**Purpose**

`void setLabelFor(component)`
`Component getLabelFor()`
	Set or get which component the label describes.

Examples that Use Labels

The following table lists some of the many examples that use labels.

Example	**Where Described**	**Notes**
`LabelDemo`	This section	Shows how to specify horizontal and vertical alignment, as well as aligning a label's text and image.
`HtmlDemo`	This section	Lets you experiment with specifying HTML text for a label.
`AlignmentDemo`	Fixing Alignment Problems	Demonstrates a possible alignment problem when using a label in a vertical box layout. Shows how to solve the problem.

DialogDemo	How to Use Dialogs	Uses a changeable label to display instructions and provide feedback.
SplitPaneDemo	How to Use Split Panes and How to Use Lists.	Displays an image using a label inside of a scroll pane.
SliderDemo2	How to Use Sliders	Uses `JLabel` to provide labels for a slider.
TableDialogEditDemo	How to Use Tables	Implements a label subclass, `ColorRenderer`, to display colors in table cells.
TextFieldDemo	How to Use Text Fields	Has four rows, each containing a label and the text field it describes.
TextComponentDemo	General Rules for Using Text Components	Has an inner class (`CaretListenerLabel`) that extends `JLabel` to provide a label that listens for events, updating itself based on the events. To run the example, you also need `LimitedStyledDocument.java`.
ColorChooserDemo	How to Use Color Choosers	Uses an opaque label to display the currently chosen color against a fixed-color background.

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How to Use Buttons, Check Boxes, and Radio Buttons

To create a button, you can instantiate one of the many classes that descend from the `AbstractButton`◆ class.

The following table shows the Swing-defined `AbstractButton` subclasses that you might want to use:

Class	Summary	Where Described
`JButton`◆	A common button.	How to Use the Common Button API and How to Use JButton Features
`JCheckBox`◆	A check box button.	How to Use Check Boxes
`JRadioButton`◆	One of a group of radio buttons.	How to Use Radio Buttons
`JMenuItem`◆	An item in a menu.	How to Use Menus
`JCheckBoxMenuItem`◆	A menu item that has a checkbox.	How to Use Menus and How to Use Check Boxes
`JRadioButtonMenuItem`◆	A menu item that has a radio button.	How to Use Menus and How to Use Radio Buttons
`JToggleButton`◆	Implements toggle functionality inherited by `JCheckBox` and `JRadioButton`. Can be instantiated or subclassed to create two-state buttons.	Used to implement the crayon buttons in How to Use Color Choosers, the **cm** button in How to Use Scroll Panes, and `NumberButton`◆ in the BINGO!◆

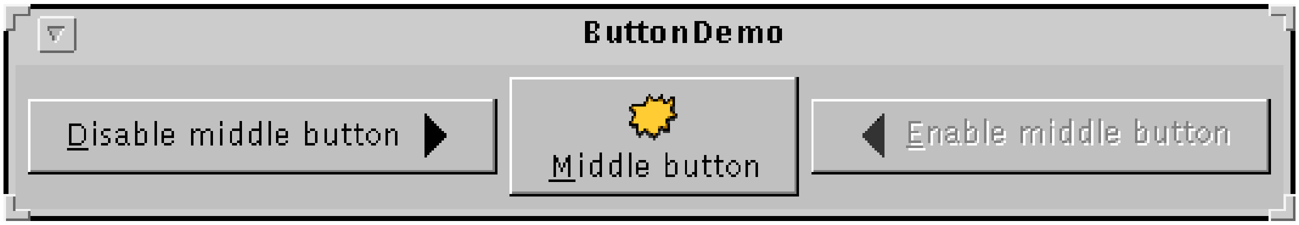
Note: If you want to collect a group of buttons into a row or column, then you should check out tool bars.

First, this section explains the basic button API that `AbstractButton` defines -- and thus all Swing buttons have in common. Next, it describes the small amount of API that `JButton` adds to

AbstractButton. After that, this section shows you how to use specialized API to implement check boxes and radio buttons.

How to Use the Common Button API

Here is a picture of an application that displays three buttons:



Try this:

1. Compile and run the application. The source file is ButtonDemo.java◆.
   You will also need to put three image files in a directory named images: left.gif, middle.gif, and right.gif.
   See Getting Started with Swing if you need help compiling or running this application.
2. Click the left button.
   It disables the middle button (and itself, since it's no longer useful) and enables the right button.
3. Click the right button.
   It enables the middle button and the left button, and disables itself.

As the ButtonDemo example shows, a Swing button can display both text and an image. In ButtonDemo, each button has its text in a different place, relative to its image. The underlined letter in each button's text shows the *mnemonic* -- the keyboard alternative -- for each button.

When a button is disabled, the look and feel automatically generates the button's disabled appearance. However, you could provide an image to be substituted for the normal image. For example, you could provide gray versions of the images used in the left and right buttons.

How you implement event handling depends on the type of button you use and how you use it. Generally, you implement an action listener◆, which is notified every time the user clicks the button. For check boxes you usually use an item listener◆, which is notified when the check box is selected or deselected.

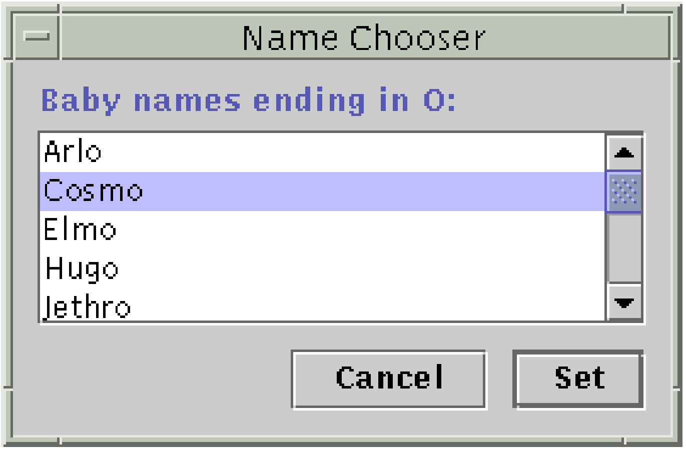
Below is the code from ButtonDemo.java◆ that creates the buttons in the previous example and reacts to button clicks. The bold code is the code that would remain if the buttons had no images.

```
//In initialization code:
    ImageIcon leftButtonIcon = new ImageIcon("images/right.gif");
    ImageIcon middleButtonIcon = new ImageIcon("images/middle.gif");
    ImageIcon rightButtonIcon = new ImageIcon("images/left.gif");

    b1 = new JButton("Disable middle button", leftButtonIcon);
    b1.setVerticalTextPosition(AbstractButton.CENTER);
    b1.setHorizontalTextPosition(AbstractButton.LEFT);
    b1.setMnemonic(KeyEvent.VK_D);
    b1.setActionCommand("disable");

    b2 = new JButton("Middle button", middleButtonIcon);
    b2.setVerticalTextPosition(AbstractButton.BOTTOM);
    b2.setHorizontalTextPosition(AbstractButton.CENTER);
    b2.setMnemonic(KeyEvent.VK_M);

    b3 = new JButton("Enable middle button", rightButtonIcon);
    //Use the default text position of CENTER, RIGHT.
    b3.setMnemonic(KeyEvent.VK_E);
    b3.setActionCommand("enable");
    b3.setEnabled(false);

    //Listen for actions on buttons 1 and 3.
    b1.addActionListener(this);
    b3.addActionListener(this);

    b1.setToolTipText("Click this button to disable "
                      + "the middle button.");
    b2.setToolTipText("This middle button does nothing "
                      + "when you click it.");
    b3.setToolTipText("Click this button to enable the "
                      + "middle button.");
    ...
}

public void actionPerformed(java.awt.event.ActionEvent e) {
    if (e.getActionCommand().equals("disable")) {
        b2.setEnabled(false);
        b1.setEnabled(false);
        b3.setEnabled(true);
    } else {
        b2.setEnabled(true);
        b1.setEnabled(true);
        b3.setEnabled(false);
    }
}
```

How to Use JButton Features

Ordinary buttons -- `JButton` objects -- have just a bit more functionality than the `AbstractButton` class provides. You can make a `JButton` be the default button, and if you're using the right release, you can specify the text and formatting of a button's label using HTML.

At most one button in a top-level container can be the default button. The default button typically has a highlighted appearance and acts clicked whenever the top-level container has the keyboard focus and the user presses the Return or Enter key. The exact implementation depends on the look and feel. Here is a picture of a dialog, implemented in `ListDialog.java`◆ in which the **Set** button is the default button:



You set the default button by invoking the `setDefaultButton` method on a top-level container's root pane. Here is the code that sets up the default button for the `ListDialog` example:

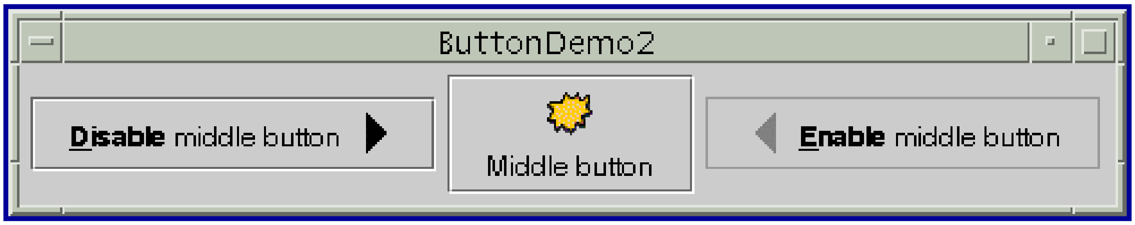
```
//In the constructor for a JDialog subclass:
getRootPane().setDefaultButton(setButton);
```

In the Swing 1.1.1 Beta 1 release of JFC 1.1, the Swing team added the ability to use HTML to specify a button's text. To do so, simply put the `<html>` tag at the beginning of a string, then use any valid HTML in the remainder of the string. Using HTML can be useful for varying the text font or color within a button, and for putting line breaks in a button.

Here's an example of specifying HTML for the buttons in `ButtonDemo`:

```
b1 = new JButton("<html><font size=-1><b><u>D</u>isable</b>"
                 + " middle button</font>",
                 leftButtonIcon);
...
b2 = new JButton("<html><font size=-1>Middle button</font>",
                 middleButtonIcon);
...
b3 = new JButton("<html><font size=-1><b><u>E</u>nable</b>"
                 + " middle button</font>",
                 rightButtonIcon);
```

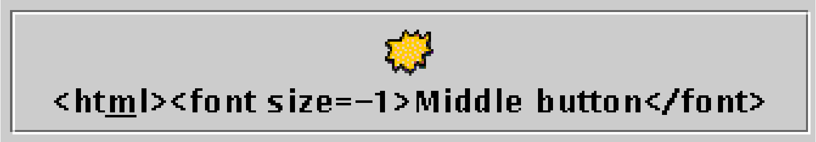
Here is a picture of the buttons when the program is run in a platform that supports Swing 1.1.1 Beta 1 or a compatible release:



This figure has been reduced to fit on the page.
Click the image to view it at its natural size.

Note that we had to use a <u> tag to cause the mnemonic character to be underlined in the button. The middle button has no underlined character because we didn't use the <u> tag in it. Note also that when a button is disabled, its HTML text remains dark, instead of becoming gray.

Warning: Don't use HTML in buttons unless you're absolutely sure that the program is running in a release that supports this feature. In releases that support only the Swing 1.1 API, putting HTML in a button results in one ugly-looking button, such as this one:



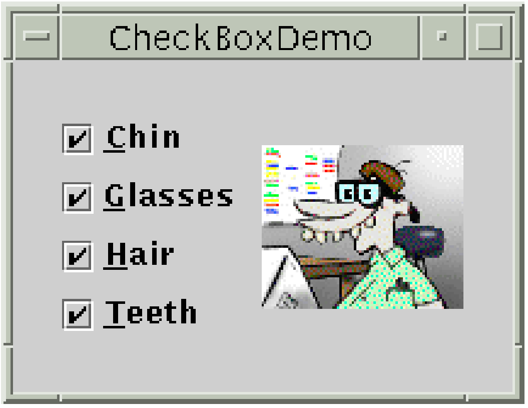
For more information, see Using HTML on a Label.

How to Use Check Boxes

The `JCheckBox` class provides support for check box buttons. You can also put check boxes in menus, using the `JCheckBoxMenuItem` class. Because `JCheckBox` and `JCheckBoxMenuItem` inherit from `AbstractButton`, Swing check boxes have all the usual button characteristics, as discussed earlier in this section. For example, you can specify images to be used in check boxes.

Check boxes are similar to radio buttons but their selection model is different, by convention. Any number of check boxes in a group -- none, some, or all -- can be selected. A group of radio buttons, on the other hand, can have only one button selected.

Here is a picture of an application that uses four check boxes to customize a cartoon:



Try this:

1. Compile and run the application. The source file is `CheckBoxDemo.java`. You will also need to put 16 image files in a directory named `images/geek`.
   See the examples index for links to all the files required by this example.
   See Getting Started with Swing if you need help compiling or running this application.
2. Click the **Chin** button or press Alt-c.
   The **Chin** check box becomes unselected, and the chin disappears from the picture. The other check boxes remain selected. This application has one item listener that listens to all the check boxes. Each time the item listener receives an event, the application loads a new picture that reflects the current state of the check boxes.

A check box generates one item event and one action event per click. Usually, you listen only for item events, since they let you determine whether the click selected or deselected the check box. Below is the code from `CheckBoxDemo.java` that creates the check boxes in the previous example and reacts to clicks.

```
//In initialization code:
    chinButton = new JCheckBox("Chin");
    chinButton.setMnemonic(KeyEvent.VK_C);
    chinButton.setSelected(true);

    glassesButton = new JCheckBox("Glasses");
    glassesButton.setMnemonic(KeyEvent.VK_G);
    glassesButton.setSelected(true);

    hairButton = new JCheckBox("Hair");
    hairButton.setMnemonic(KeyEvent.VK_H);
    hairButton.setSelected(true);

    teethButton = new JCheckBox("Teeth");
    teethButton.setMnemonic(KeyEvent.VK_T);
    teethButton.setSelected(true);

    // Register a listener for the check boxes.
    CheckBoxListener myListener = new CheckBoxListener();
    chinButton.addItemListener(myListener);
    glassesButton.addItemListener(myListener);
    hairButton.addItemListener(myListener);
    teethButton.addItemListener(myListener);
...
class CheckBoxListener implements ItemListener {
    public void itemStateChanged(ItemEvent e) {
        ...
        Object source = e.getItemSelectable();

        if (source == chinButton) {
            //...make a note of it...
        } else if (source == glassesButton) {
            //...make a note of it...
        } else if (source == hairButton) {
            //...make a note of it...
        } else if (source == teethButton) {
            //...make a note of it...
        }

        if (e.getStateChange() == ItemEvent.DESELECTED)
            //...make a note of it...
        picture.setIcon(/* new icon */);
        ...
    }
}
```

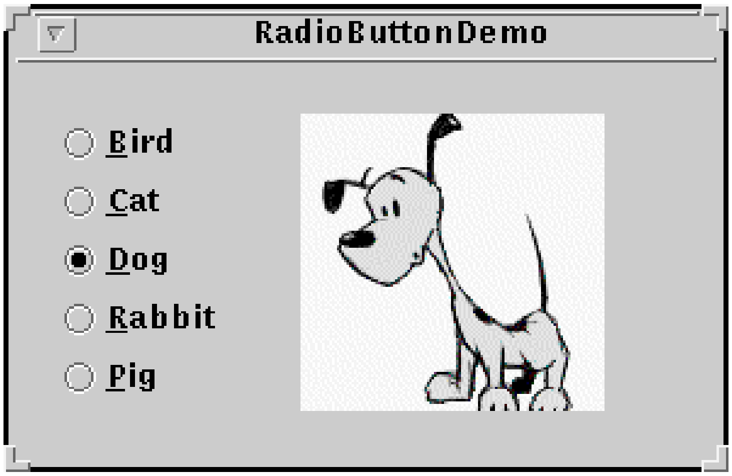
Note: In a future release, we expect check boxes to support HTML text. See Using HTML on a Label for information about HTML text support.

How to Use Radio Buttons

Radio buttons are groups of buttons in which, by convention, only one button at a time can be selected. The Swing release supports radio buttons with the `JRadioButton` and `ButtonGroup` classes. To put a radio button in a menu, use the `JRadioButtonMenuItem` class. Other ways of displaying one-of-many choices are combo boxes and lists. Radio buttons look similar to check boxes, but, by convention, check boxes place no limits on how many items can be selected at a time.

Because `JRadioButton` inherits from `AbstractButton`, Swing radio buttons have all the usual button characteristics, as discussed earlier in this section. For example, you can specify the image displayed in a radio button.

Here is a picture of an application that uses five radio buttons to let you choose which kind of pet is displayed:



Try this:

1. Compile and run the application. The source file is RadioButtonDemo.java◆. You will also need to put five image files in a directory named `images`. See the examples index for links to all the files required by this example.
   See Getting Started with Swing if you need help compiling or running this application.
2. Click the **Dog** button or press Alt-d.
   The **Dog** button becomes selected, which makes the **Bird** button become unselected. The picture switches from a bird to a dog. This application has one action listener that listens to all the radio buttons. Each time the action listener receives an event, the application displays the picture for the radio button that was just clicked.

Each time the user clicks a radio button (even if it was already selected), the button fires an action event◆. One or two item events◆ also occur -- one from the button that was just selected, and another from the button that lost the selection (if any). Usually, you handle radio button clicks using an action listener.

Below is the code from RadioButtonDemo.java◆ that creates the radio buttons in the previous example and reacts to clicks.

```
//In initialization code:
    // Create the radio buttons.
```

```
        JRadioButton birdButton = new JRadioButton(birdString);
        birdButton.setMnemonic(KeyEvent.VK_B);
        birdButton.setActionCommand(birdString);
        birdButton.setSelected(true);

        JRadioButton catButton = new JRadioButton(catString);
        catButton.setMnemonic(KeyEvent.VK_C);
        catButton.setActionCommand(catString);

        JRadioButton dogButton = new JRadioButton(dogString);
        dogButton.setMnemonic(KeyEvent.VK_D);
        dogButton.setActionCommand(dogString);

        JRadioButton rabbitButton = new JRadioButton(rabbitString);
        rabbitButton.setMnemonic(KeyEvent.VK_R);
        rabbitButton.setActionCommand(rabbitString);

        JRadioButton pigButton = new JRadioButton(pigString);
        pigButton.setMnemonic(KeyEvent.VK_P);
        pigButton.setActionCommand(pigString);

        // Group the radio buttons.
        ButtonGroup group = new ButtonGroup();
        group.add(birdButton);
        group.add(catButton);
        group.add(dogButton);
        group.add(rabbitButton);
        group.add(pigButton);

        // Register a listener for the radio buttons.
        RadioListener myListener = new RadioListener();
        birdButton.addActionListener(myListener);
        catButton.addActionListener(myListener);
        dogButton.addActionListener(myListener);
        rabbitButton.addActionListener(myListener);
        pigButton.addActionListener(myListener);
    ...
    class RadioListener implements ActionListener ... {
        public void actionPerformed(ActionEvent e) {
            picture.setIcon(new ImageIcon("images/"
                                          + e.getActionCommand()
                                          + ".gif"));
        }
    }
```

For each group of radio buttons, you need to create a `ButtonGroup` instance and add each radio button to it. The `ButtonGroup` takes care of unselecting the previously selected button when the user selects another button in the group.

You should generally initialize a group of radio buttons so that one is selected. However, the API doesn't enforce this rule -- a group of radio buttons can have no initial selection. Once the user has made a selection, exactly one button is selected from then on. There's no supported API for unselecting all the buttons. However, if you really want to unselect all the buttons (not that we recommend it), invoking `setSelected(null, true)` on the `ButtonGroup` should do the trick.

Note: In a future release, we expect radio buttons to support HTML text. See Using HTML on a Label for information about HTML text support.

The Button API

The following tables list the commonly used button-related API. You can see most of this API in action by playing with the Buttons, Radio Buttons, and Check Boxes panes in the `SwingSet` example that's part of the Swing release. See the release's top-level README file for help finding and using `SwingSet`. Other methods you might call are listed in the API tables in The JComponent Class.

The API for using buttons falls into these categories:

- Setting or Getting the Button's Contents
- Fine Tuning the Button's Appearance
- Implementing the Button's Functionality
- Check Box Constructors
- Radio Button Constructors
- Toggle Button Constructors
- Commonly Used `ButtonGroup` Constructors/Methods

Setting or Getting the Button's Contents

Method or Constructor	**Purpose**

`JButton(String, Icon)`
`JButton(String)`
`JButton(Icon)`
`JButton()`
	Create a `JButton` instance, initializing it to have the specified text/image.

`void setText(String)`
`String getText()`
	Set or get the text displayed by the button.

`void setIcon(Icon)`
`Icon getIcon()`
	Set or get the image displayed by the button when the button isn't selected or pressed.

`void setDisabledIcon(Icon)`
`Icon getDisabledIcon()`
	Set or get the image displayed by the button when it's disabled. If you don't specify a disabled image, then the look and feel creates one by manipulating the default image.

`void setPressedIcon(Icon)`
`Icon getPressedIcon()`
	Set or get the image displayed by the button when it's being pressed.

`void setSelectedIcon(Icon)`
`Icon getSelectedIcon()`
`void setDisabledSelectedIcon(Icon)`
`Icon getDisabledSelectedIcon()`
	Set or get the image displayed by the button when it's selected. If you don't specify a disabled selected image, then the look and feel creates one by manipulating the selected image.

`setRolloverEnabled(boolean)`
`boolean getRolloverEnabled()`
`void setRolloverIcon(Icon)`
`Icon getRolloverIcon()`
`void setRolloverSelectedIcon(Icon)`
`Icon getRolloverSelectedIcon()`
	Use `setRolloverEnabled(true)` and `setRolloverIcon(someIcon)` to make the button display the specified icon when the cursor passes over it.

Fine Tuning the Button's Appearance

Method or Constructor	**Purpose**

`void setHorizontalAlignment(int)`
`void setVerticalAlignment(int)`
`int getHorizontalAlignment()`
`int getVerticalAlignment()`
	Set or get where in the button its contents should be placed. The `AbstractButton` class allows any one of the following values for horizontal alignment: `LEFT`, `CENTER` (the default), and `RIGHT`. For vertical alignment: `TOP`, `CENTER` (the default), and `BOTTOM`.

`void setHorizontalTextPosition(int)`
`void setVerticalTextPosition(int)`
`int getHorizontalTextPosition()`
`int getVerticalTextPosition()`
	Set or get where the button's text should be placed, relative to the button's image. The `AbstractButton` class allows any one of the following values for horizontal position: `LEFT`, `CENTER`, and `RIGHT` (the default). For vertical position: `TOP`, `CENTER` (the default), and `BOTTOM`.

`void setMargin(Insets)`
`Insets getMargin()`
	Set or get the number of pixels between the button's border and its contents.

`void setFocusPainted(boolean)`
`boolean isFocusPainted()`
	Set or get whether the button should look different when it has the focus.

`void setBorderPainted(boolean)`
`boolean isBorderPainted()`
	Set or get whether the border of the button should be painted.

Implementing the Button's Functionality

Method or Constructor	**Purpose**

`void setMnemonic(int)`
`char getMnemonic()`
	Set or get the keyboard alternative to clicking the button. One form of the `setMnemonic` method accepts a character argument; however, the Swing team recommends that you use an `int` argument instead, specifying a `KeyEvent.VK_`*X* constant.

`void setActionCommand(String)`
`String getActionCommand(void)`
	Set or get the name of the action performed by the button.

`void addActionListener(ActionListener)`
`ActionListener removeActionListener()`
	Add or remove an object that listens for action events fired by the button.

`void addItemListener(ItemListener)`
`ItemListener removeItemListener()`
	Add or remove an object that listens for item events fired by the button.

`void setSelected(boolean)`
`boolean isSelected()`
	Set or get whether the button is selected. Makes sense only for buttons that have on/off state, such as check boxes.

`void doClick()`
`void doClick(int)`
	Programmatically perform a "click". The optional argument specifies the amount of time (in milliseconds) that the button should look pressed.

Check Box Constructors

Constructor	**Purpose**

`JCheckBox(String)`
`JCheckBox(String, boolean)`
`JCheckBox(Icon)`
`JCheckBox(Icon, boolean)`
`JCheckBox(String, Icon)`
`JCheckBox(String, Icon, boolean)`
`JCheckBox()`
	Create a `JCheckBox` instance. The string argument specifies the text, if any, that the check box should display. Similarly, the `Icon` argument specifies the image that should be used instead of the look and feel's default check box image. Specifying the boolean argument as `true` initializes the check box to be selected. If the boolean argument is absent or `false`, then the check box is initially unselected.

`JCheckBoxMenuItem(String)`
`JCheckBoxMenuItem(String, boolean)`
`JCheckBoxMenuItem(Icon)`
`JCheckBoxMenuItem(String, Icon)`
`JCheckBoxMenuItem(String, Icon, boolean)`
`JCheckBoxMenuItem()`
	Create a `JCheckBoxMenuItem` instance. The arguments are interpreted in the same way as the arguments to the `JCheckBox` constructors, except that any specified icon is shown in addition to the normal check box icon.

Radio Button Constructors

Constructor	**Purpose**

JRadioButton(String)
JRadioButton(String, boolean)
JRadioButton(Icon)
JRadioButton(Icon, boolean)
JRadioButton(String, Icon)
JRadioButton(String, Icon, boolean)
JRadioButton()
	Creates a JRadioButton instance. The string argument specifies the text, if any, that the radio button should display. Similarly, the Icon argument specifies the image that should be used instead of the look and feel's default radio button image. Specifying the boolean argument as true initializes the radio button to be selected, subject to the approval of the ButtonGroup object. If the boolean argument is absent or false, then the radio button is initially unselected.

JRadioButtonMenuItem(String)
JRadioButtonMenuItem(Icon)
JRadioButtonMenuItem(String, Icon)
JRadioButtonMenuItem()
	Creates a JRadioButtonMenuItem instance. The arguments are interpreted in the same way as the arguments to the JRadioButton constructors, except that any specified icon is shown in addition to the normal radio button icon.

Toggle Button Constructors

Constructor	**Purpose**

JToggleButton(String)
JToggleButton(String, boolean)
JToggleButton(Icon)
JToggleButton(Icon, boolean)
JToggleButton(String, Icon)
JToggleButton(String, Icon, boolean)
JToggleButton()
	Creates a JToggleButton instance, which is similar to a JButton, but with two states. Normally, you use a JRadioButton or JCheckBox instead of directly instantiating JToggleButton, but JToggleButton can be useful when you don't want the typical radio button or check box appearance. The string argument specifies the text, if any, that the toggle button should display. Similarly, the Icon argument specifies the image that should be used. Specifying the boolean argument as true initializes the toggle button to be selected. If the boolean argument is absent or false, then the toggle button is initially unselected.

Commonly Used ButtonGroup Constructors/Methods

Constructor or Method	**Purpose**
ButtonGroup()	Creates a ButtonGroup instance.
void add(AbstractButton) void remove(AbstractButton)	Adds a button to the group, or removes a button from the group.

Examples that Use Various Kinds of Buttons

The following examples use buttons. Also see Examples that Use Tool Bars, which lists programs that add JButton objects to JToolBars.

Example	Where Described	Notes
`ButtonDemo`	How to Use the Common Button API	Uses mnemonics and icons. Specifies the button text position, relative to the button icon. Uses action commands.
`ListDialog`	How to Use JButton Features	Implements a dialog with two buttons, one of which is the default button.
`AppletDemo`	Running Swing Applets◆	The same example as is explained in How to Use the Common Button API, but implemented as a combined applet and application.
`DialogDemo`	How to Make Dialogs	Has "Show it" buttons whose behavior is tied to the state of radio buttons. Uses sizable, though anonymous, inner classes to implement the action listeners.
`ProgressBarDemo`	How to Monitor Progress	Implements a button's action listener with a named inner class.
`CheckBoxDemo`	How to Use Check Boxes	Uses check box buttons to determine which of 16 images it should display.
`ActionDemo`	How to Use Actions◆	Uses check box menu items to set the state of the program.
`RadioButtonDemo`	How to Use Radio Buttons	Uses radio buttons to determine which of five images it should display.
`DialogDemo`	How to Make Dialogs	Contains several sets of radio buttons, which it uses to determine which dialog to bring up.
`MenuDemo`	How to Use Menus	Contains radio button menu items and check box menu items.

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Feedback Form

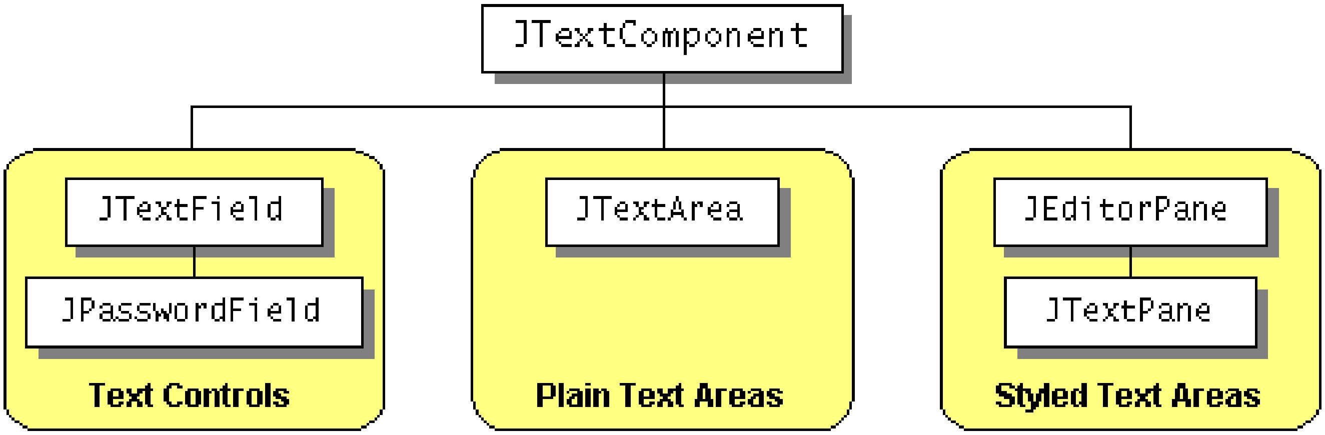
Trail: Creating a GUI with JFC/Swing
Lesson: Using Swing Components

Using Text Components

Swing's text components display text and optionally allow the user to edit the text. Programs need text components for tasks ranging from the straightforward (enter a word and press Return) to the complex (display and edit styled text with embedded images in an Asian language).

Swing provides five text components, along with supporting classes and interfaces, that meet even the most complex text requirements. In spite of their different uses and capabilities, all of Swing's text components inherit from the same superclass, `JTextComponent`, which provides a highly-configurable and powerful foundation for text manipulation.

The following figure shows the `JTextComponent` hierarchy and places each text component class into one of three groups:



The following paragraphs describe the three groups of text components.

Group	Description	Swing Classes

Text Controls	Also known simply as text fields, text controls can display and edit only one line of text and are action-based, like buttons. Use them to get a small amount of textual information from the user and take some action after the text entry is complete.	`JTextField`
		and its subclass
		`JPasswordField`

Plain Text Areas	`JTextArea` can display and edit multiple lines of text. Although a text area can display text in any font, all of the text is in the same font. Use a text area to allow the user to enter unformatted text of any length or to display unformatted help information.	`JTextArea`

Styled Text Areas	A styled text component can display and edit text using more than one font. Some styled text components allow embedded images and even embedded components. Styled text components are powerful and multi-faceted components suitable for high-end needs, and offer more avenues for customization than the other text components. Because they are so powerful and flexible,	`JEditorPane`
		and its subclass
		`JTextPane`

	styled text components typically require more up-front programming to set up and use. The one exception is that editor panes can be easily loaded with formatted text from a URL, which makes them useful for displaying uneditable help information.	

The next section, An Example of Using Each Text Component, shows an application that creates one of each of the Swing text components. By studying this example you can learn the basics of creating and including each text component in a program, what each component can and cannot do, and how the components differ.

The following sections discuss different aspects of text components:

- An Example of Using Each Text Component
- General Rules for Using Text Components
  (This section is a prerequisite for the following two.)
- How to Use Text Fields
- Concepts: About Editor Panes and Text Panes
- Summary of Text

In this tutorial, we give you information about the foundation laid by `JTextComponent` and tell you how to accomplish some common text-related tasks. Because `JTextComponent` and its subclasses have too many features to be completely described in this tutorial, please periodically search The Swing Connection for pointers to more information.

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Trail: Creating a GUI with JFC/Swing
Lesson: Using Other Swing Features

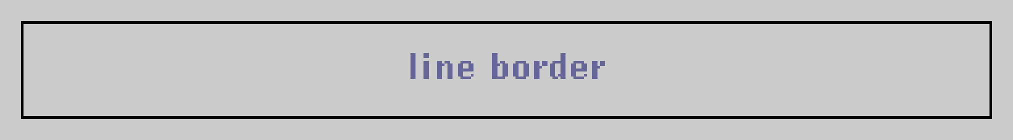
How to Use Borders

Every `JComponent` can have one or more borders. Borders are incredibly useful objects that, while not themselves components, know how to draw the edges of Swing components. Borders are useful not only for drawing lines and fancy edges, but also for providing titles and empty space around components.

To put a border around a `JComponent`, you use its `setBorder` method. You can use the `BorderFactory` class to create most of the borders that Swing provides. Here is an example of code that creates a bordered container:

```
JPanel pane = new JPanel();
pane.setBorder(BorderFactory.createLineBorder(Color.black));
```

Here's a picture of the container, which contains a label component. The black line drawn by the border marks the edge of the container.



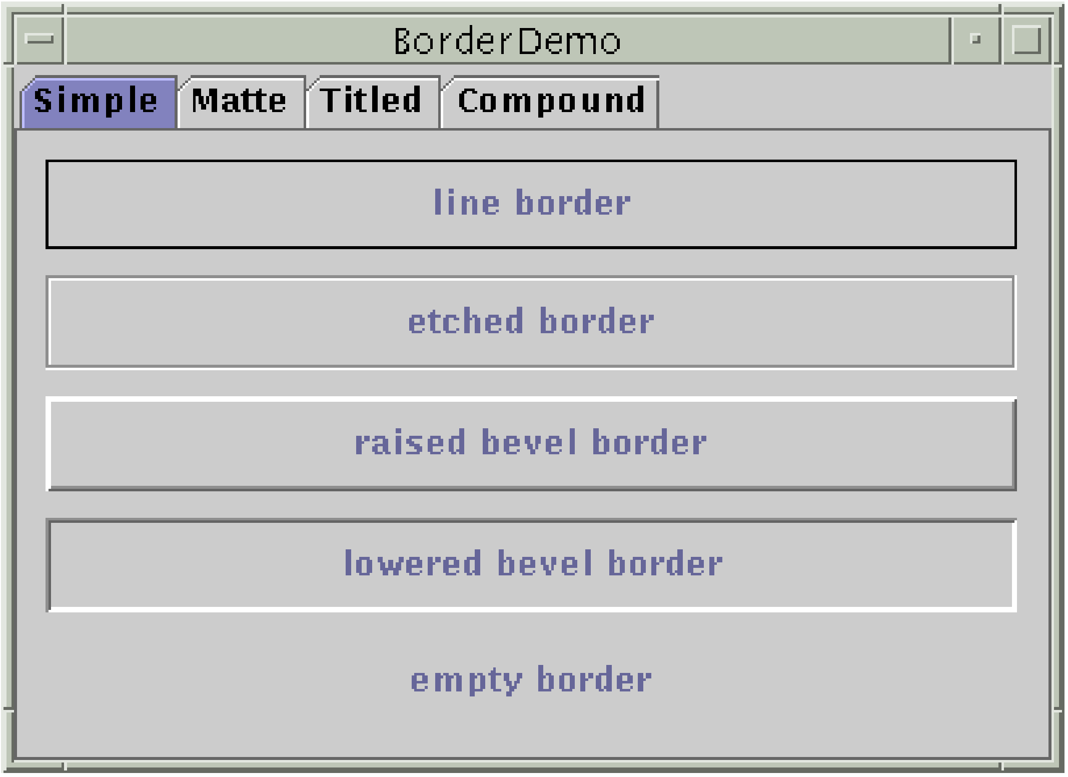
The rest of this page discusses the following topics:

- The BorderDemo Example
- Using the Borders Provided by Swing
- Creating Custom Borders
- Adding a Border to a Bordered Swing Component
- The Border API
- Examples of Using Borders

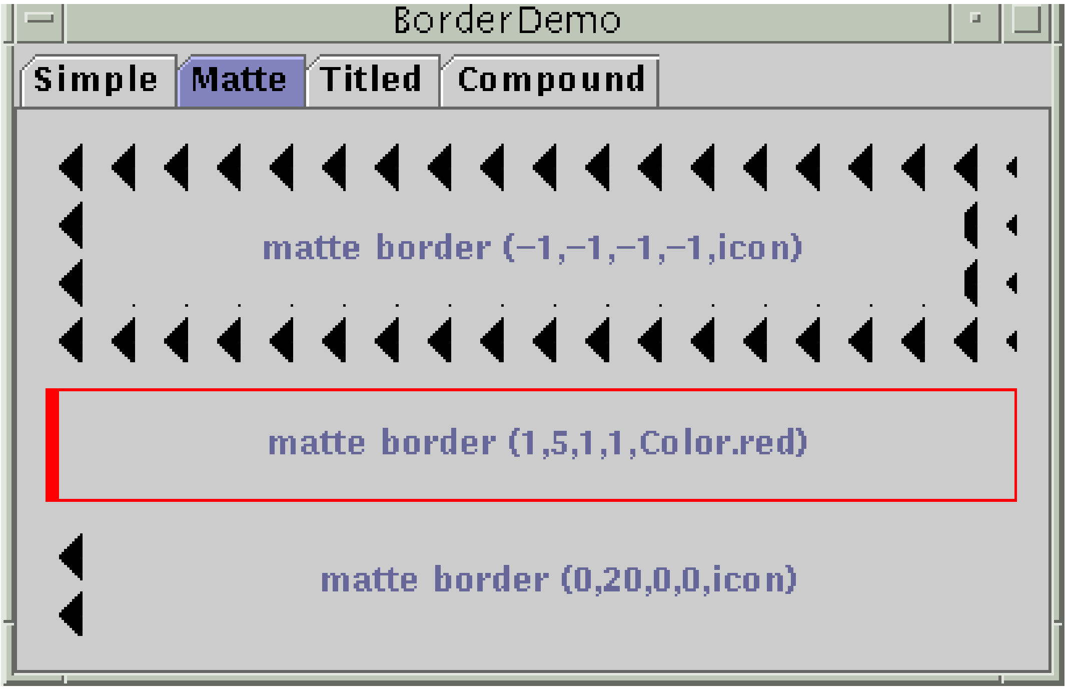
The BorderDemo example

The following pictures show an application called `BorderDemo` that displays the borders

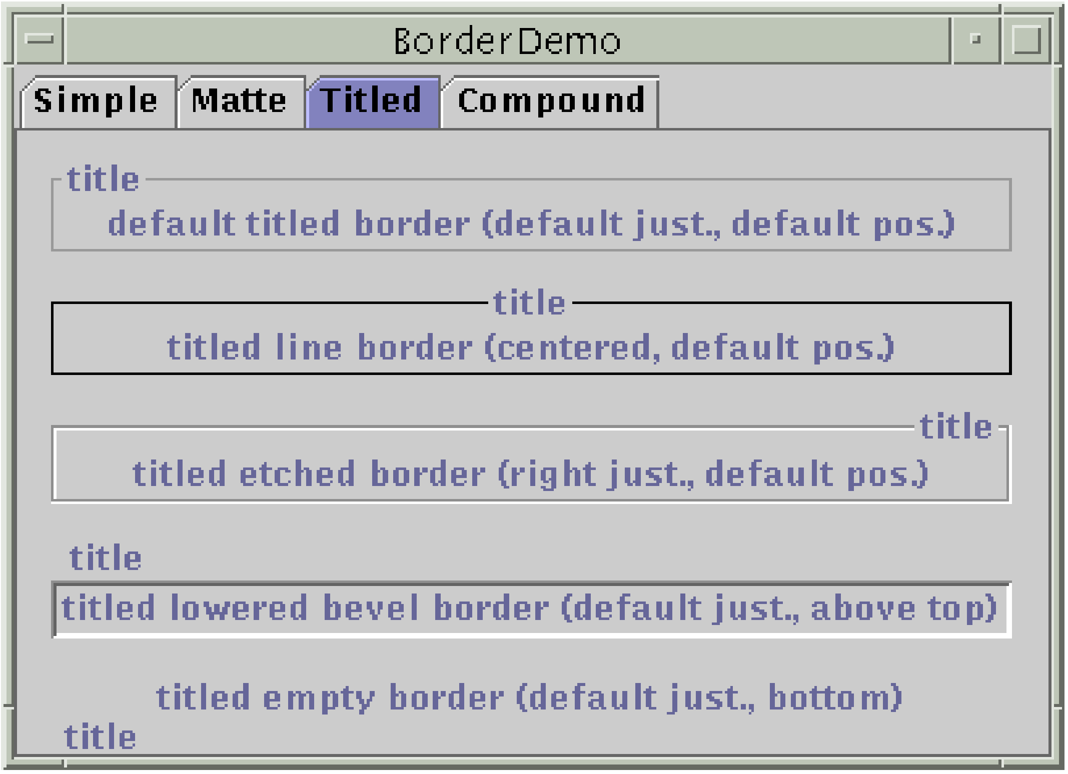
Swing provides. We show the code for creating these borders a little later, in Using the Borders Provided by Swing.



The next picture shows some matte borders. When creating a matte border, you specify how many pixels it occupies at the top, left, bottom, and right of a component. You then specify either a color or an icon for the matte border to draw. You need to be careful when choosing the icon and determining your component's size; otherwise, the icon might get chopped off or have mismatch at the component's corners.


BorderDemo
Simple
Matte
Titled
Compound
matte border (-1,-1,-1,-1,icon)
matte border (1,5,1,1,Color.red)
matte border (0,20,0,0,icon)

The next picture shows titled borders. Using a titled border, you can convert any border into one that displays a text description. If you don't specify a border, then a look-and-feel-specific border is used. For example, the default titled border in the Java look and feel uses a gray line, and the default titled border in the Windows look and feel uses an etched border. By default, the title straddles the upper left of the border, as shown at the top of the following figure.



BorderDemo

Simple | Matte | Titled | Compound

title
default titled border (default just., default pos.)

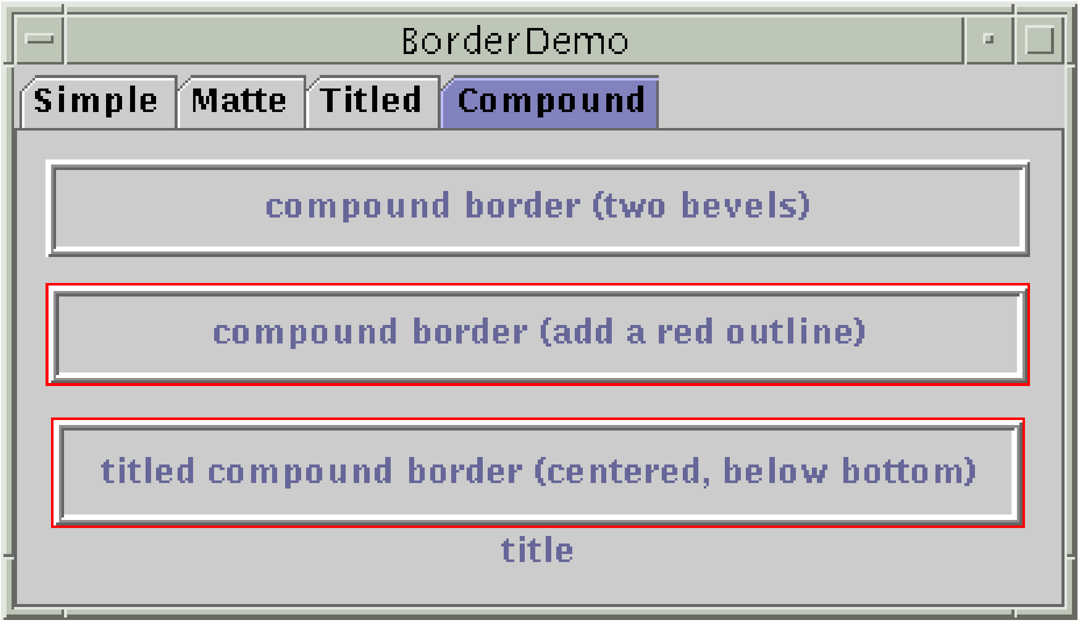
title
titled line border (centered, default pos.)

title
titled etched border (right just., default pos.)

title
titled lowered bevel border (default just., above top)

titled empty border (default just., bottom)
title

The next picture shows compound borders. With compound borders, you can combine any two borders, which can themselves be compound borders.



BorderDemo

Simple | Matte | Titled | Compound

compound border (two bevels)

compound border (add a red outline)

titled compound border (centered, below bottom)
title

Using the Borders Provided by Swing

The code that follows shows how to create and set the borders you saw in the preceding figures. You can find the program's code in BorderDemo.java. To run the program, you will also need to put an image file in a directory named `images`: left.gif.

```
//Keep references to the next few borders, for use in titles
//and compound borders.
Border blackline, etched, raisedbevel, loweredbevel, empty;

blackline = BorderFactory.createLineBorder(Color.black);
etched = BorderFactory.createEtchedBorder();
raisedbevel = BorderFactory.createRaisedBevelBorder();
loweredbevel = BorderFactory.createLoweredBevelBorder();
empty = BorderFactory.createEmptyBorder();

//Simple borders
jComp2.setBorder(blackline);
jComp3.setBorder(raisedbevel);
jComp4.setBorder(loweredbevel);
jComp5.setBorder(empty);

//Matte borders
ImageIcon icon = new ImageIcon("images/left.gif"); //20x22
jComp6.setBorder(BorderFactory.createMatteBorder(
                                    -1, -1, -1, -1, icon));
jComp7.setBorder(BorderFactory.createMatteBorder(
                                     1, 5, 1, 1, Color.red));
jComp8.setBorder(BorderFactory.createMatteBorder(
                                     0, 20, 0, 0, icon));

//Titled borders
TitledBorder title1, title2, title3, title4, title5;
title1 = BorderFactory.createTitledBorder("title");
jComp9.setBorder(title1);

title2 = BorderFactory.createTitledBorder(
                       blackline, "title");
title2.setTitleJustification(TitledBorder.CENTER);
jComp10.setBorder(title2);

title3 = BorderFactory.createTitledBorder(
                       etched, "title");
title3.setTitleJustification(TitledBorder.RIGHT);
```

```
jComp11.setBorder(title3);

title4 = BorderFactory.createTitledBorder(
                       loweredbevel, "title");
title4.setTitlePosition(TitledBorder.ABOVE_TOP);
jComp12.setBorder(title4);

title5 = BorderFactory.createTitledBorder(
                       empty, "title");
title5.setTitlePosition(TitledBorder.BOTTOM);
jComp13.setBorder(title5);

//Compound borders
Border compound1, compound2, compound3;
Border redline = BorderFactory.createLineBorder(Color.red);

//This creates a nice frame.
compound1 = BorderFactory.createCompoundBorder(
                          raisedbevel, loweredbevel);
jComp14.setBorder(compound1);

//Add a red outline to the frame.
compound2 = BorderFactory.createCompoundBorder(
                          redline, compound1);
jComp15.setBorder(compound2);

//Add a title to the red-outlined frame.
compound3 = BorderFactory.createTitledBorder(
                          compound2, "title",
                          TitledBorder.CENTER,
                          TitledBorder.BELOW_BOTTOM);
jComp16.setBorder(compound3);
```

As you probably noticed, the code uses the `BorderFactory` class to create each border. The `BorderFactory` class, which is in the `javax.swing` package, returns objects that implement the `Border` interface.

The `Border` interface, as well as its Swing-provided implementations, is in the `javax.swing.border` package. You often don't need to directly use anything in the border package, except when specifying constants that are specific to a particular border class or when referring to the `Border` type.

Creating Custom Borders

If `BorderFactory` doesn't offer you enough control over a border's form, then you might need to directly use the API in the border package -- or even define your own border. In addition to containing the `Border` interface, the border package contains the classes that implement the borders you've already seen: `LineBorder`, `EtchedBorder`, `BevelBorder`, `EmptyBorder`, `MatteBorder`, `TitledBorder`, and `CompoundBorder`. The border package also contains a class named `SoftBevelBorder`, which produces a result similar to `BevelBorder`, but with softer edges.

If none of the Swing borders is suitable, you can implement your own border. Generally, you do this by creating a subclass of the `AbstractBorder` class. In your subclass, you must implement at least one constructor and the following two methods:

- `paintBorder`, which contains the drawing code that a `JComponent` executes to draw the border.
- `getBorderInsets`, which specifies the amount of space the border needs to draw itself.

In addition, if your border is opaque, you might be able to decrease component drawing time by overriding the border's `isBorderOpaque` method so that it returns `true`. For examples of implementing borders, see the source code for the classes in the `javax.swing.border` package.

Adding a Border to a Bordered Swing Component

Many of the ready-to-use Swing components use borders to draw the outline of the component. If you want to draw an additional border around an already bordered component -- to provide some extra space above a scroll pane, for example -- then you need to add the new border to the existing border. Be sure to test the component to make sure that it works well with your extra border; components that change their border depending on their state probably aren't good candidates for additional borders. Here's an example of adding to an existing border:

```
aJComponent.setBorder(
    BorderFactory.createCompoundBorder(
                    BorderFactory.createEmptyBorder(20,0,0,0),
                    aJComponent.getBorder())
);
```

The new border returned by `createEmptyBorder` adds 20 pixels of empty space above any component that uses it. The code uses the `createCompoundBorder` method to combine the new border with the existing border, which is returned by `getBorder`.

The Border API

The following tables list the commonly used border methods. The API for using borders falls into two categories:

- Creating a Border with BorderFactory
- Setting or Getting a Component's Border

Creating a Border with BorderFactory

Method	Purpose

`Border createLineBorder(Color)`
`Border createLineBorder(Color, int)`
	Create a line border. The first argument is a `java.awt.Color` object that specifies the color of the line. The optional second argument specifies the width in pixels of the line.

`Border createEtchedBorder()`
`Border createEtchedBorder(Color, Color)`
	Create an etched border. The optional arguments specify the highlight and shadow colors to be used.

`Border createLoweredBevelBorder()`	Create a border that gives the illusion of the component being lower than the surrounding area.
`Border createRaisedBevelBorder()`	Create a border that gives the illusion of the component being higher than the surrounding area.

`Border createBevelBorder(int, Color, Color)`
`Border createBevelBorder(int, Color, Color, Color, Color)`
	Create a raised or lowered beveled border, specifying the colors to use. The integer argument can be either `RAISED` or `LOWERED` (constants defined in `BevelBorder`). With the three-argument constructor, you specify the highlight and shadow colors, With the five-argument constructor, you specify the outer highlight, inner highlight, outer shadow, and inner shadow

	colors, in that order.

`Border createEmptyBorder()`
`Border createEmptyBorder(int, int, int, int)`
	Create an invisible border. If you specify no arguments, then the border takes no space, which is useful when creating a titled border with no visible boundary. The optional arguments specify the number of pixels that the border occupies at the top, left, bottom, and right (in that order) of whatever component uses it.

`MatteBorder createMatteBorder(int, int, int, int, Color)`
`MatteBorder createMatteBorder(int, int, int, int, Icon)`
	Create a matte border. The integer arguments specify the number of pixels that the border occupies at the top, left, bottom, and right (in that order) of whatever component uses it. The Color argument specifies the color which with the border should fill its area. The Icon argument specifies the icon which with the border should tile its area.

`TitledBorder createTitledBorder(String)`
`TitledBorder createTitledBorder(Border)`
`TitledBorder createTitledBorder(Border, String)`
`TitledBorder createTitledBorder(Border, String, int, int)`
`TitledBorder createTitledBorder(Border, String, int, int, Font)`
`TitledBorder createTitledBorder(Border, String, int, int, Font, Color)`
	Create a titled border. The string argument specifies the title to be displayed. The optional font and color arguments specify the font and color to be used for the title's text. The border argument specifies the border that should be displayed along with the title. If no border is specified, then a look-and-feel-specific default border is used.
	
	By default, the title straddles the top of its companion border and is left-justified. The optional integer arguments specify the title's position and justification, in that order. `TitledBorder` defines

	these possible positions: `ABOVE_TOP`, `TOP` (the default), `BELOW_TOP`, `ABOVE_BOTTOM`, `BOTTOM`, and `BELOW_BOTTOM`. You can specify the justification as `LEFT` (the default), `CENTER`, or `RIGHT`.
`CompoundBorder createCompoundBorder(Border, Border)`	Combine two borders into one. The first argument specifies the outer border; the second, the inner border.

Setting or Getting a Component's Border

Method	**Purpose**

`void setBorder(Border)`
`Border getBorder()`
	Set or get the border of the receiving `JComponent`.

`void setBorderPainted(boolean)`
`boolean isBorderPainted()`
(in `AbstractButton`, `JMenuBar`, `JPopupMenu`, `JProgressBar`, and `JToolBar`)
	Set or get whether the border of the component should be painted.

Examples that Use Borders

Many examples in this lesson use borders. The following table lists a few interesting cases.

Example	**Where Described**	**Notes**
`BorderDemo`	This section	Shows an example of each type of border that `BorderFactory` can create. Also uses an empty border to add breathing space between each pane and its contents.
`AlignmentDemo`	How to Use BoxLayout	Uses titled borders.
`BoxLayoutDemo`	How to Use BoxLayout	Uses a red line to show where the edge of a container is, so that you can see how the extra space in a box layout is distributed.
`ComboBoxDemo2`	How to Use Combo Boxes	Uses a compound border to combine a line border with an empty border. The empty border provides space between the line and the component's innards.

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Using Graphics Primitives

The next few pages provide the details you'll need to generate primitive graphics and text.

Painting Shapes

This page tells you how to paint shapes, such as lines, rectangles, ovals, arcs, and polygons.

Working with Text

This page tells you how to use paint text using the `Graphics` `drawString` method. It also tells you how to use `Font` and `FontMetrics` objects to get information about a font's size characteristics.

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Using Images

This is an image:

The next few pages provide the details you'll need to work with images. You'll learn how to load, display, and manipulate them.

Wait!: Although the API this section describes is valid for both JDK 1.1 and Java 2 (JDK 1.2), we recommend that you use Swing's built-in icon◆ support instead. If Swing icons aren't sufficient and you're writing a program for Java 2, then consider using the Java 2D API, which is described in the 2D Graphics◆ trail.

Support for using images is spread across the `java.applet`, `java.awt`, and `java.awt.image` packages. Every image is represented by a `java.awt.Image` object. In addition to the `Image` class, the `java.awt` package provides other basic image support, such as the `Graphics` `drawImage` methods, the `Toolkit` `getImage` methods, and the `MediaTracker` class. In `java.applet`, the `Applet` `getImage` methods make it easy for applets to load images using URLs. Finally, the `java.awt.image` package provides interfaces and classes that let you create, manipulate, and observe images.

Loading Images

The AWT makes it easy to load images in either of two formats: GIF and JPEG. The `Applet` and `Toolkit` classes provide `getImage` methods that work for either format. You use them like this:

```
myImage = getImage(URL); //in a method in an Applet subclass only
    or
myImage = Toolkit.getDefaultToolkit().getImage(filenameOrURL);
```

The `getImage` methods return immediately, so that you don't have to wait for an image to be loaded before going on to perform other operations in your program. While this improves performance, some programs require more control or information about image loading. You can track image loading status either by using the `MediaTracker` class or by implementing the `imageUpdate` method, which is defined by the `ImageObserver` interface.

This section will also tell you how to create images on the fly by using the `MemoryImageSource` class.

Displaying Images

It's easy to display an image using the `Graphics` object that's passed into your `paintComponent` method. You simply invoke a `drawImage` method on the `Graphics` object. For example:

```
g.drawImage(myImage, 0, 0, this);
```

This section explains the four forms of `drawImage`, two of which scale the image. Like `getImage`, `drawImage` is asynchronous, returning immediately even if the image hasn't been fully loaded or painted yet.

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Performing Animation

What all forms of animation have in common is that they create some kind of perceived motion by showing successive frames at a relatively high speed. Computer animation usually shows 10-20 frames per second. By comparison, traditional hand-drawn animation uses anywhere from 8 frames per second (for poor quality animation) to 12 frames per second (for standard animation) to 24 frames per second (for short bursts of smooth, realistic motion). The next few pages tell you everything you need to know to write a Java program that performs animation.

Before you start: Check out existing animation tools and applets, such as Animator◆, to see whether you can use one of them instead of writing your own program.

Creating an Animation Loop with Timer

The most important step in creating a program that animates is to set up the framework correctly. Except for animation performed only in direct response to external events (such as the user dragging an onscreen object), a program that performs animation needs an animation loop.

The animation loop is responsible for keeping track of the current frame and for requesting periodic screen updates. For applets and many applications, you need a separate thread to run the animation loop. This section contains an example applet and an example application that both use a `Timer` object to implement the animation loop. You can use these examples as templates for your own animation.

Moving an Image Across the Screen

The simplest form of image animation involves moving an unchanging image across the screen. In the traditional animation world, this is known as *cutout animation*, since it's generally accomplished by cutting a shape out of paper and moving the shape in front of the camera.

Displaying a Sequence of Images

This section tells you how to perform classic, cartoon-style animation, given a sequence of images.

Improving the Appearance and Performance of Image Animation

This section tells you how to use the `MediaTracker` so that you can delay displaying an animation until all its images are loaded. You'll also get some hints on improving applet animation performance by combining image files and by using a compression scheme.

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Solving Common Graphics Problems

Problem: I don't know where to put my painting code.

- Painting code belongs in the `paintComponent` method of any component descended from `JComponent`. See Overview of Custom Painting for details.

Problem: The stuff I paint doesn't show up.

- Check whether your component is showing up at all. Solving Common Component Problems◆ should help you with this.

Problem: The background of my applet shows up, but the foreground stuff doesn't show up.

- Did you make the mistake of performing painting directly in a `JApplet` subclass? If so, then your contents will be covered by the content pane that is automatically created for every `JApplet` instance. Instead, create another class that performs the painting and then add that class to the `JApplet`'s content pane. See Painting◆ for more information on how painting in Swing works.

Problem: My component's foreground shows up, but its background is invisible. The result is that one or more components directly behind my component are unexpectedly visible.

- Make sure your component is opaque. `JPanel`s, for example, are opaque by default. To make other components such as `JLabel`s opaque, you must invoke `setOpaque(true)` on them.
- If your custom component extends `JPanel` or a more specialized `JComponent` descendant, then you can paint the background by invoking `super.paintComponent` before painting the contents of your component.
- You can paint the background yourself using this code at the top of a custom component's `paintComponent` method:

```
g.setColor(getBackground());
g.fillRect(0, 0, getWidth(), getHeight());
g.setColor(getForeground());
```

Problem: I used `setBackground` to set my component's background color, but it seemed to have no effect.

- Most likely, your component isn't painting its background, either because it's not opaque or your custom painting code doesn't paint the background. If you set the background color for a `JLabel`, for example, you must also invoke `setOpaque(true)` on the label to make the label's background be painted. For more help, see the preceding problem.

Problem: I'm using the exact same code as a tutorial example, but it doesn't work. Why?

- Is the code executed in the exact same method as the tutorial example? For example, if the tutorial example has the code in the example's `paintComponent` method, then this method might be the only place where the code is guaranteed to work.

Problem: How do I paint thick lines? patterns?

- The Java$^{\text{TM}}$ 2D API provides extensive support for implementing line widths and styles, as well as patterns for use in filling and stroking shapes. See the 2D Graphics ◆ trail for more information on using the Java 2D API.

If you don't see your problem in this list, see Solving Common Component Problems◆ and Solving Common Layout Problems◆.

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```
/*
 * Swing version.
 */

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

/*
 * A template for animation applets.
 */

public class AnimatorAppletTimer extends JApplet
                                 implements ActionListener {
    int frameNumber = -1;
    Timer timer;
    boolean frozen = false;
    JLabel label;

    public void init() {
        String str;
        int fps = 0;

        //How many milliseconds between frames?
        str = getParameter("fps");
        try {
            if (str != null) {
                fps = Integer.parseInt(str);
            }
        } catch (Exception e) {}

        int delay = (fps > 0) ? (1000 / fps) : 100;

        //Set up a timer that calls this object's action handler.
        timer = new Timer(delay, this);
        timer.setInitialDelay(0);
        timer.setCoalesce(true);

        label = new JLabel("Frame   ", JLabel.CENTER);

        label.addMouseListener(new MouseAdapter() {
            public void mousePressed(MouseEvent e) {
                if (frozen) {
                    frozen = false;
                    startAnimation();
                } else {
                    frozen = true;
                    stopAnimation();
                }
            }
        });

        getContentPane().add(label, BorderLayout.CENTER);
    }

    //Invoked by the browser only.  invokeLater not needed
    //because startAnimation can be called from any thread.
    public void start() {
        startAnimation();
    }

    //Invoked by the browser only.  invokeLater not needed
    //because stopAnimation can be called from any thread.
    public void stop() {
        stopAnimation();
    }

    //Can be invoked from any thread.
    public synchronized void startAnimation() {
        if (frozen) {
            //Do nothing.  The user has requested that we
            //stop changing the image.
        } else {
            //Start animating!
            if (!timer.isRunning()) {
                timer.start();
            }
        }
    }

    //Can be invoked from any thread.
    public synchronized void stopAnimation() {
        //Stop the animating thread.
        if (timer.isRunning()) {
            timer.stop();
        }
    }

    public void actionPerformed(ActionEvent e) {
        //Advance the animation frame.
        frameNumber++;

        //Request that the frame be painted.
        label.setText("Frame " + frameNumber);
    }
}
```

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Run AnimatorAppletTimer

Note: Because the preceding applet uses the Swing 1.1 API, it requires Java Plug-in 1.1.2 or Java Plug-in 1.2. It won't work with Java Plug-in 1.1.1 or uncustomized 1.1 browsers. For more information about running applets in the tutorial, refer to About Our Examples. That page includes a section about Downloading Java Plug-in.

```
<APPLET CODE="AnimatorAppletTimer.class"
        ARCHIVE="example-swing/animApp.jar"
        WIDTH="150" HEIGHT="30"
        ALT="Your browser understands the applet tag but isn't displaying any applet.">
</APPLET>
```

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Creating an Animation Loop with Timer

Every program that performs animation by painting at regular intervals needs an animation loop. Generally, this loop should be in its own thread. It should **never** be in the `paintComponent` method, since that would take over the event-dispatching thread, which is in charge of painting and event handling.

The `Timer`◆ class makes implementing an animation loop easy. This section provides two `Timer`-based templates for performing animation, one for applets and another for applications. The applet version is pictured below. When running the applet, you can click on it to stop the animation. Click again to restart it.

Frame 16

This is a picture of the applet's GUI. To run the applet, click the picture. The applet will appear in a new browser window.

The animation the template performs is a bit boring: it simply displays the current frame number, using a default rate of 10 frames per second. The next few sections build on this example, showing you how to animate images.

You can find the code for the applet version of the animation template in `AnimatorAppletTimer.java`◆. The code for the application version is in `AnimatorApplicationTimer.java`◆. The rest of this section explains the templates' common code. Here is a summary of what both templates do:

```
public class AnimatorClass ... implements ActionListener {
    int frameNumber = -1;
    Timer timer;
    boolean frozen = false;
    JLabel label;

    //In initialization code:
        //From user-specified frames-per-second value, determine
        //how long to delay between frames.
        ...
        //Set up a timer that calls this object's action handler.
```

```
            timer = new Timer(delay, this);
            ...
            //Set up the components in the GUI.

        public synchronized void startAnimation() {
            ...
            timer.start();
            ...
        }

        public synchronized void stopAnimation() {
            ...
            timer.stop();
            ...
        }

        public void actionPerformed(ActionEvent e) {
            //Advance the animation frame.
            frameNumber++;

            //Request that the frame be painted.
            label.setText("Frame " + frameNumber);
        }
        ...
        //When the application's GUI appears:
            startAnimation();
        ...
    }
```

Initializing Instance Variables

The animation templates use four instance variables. The first (`frameNumber`) represents the current frame. It's initialized to -1, even though the first frame number is 0. The reason: the frame number is incremented at the start of the animation loop, before the first frame is painted. Thus, the first frame to be painted is frame 0.

The second instance variable (`timer`) is the `Timer` object that implements the animation loop. It's initialized to fire an action event every `delay` milliseconds.

The `delay` variable is a local variable that's initialized using a *frames per second* number provided by the user. The following code converts frames per second into the number of milliseconds between frames:

```
delay = (fps > 0) ? (1000 / fps) : 100;
```

The `? :` notation in the previous code snippet is shorthand for `if else`. If the user provides a number of frames per second greater than 0, then the delay is 1000 milliseconds divided by the number of frames per second. Otherwise, the delay between frames is 100 milliseconds (ten frames per second).

The third instance variable (`frozen`) is a boolean value that's initialized to `false`. The templates set it to `true` when the user requests that the animation stop. You'll see more about this later in this section.

The fourth instance variable (`label`) is a reference to the component that performs the painting.

The Animation Loop

The `Timer` object implements the animation loop by continuously firing action events every `delay` milliseconds. In response to each action event, the `actionPerformed` method does the following:

1. Advances the frame number.
2. Requests that the current frame of animation be painted.

For more information about timers, see How to Use Timers◆.

Behaving Politely

Two more features of the animation templates belong in the category of polite behavior.

The first feature is allowing the user to explicitly stop (and restart) the animation, while the applet or application is still visible. Animation can be quite distracting, and it's a good idea to give the user the power to stop the animation so that the user can concentrate on something else. This feature is implemented by overriding the `mousePressed` method so that it stops or starts the timer, depending on the program's current state. Here's the code that implements this:

```
...//In initialization code:
boolean frozen = false;
...
public synchronized void startAnimation() {
    if (frozen) {
        //Do nothing.  The user has requested that we
        //stop changing the image.
    } else {
        //Start animating!
        ...
        timer.start();
        ...
    }

public synchronized void stopAnimation() {
    ...
    timer.stop();
    ...
}
...
//In a mouse listener registered on the animating component:
public void mousePressed(MouseEvent e) {
    if (frozen) {
        frozen = false;
        startAnimation();
    } else {
        frozen = true;
        stopAnimation();
    }
}
```

The second feature is suspending the animation whenever the applet or application is known not to be visible. For the applet animation template, this is achieved by implementing the `Applet` `stop` and `start` methods to call `stopAnimation` and `startAnimation`, respectively. For the application animation template, this is achieved by implementing a window event handler that reacts to iconification and deiconification by, again, calling `stopAnimation` and `startAnimation`, respectively.

In both templates, if the user hasn't frozen the animation, then when the program detects that the animation isn't visible, it tells the timer to stop. When the user revisits the animation, the program restarts the timer, unless the user has explicitly requested that the animation be stopped.

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Moving an Image Across the Screen

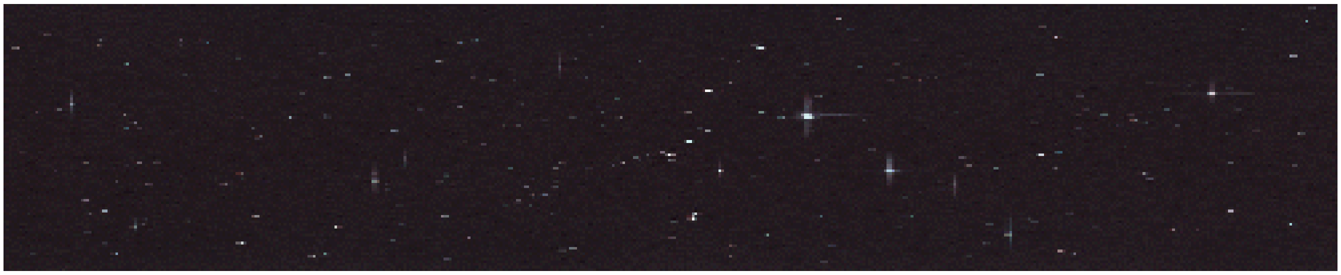
This page features an example applet that moves one image (a rocketship) in front of a background image (a field of stars). You could implement this in one of two ways -- either using one label per image, or using one custom component that paints both images. Because this lesson features painting, this section features the custom component approach, as implemented in `MovingImageTimer.java`◆.

Note: You can also see an alternate implementation, which uses labels and a layered pane. You can find it in `MovingLabels.java`◆, which you can run by visiting `MovingLabels.html`.

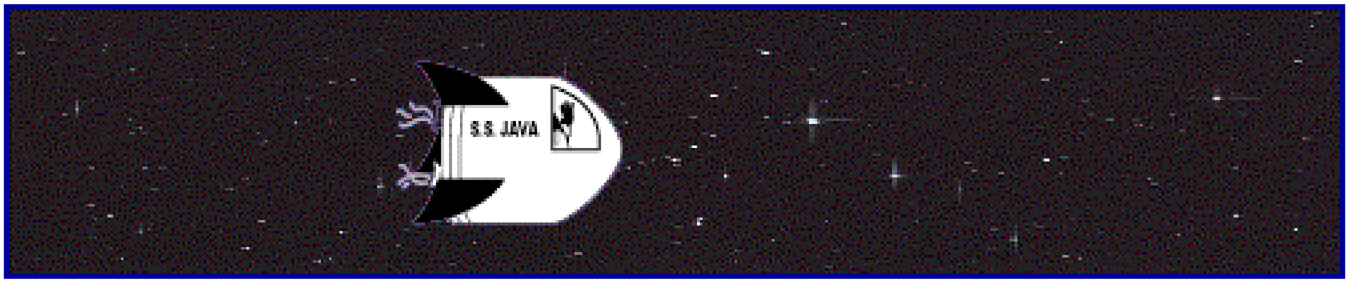
Below are the two images this applet uses.

rocketship.gif:

starfield.gif:



Here's a picture of the applet's GUI. Remember that you can click on the applet to stop or start the animation.



This is a picture of the applet's GUI. To run the applet, click the picture. The applet will appear in a new browser window.

Note: The rocketship image has a transparent background. The transparent background makes the rocketship image appear to have a rocketship shape, no matter what color background it's painted on top of. If the rocketship background weren't transparent, then instead of the illusion of a rocketship moving through space, you'd see a rocketship on top of a rectangle moving through space.

The code for performing this animation isn't complex. Essentially, it's a copy of the animation template that, instead of using a label to perform animation, uses a custom component. The custom component is a `JPanel` subclass that paints two images, one of which has a position that depends on the current frame number. Here is the code that paints the custom component:

```
...//Where the images are initialized:
Image background = getImage(getCodeBase(),
                            "images/rocketship.gif");
Image foreground = getImage(getCodeBase(),
                            "images/starfield.gif");
...
public void paintComponent(Graphics g) {
    super.paintComponent(g); //paint any space not covered
                             //by the background image
    int compWidth = getWidth();
    int compHeight = getHeight();

    //If we have a valid width and height for the
    //background image, paint it.
    imageWidth = background.getWidth(this);
    imageHeight = background.getHeight(this);
    if ((imageWidth > 0) && (imageHeight > 0)) {
        g.drawImage(background,
                    (compWidth - imageWidth)/2,
                    (compHeight - imageHeight)/2, this);
    }

    //If we have a valid width and height for the
    //foreground image, paint it.
    imageWidth = foreground.getWidth(this);
    imageHeight = foreground.getHeight(this);
    if ((imageWidth > 0) && (imageHeight > 0)) {
        g.drawImage(foreground,
                    ((frameNumber*5)
                      % (imageWidth + compWidth))
                      - imageWidth,
                    (compHeight - imageHeight)/2,
                    this);
    }
}
```

You might think that this program doesn't need to clear the background, since it uses a background image. However, clearing the background is still necessary. One reason is that the applet usually starts painting before the images are fully loaded. If the rocketship image loaded before the background image, you would see parts of multiple rocketship until the background image loaded. Another reason is that if the applet painting area were wider than the background image, for some reason, then you'd see multiple rocketships to either side of the background image.

You could solve the first problem by delaying all painting until both images are fully loaded. The second problem could be solved by scaling the background image to fit the entire applet area. You'll learn how to wait for images to be fully loaded in Improving the Appearance and Performance of Image Animation, later in this lesson. Scaling is described in Displaying Images.

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Lesson: Using Other Swing Features

How to Use Timers

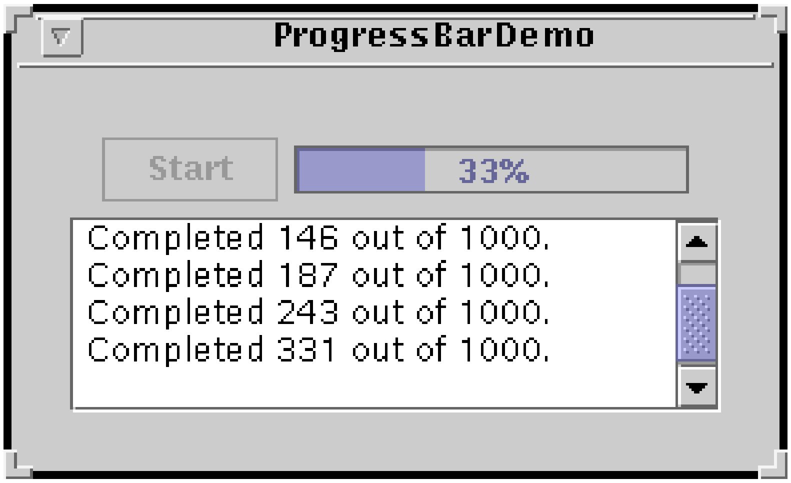
A Swing timer (an instance of `javax.swing.Timer`◆) fires one or more action events after a specified delay. Don't confuse Swing timers with the general-purpose timer facility that was added to the `java.util` package in v 1.3. This page describes only Swing timers; you can find information on general-purpose timers in Using the Timer and TimerTask Classes◆. In general, we recommend using Swing timers rather than general-purpose timers for GUI-related tasks. However, you might use general-purpose timers if you prefer their API or need their features.

You can use Swing timers in two ways:

- To perform a task once, after a delay.
  For example, the tool tip manager uses Swing timers to determine when to show a tool tip and when to hide it.
- To perform a task repeatedly.
  For example, you might perform animation or update a component that displays progress toward a goal. See Creating an Animation Loop with Timer◆ for an example and discussion of using a timer for animation.

Note that the Swing timer's task is performed in the event-dispatching thread. This means that the task can safely manipulate components, but it also means that the task should execute quickly. If the task might take a while to execute, then consider using a `SwingWorker` instead of or in addition to the timer. See How to Use Threads for instructions about using the `SwingWorker` class and information on using Swing components in multi-threaded programs.

Let's look at an example of using a timer to periodically update a component that displays progress toward a goal. Here's a picture of an application that uses a timer and a progress bar to display the progress of a long-running task.



Completed 146 out of 1000.
Completed 187 out of 1000.
Completed 243 out of 1000.
Completed 331 out of 1000.

Try this:

1. Compile and run the application. The main source file is `ProgressBarDemo.java`. You will also need two other source files.
   See Getting Started with Swing if you need help compiling or running this application.
2. Push the **Start** button. Watch the progress bar as the task makes progress.

Here's the code from `ProgressBarDemo.java` that creates a timer set up to "go off" every second. Each time a timer goes off it fires an action event. Conveniently, the constructor also takes an action listener, which is implemented as an anonymous inner class. The action listener contains the code that implements the timer's task.

```
public final static int ONE_SECOND = 1000;
...
timer = new Timer(ONE_SECOND, new ActionListener() {
    public void actionPerformed(ActionEvent evt) {
        //...Perform a task...
    }
});
```

When the user presses the **Start** button, the program starts the timer:

```
timer.start();
```

When the task is finished, the timer's action listener stops the timer:

```
if (/* task is done */) {
    ...
    timer.stop();
    ...
}
```

The Timer API

The following tables list the commonly used `javax.swing.Timer` constructors and methods. The API for using Swing timers falls into two categories:

- Creating and Initializing the Timer
- Running the Timer

Creating and Initializing the Timer

Method or Constructor	**Purpose**
`Timer(int, ActionListener)`	Create a Swing timer. The `int` argument specifies the number of milliseconds to pause between action events. Use `setDelay` to change the delay after construction. The second argument is an action listener, which the constructor registers with the timer. You can also register action listeners with `addActionListener` and remove them with `removeActionlistener`.

`void setDelay(int)`
`int getDelay()`
	Set or get the number of milliseconds between action events.

`void setInitialDelay(int)`
`int getInitialDelay()`
	Set or get the number of milliseconds to wait before firing the first action event. By default the initial delay is equal to the regular delay.

`void setRepeats(boolean)`
`boolean isRepeats()`
	Set or get whether the timer repeats. By default this value is true. Call `setRepeats(false)` to set up a timer that fires a single action event and then stops.

`void setCoalesce(boolean)`
`boolean isCoalesce()`
	Set or get whether the timer coalesces multiple, pending action events into a single action event. By default this value is true.

Running the Timer

Method	Purpose

`void start()`
`void restart()`
	Turn the timer on. `restart` also cancels any pending action events.

`void stop()`	Turn the timer off.
`boolean isRunning()`	Get whether the timer is running.

Examples that Use Timer

This table shows the examples that use `javax.swing.Timer` and where those examples are described.

Example	Where Described	Notes
`ProgressBarDemo`	This section and How to Monitor Progress	Uses a Swing timer to show periodic progress.
`AnimatorApplicationTimer` and `AnimatorAppletTimer`	Creating an Animation Loop with Timer	Uses a Swing timer to control an animation loop.
`SliderDemo`	How to Use Sliders	Another animation program that uses a Swing timer. Allows the user to change the timer's delay dynamically. Also shows how to use the initial delay and `restart` to create a longer pause in an animation between certain frames.

```
/*
 * Swing version.
 */

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

/*
 * This displays a framed area.  When the user clicks within
 * the area, this program displays a dot and a string indicating
 * the coordinates where the click occurred.
 */
public class CoordinatesDemo extends JApplet {
    JLabel label;

    //Called only when this is run as an applet.
    public void init() {
        buildUI(getContentPane());
    }

    void buildUI(Container container) {
        container.setLayout(new BoxLayout(container,
                                          BoxLayout.Y_AXIS));

        CoordinateArea coordinateArea = new CoordinateArea(this);
        container.add(coordinateArea);

        label = new JLabel("Click within the framed area.");
        container.add(label);

        //Align the left edges of the components.
        coordinateArea.setAlignmentX(LEFT_ALIGNMENT);
        label.setAlignmentX(LEFT_ALIGNMENT); //redundant
    }

    public void updateLabel(Point point) {
        label.setText("Click occurred at coordinate ("
                      + point.x + ", " + point.y + ").");
    }

    public static void main(String[] args) {
        JFrame f = new JFrame("CoordinatesDemo");
        f.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });
        CoordinatesDemo controller = new CoordinatesDemo();
        controller.buildUI(f.getContentPane());
        f.pack();
        f.setVisible(true);
    }
}

class CoordinateArea extends JPanel {
    Point point = null;
    CoordinatesDemo controller;
    Dimension preferredSize = new Dimension(400,150);
    public CoordinateArea(CoordinatesDemo controller) {
        this.controller = controller;

        Border raisedBevel = BorderFactory.createRaisedBevelBorder();
        Border loweredBevel = BorderFactory.createLoweredBevelBorder();
        Border compound = BorderFactory.createCompoundBorder
                              (raisedBevel, loweredBevel);
        setBorder(compound);

        addMouseListener(new MouseAdapter() {
            public void mousePressed(MouseEvent e) {
                int x = e.getX();
                int y = e.getY();
                if (point == null) {
                    point = new Point(x, y);
                } else {
                    point.x = x;
                    point.y = y;
                }
                repaint();
            }
        });
    }

    public Dimension getPreferredSize() {
        return preferredSize;
    }

    public void paintComponent(Graphics g) {
        super.paintComponent(g);  //paint background

        //If user has chosen a point, paint a tiny rectangle on top.
        if (point != null) {
            controller.updateLabel(point);
            g.fillRect(point.x - 1, point.y - 1, 2, 2);
        }
    }
}
```

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Run CoordinatesDemo

Note: Because the preceding applet uses the Swing 1.1 API, it requires Java Plug-in 1.1.2 or Java Plug-in 1.2. It won't work with Java Plug-in 1.1.1 or uncustomized 1.1 browsers. For more information about running applets in the tutorial, refer to About Our Examples. That page includes a section about Downloading Java Plug-in.

```
<APPLET CODE="CoordinatesDemo.class"
        ARCHIVE="example-swing/coordinatesDemo.jar"
        WIDTH="400" HEIGHT="150"
        ALT="Your browser understands the applet tag but isn't displaying any applet.">
</APPLET>
```

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Painting

You might not need the information in this section at all. However, if your components don't seem to be painting themselves correctly, understanding the concepts in this section might help you figure out what's wrong. If you plan to create custom painting code for a component, this section is required reading.

How Painting Works

When a Swing GUI needs to paint itself -- whether for the first time, in response to becoming unhidden, or because it needs to reflect a change in the program's state -- it starts with the highest component that needs to be repainted and works its way down the containment hierarchy. This process is orchestrated by the AWT painting system, and made more efficient and smooth by the Swing repaint manager and double-buffering code.

Swing components generally repaint themselves whenever necessary. When you invoke the `setText` method on a component, for example, the component should automatically repaint itself and, if appropriate, resize itself. If it doesn't, it's a bug. The workaround is to invoke the **`repaint`** method on the component to request that the component be scheduled for painting. If the component's size or position needs to change but doesn't do so automatically, you should invoke **`revalidate`** upon the component before invoking `repaint`.

Like event-handling code, painting code executes on the event-dispatching thread. While an event is being handled, no painting will occur. Similarly, if a painting operation takes a long time, no events will be handled during that time.

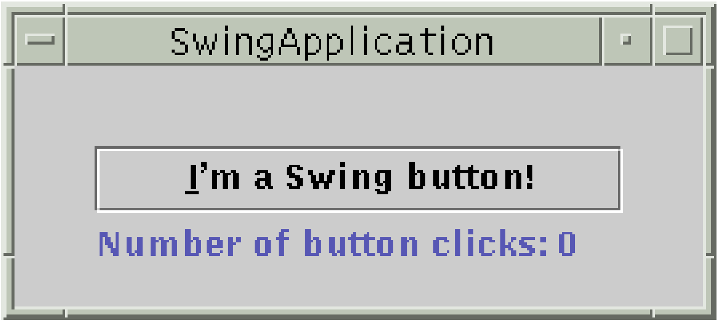
Programs should paint only when the painting system tells them to because each occurrence of a component painting itself must execute without interruption. Otherwise, unpredictable results could occur, such as a button being painted as half pressed and half unpressed.

For smoothness, Swing painting is *double-buffered* by default -- performed to an offscreen buffer and then flushed to the screen once finished. It might slightly help performance if you make a Swing component opaque, so that the Swing painting system can know not to paint anything behind the component. To make a Swing component opaque, invoke `setOpaque(true)` on the component.

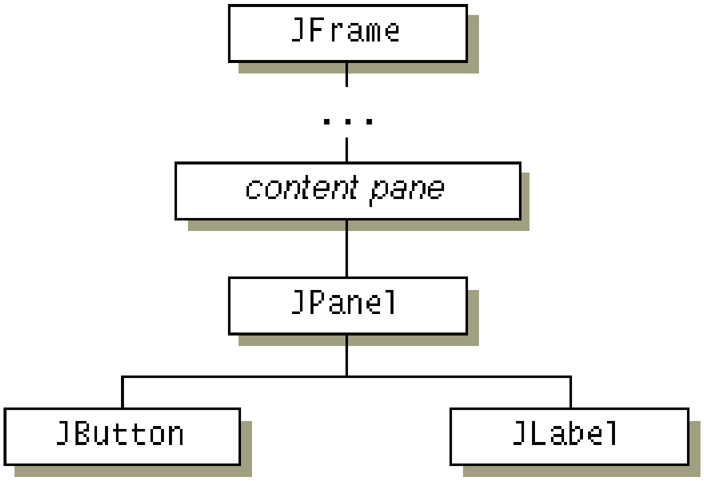
Although their available painting area is always rectangular, non-opaque Swing components can appear to be any shape. A button, for instance, might display itself by painting a filled octagon. The component behind the button (its container, most likely) would then be visible, showing through at the corners of the button's bounds. The button would have to include special hit detection code to avoid acting pressed if the user happens to click on its corners.

An Example of Painting

To illustrate painting, we'll use the `SwingApplication` program, which is explained in A Quick Tour of a Swing Application's Code◆. Here is `SwingApplication`'s GUI:



Here, again, is its containment hierarchy:



When the GUI for `SwingApplication` is painted, here's what happens:

1. The top-level container, `JFrame`, paints itself.
2. The content pane first paints its background, which is a solid gray rectangle. It then

tells the `JPanel` to paint itself. The content pane's background rectangle doesn't actually appear in the finished GUI because the content pane is completely obscured by the `JPanel`.

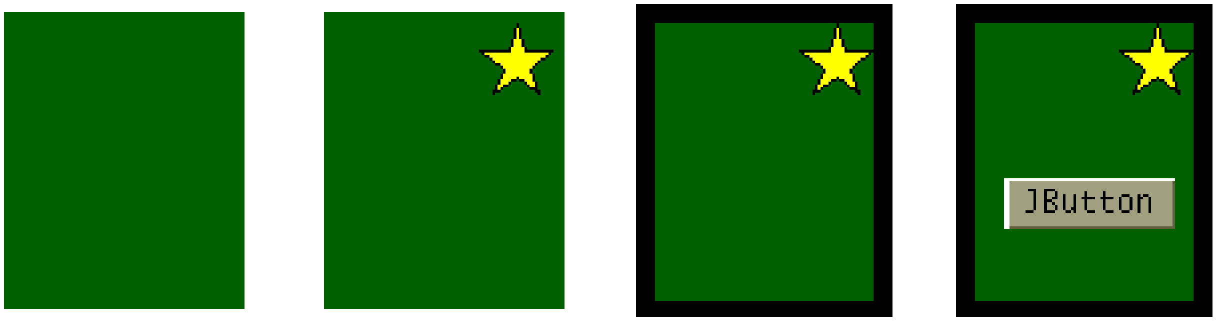
Note: It's important that the content pane be opaque. Otherwise, messy repaints will result. Because the `JPanel` is opaque, we could make it the content pane (by substituting `setContentPane` for the existing code `getContentPane().add`). This would slightly simplify the containment hierarchy and painting by removing an unnecessary container.

---

3. The `JPanel` first paints its background, a solid gray rectangle. Next, it paints its border. The border is an `EmptyBorder`, which has no effect except for increasing the `JPanel`'s size by reserving some space at the edge of the panel. Finally, the panel asks its children to paint themselves.
4. To paint itself, the `JButton` paints its background rectangle, if necessary, and then paints the text that it contains. If the button has the keyboard focus, meaning that any typing goes directly to the button for processing, then the button does some look-and-feel-specific painting to make clear that it has the focus.
5. To paint itself, the `JLabel` paints its text.

In this way, each component paints itself before any of the components it contains. This ensures that the background of a `JPanel`, for example, is visible only where it isn't covered by painting performed by one of the components it contains. The following figure illustrates the order in which each component that inherits from `JComponent` paints itself:

1. background (if opaque)	**2. custom painting (if any)**	**3. border (if any)**	**4. children (if any)**



For more information on how to paint, see the Working with Graphics lesson.

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Run ImageDisplayer

Note: Because the preceding applet uses the Swing 1.1 API, it requires Java Plug-in 1.1.2 or Java Plug-in 1.2. It won't work with Java Plug-in 1.1.1 or uncustomized 1.1 browsers. For more information about running applets in the tutorial, refer to About Our Examples. That page includes a section about Downloading Java Plug-in.

```
/*
 * Swing.
 */

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

/*
 * This applet displays a single image twice,
 * once at its normal size and once much wider.
 */

public class ImageDisplayer extends JApplet {
    static String imageFile = "images/rocketship.gif";

    public void init() {
        Image image = getImage(getCodeBase(), imageFile);
        ImagePanel imagePanel = new ImagePanel(image);
        getContentPane().add(imagePanel, BorderLayout.CENTER);
    }

    public static void main(String[] args) {
        Image image = Toolkit.getDefaultToolkit().getImage(
                                        ImageDisplayer.imageFile);
        ImagePanel imagePanel = new ImagePanel(image);

        JFrame f = new JFrame("ImageDisplayer");
        f.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });

        f.getContentPane().add(imagePanel, BorderLayout.CENTER);
        f.setSize(new Dimension(550,100));
        f.setVisible(true);
    }
}

class ImagePanel extends JPanel {
    Image image;

    public ImagePanel(Image image) {
        this.image = image;
    }

    public void paintComponent(Graphics g) {
        super.paintComponent(g); //paint background

        //Draw image at its natural size first.
        g.drawImage(image, 0, 0, this); //85x62 image

        //Now draw the image scaled.
        g.drawImage(image, 90, 0, 300, 62, this);
    }
}
```

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Displaying Images

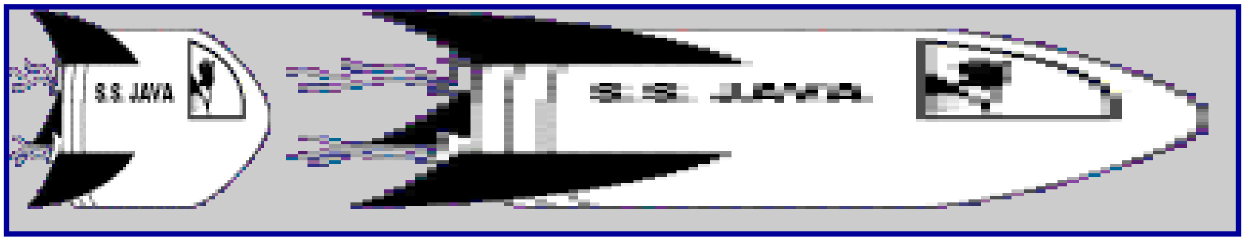
Here is a code example that displays an image at its normal size in the upper left corner of the component area (0, 0):

```
g.drawImage(image, 0, 0, this);
```

Here is a code example that displays an image scaled to be 300 pixels wide and 62 pixels tall, starting at the coordinates (90, 0):

```
g.drawImage(myImage, 90, 0, 300, 62, this);
```

The following snapshot shows an applet that loads a single image and displays it twice, using both code snippets that you see above. You can find the program's full code in ImageDisplayer.java.



This is a picture of the applet's GUI. To run the applet, click the picture. The applet will appear in a new browser window.

The `Graphics` class declares the following `drawImage` methods. They all return a boolean value, although this value is rarely used. The return value is `true` if the image has been completely loaded and thus completely painted; otherwise, it's `false`.

- `boolean drawImage(Image img, int x, int y, ImageObserver observer)`
- `boolean drawImage(Image img, int x, int y, int width, int height, ImageObserver observer)`
- `boolean drawImage(Image img, int x, int y, Color bgcolor, ImageObserver observer)`

- `boolean drawImage(Image img, int x, int y, int width, int height, Color bgcolor, ImageObserver observer)`

The `drawImage` methods have the following arguments:

`Image img`
: The image to paint.

`int x, int y`
: The coordinates of the upper left corner of the image.

`int width, int height`
: The width and height (in pixels) of the image.

`Color bgcolor`
: The color to paint underneath the image. This can be useful if the image contains transparent pixels and you know that the image will be displayed against a solid background of the indicated color.

`ImageObserver observer`
: An object that implements the `ImageObserver` interface. This registers the object as the image observer so that it's notified whenever new information about the image becomes available. Most components can simply specify `this`.

The reason why components can specify `this` as the image observer is that the `Component` class implements the `ImageObserver` interface. Its implementation invokes the `repaint` method as the image data is loaded, which is usually what you want to happen.

The `drawImage` method returns after displaying the image data that has been loaded, so far. If you want to make sure that `drawImage` paints only complete images, then you must track image loading. See the previous page for information on tracking image loading.

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Painting Shapes

The `Graphics`◆ class defines methods for painting the following kinds of shapes:

- Lines (`drawLine`)
- Rectangles (`drawRect` and `fillRect`)
- Raised or lowered rectangles (`draw3DRect` and `fill3DRect`)
- Round-edged rectangles (`drawRoundRect` and `fillRoundRect`)
- Ovals (`drawOval` and `fillOval`)
- Arcs (`drawArc` and `fillArc`)
- Polygons (`drawPolygon`, `drawPolyline`, and `fillPolygon`)

Here is an example of painting the outline of a rectangle:

```
g.drawRect(x, y, rectWidth - 1, rectHeight - 1);
```

Here is an example of painting a filled rectangle of the same size.

```
g.fillRect(x, y, rectWidth, rectHeight);
```

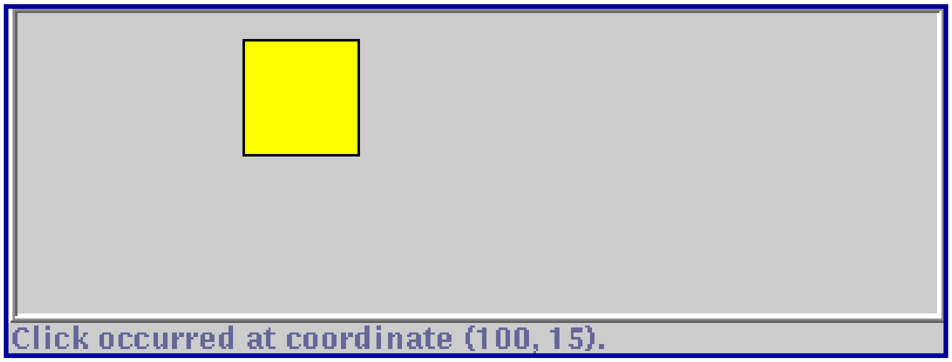
Note that for the `drawRect` method, you must specify one pixel less than the desired width and height. This is because the painting system draws lines just below the specified rectangle, instead of within the specified rectangle. The same rule of specifying one less than the desired width applies to other `draw`*`Xxx`* methods, such as `draw3DRect`. For the `fill`*`Xxx`* methods, on the other hand, you specify exactly the desired width and height in pixels.

Java^{TM} 2 Note: If you are using Java 2 (JDK^{TM} 1.2), you can use the new Java^{TM} 2D API, which allows you to create virtually any kind of geometric shape and to specify line styles, line sizes, and fancy fill patterns. To learn how to take advantage of this new functionality, see the 2D Graphics◆ trail. In particular, see the Stroking and Filling Graphics Primitives◆ and Shapes◆ lessons, which present a Java 2D implementation of the program presented in Example 2: A Shape Sampler.

Example 1: Simple Rectangle Painting

Here's a picture of a program that's almost the same as the `CoordinatesDemo` program shown in The Coordinate System. Like `CoordinatesDemo`, this program paints a rectangle wherever the user clicks.

However, this program's rectangle is larger and has a yellow fill. Here is a picture of its GUI:



Click occurred at coordinate (100, 15).

This is a picture of the applet's GUI. To run the applet, click the picture. The applet will appear in a new browser window.

The program features two components. The largest is a custom component implemented by a class named `RectangleArea`. It paints the beveled border and everything inside it, including the yellow rectangle. The other component is a label that appears at the bottom of the GUI, under the custom component. The label describes the program's current state.

You can find the program's code in `RectangleDemo.java`. Here is the painting-related code for the custom component:

```
class RectangleArea extends JPanel {
    ...
    int rectWidth = 50;
    int rectHeight = 50;
    ...
    public RectangleArea(...) {
        ...
        Border raisedBevel = BorderFactory.createRaisedBevelBorder();
        Border loweredBevel = BorderFactory.createLoweredBevelBorder();
        Border compound = BorderFactory.createCompoundBorder
                              (raisedBevel, loweredBevel);
        setBorder(compound);
        ...
    }
    ...
    public void paintComponent(Graphics g) {
        super.paintComponent(g);  //paint background

        //Paint a filled rectangle at user's chosen point.
        if (point != null) {
            g.drawRect(point.x, point.y,
                       rectWidth - 1, rectHeight - 1);
            g.setColor(Color.yellow);
            g.fillRect(point.x + 1, point.y + 1,
                       rectWidth - 2, rectHeight - 2);

            controller.updateLabel(point);
            }
        }
    }
```

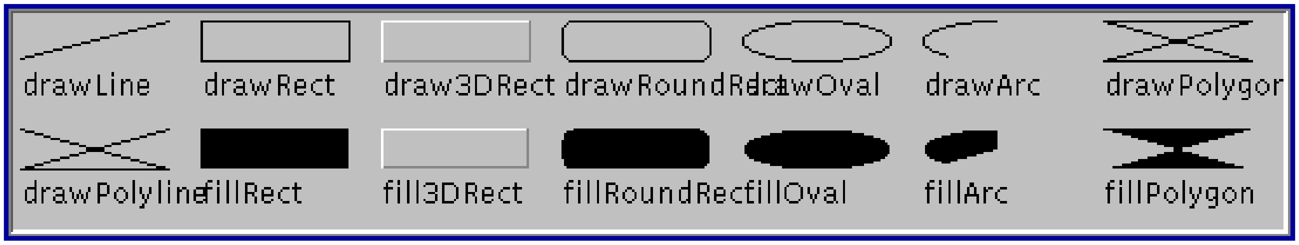
The component's implementation of `paintComponent` uses the `fillRect` method to paint a 50-by-50-pixel rectangle outline, filled with a 48-by-48-pixel yellow rectangle. Note the differences in the arguments specified to `drawRect` and `fillRect`.

Note: It's perfectly legal to specify x, y, height, or width values that are negative or cause a result larger than the painting area. Values outside the painting area don't matter too much because they're clipped to the painting area. You just won't see part of the shape. Negative height or width results in the shape not being painted at all.

For a little more information about this example, see The Coordinate System, which features the `CoordinatesDemo` example on which `RectangleDemo` is based.

Example 2: A Shape Sampler

The `ShapesDemo` program demonstrates all the shapes you can draw and fill, using API supported with both JDK 1.1 and Java 2. Here is a picture of its GUI:



This is a picture of the applet's GUI. To run the applet, click the picture. The applet will appear in a new browser window.

Note: Unless the default font is very small, some of the strings displayed by ShapesDemo overlap with other strings. A fix for this problem is demonstrated in Getting Information About a Font: FontMetrics.

You can find the code for the entire program in `ShapesDemo.java`. The following snippet is just the code that paints the geometric shapes, where the bold lines are the actual invocations of painting methods. The `rectHeight` and `rectWidth` variables specify the size in pixels of the rectangle that contains the shape to be drawn. The `x` and `y` variables are changed for every shape, so that the shapes aren't painted on top of each other. The `bg` and `fg` variables are `Color` objects that specify the component's background and foreground colors, respectively.

```
Color fg3D = Color.lightGray;
...
```

```
// drawLine(x1, y1, x2, y2)
g.drawLine(x, y+rectHeight-1, x + rectWidth, y);
...
// drawRect(x, y, w, h)
g.drawRect(x, y, rectWidth, rectHeight);
...
// draw3DRect(x, y, w, h, raised)
g.setColor(fg3D);
g.draw3DRect(x, y, rectWidth, rectHeight, true);
g.setColor(fg);
...
// drawRoundRect(x, y, w, h, arcw, arch)
g.drawRoundRect(x, y, rectWidth, rectHeight, 10, 10);
...
// drawOval(x, y, w, h)
g.drawOval(x, y, rectWidth, rectHeight);
...
// drawArc(x, y, w, h, startAngle, arcAngle)
g.drawArc(x, y, rectWidth, rectHeight, 90, 135);
...
// drawPolygon(xPoints, yPoints, numPoints)
int x1Points[] = {x, x+rectWidth, x, x+rectWidth};
int y1Points[] = {y, y+rectHeight, y+rectHeight, y};
g.drawPolygon(x1Points, y1Points, x1Points.length);
...
// drawPolyline(xPoints, yPoints, numPoints)
// Note: drawPolygon would close the polygon.
int x2Points[] = {x, x+rectWidth, x, x+rectWidth};
int y2Points[] = {y, y+rectHeight, y+rectHeight, y};
g.drawPolyline(x2Points, y2Points, x2Points.length);
...
// fillRect(x, y, w, h)
g.fillRect(x, y, rectWidth, rectHeight);
...
// fill3DRect(x, y, w, h, raised)
g.setColor(fg3D);
g.fill3DRect(x, y, rectWidth, rectHeight, true);
g.setColor(fg);
...
// fillRoundRect(x, y, w, h, arcw, arch)
g.fillRoundRect(x, y, rectWidth, rectHeight, 10, 10);
...
// fillOval(x, y, w, h)
g.fillOval(x, y, rectWidth, rectHeight);
...
// fillArc(x, y, w, h, startAngle, arcAngle)
g.fillArc(x, y, rectWidth, rectHeight, 90, 135);
...
// fillPolygon(xPoints, yPoints, numPoints)
```

```
int x3Points[] = {x, x+rectWidth, x, x+rectWidth};
int y3Points[] = {y, y+rectHeight, y+rectHeight, y};
g.fillPolygon(x3Points, y3Points, x3Points.length);
...
```

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Run SelectionDemo

Note: Because the preceding applet uses the Swing 1.1 API, it requires Java Plug-in 1.1.2 or Java Plug-in 1.2. It won't work with Java Plug-in 1.1.1 or uncustomized 1.1 browsers. For more information about running applets in the tutorial, refer to About Our Examples. That page includes a section about Downloading Java Plug-in.

```java
/*
 * 1.1 Swing version.
 */

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

/*
 * This displays a framed area.  When the user drags within
 * the area, this program displays a rectangle and a string
 * indicating the bounds of the rectangle.
 */
public class SelectionDemo extends JApplet {
    JLabel label;
    static String starFile = "images/starfield.gif";

    //Called only when this is run as an applet.
    public void init() {
        ImageIcon image = new ImageIcon(getImage(getCodeBase(),
                                                 starFile));
        buildUI(getContentPane(), image);
    }

    void buildUI(Container container, ImageIcon image) {
        container.setLayout(new BoxLayout(container,
                                          BoxLayout.Y_AXIS));

        JPanel framedArea = frameItUp(new SelectionArea(image, this));
        container.add(framedArea);

        label = new JLabel("Drag within the framed area.");
        container.add(label);

        //Align the left edges of the components.
        framedArea.setAlignmentX(LEFT_ALIGNMENT);
        label.setAlignmentX(LEFT_ALIGNMENT); //redundant
    }

    JPanel frameItUp(Component insides) {
        Border raisedBevel, loweredBevel, compound;
        raisedBevel = BorderFactory.createRaisedBevelBorder();
        loweredBevel = BorderFactory.createLoweredBevelBorder();
        compound = BorderFactory.createCompoundBorder
                        (raisedBevel, loweredBevel);

        JPanel framedArea = new JPanel();
        framedArea.setBorder(compound);
        framedArea.setLayout(new GridLayout(1,0));
        framedArea.add(insides);

        return framedArea;
    }

    public void updateLabel(Rectangle rect) {
        int width = rect.width;
        int height = rect.height;

        //Make the coordinates look OK if a dimension is 0.
        if (width == 0) {
            width = 1;
        }
        if (height == 0) {
            height = 1;
        }

        label.setText("Rectangle goes from ("
                      + rect.x + ", " + rect.y + ") to ("
                      + (rect.x + width - 1) + ", "
                      + (rect.y + height - 1) + ").");
    }

    public static void main(String[] args) {
        JFrame f = new JFrame("SelectionDemo");
        f.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });
        SelectionDemo controller = new SelectionDemo();
        controller.buildUI(f.getContentPane(),
                           new ImageIcon(starFile));
        f.pack();
        f.setVisible(true);
    }
}

class SelectionArea extends JLabel {
    Rectangle currentRect = null;
    Rectangle rectToDraw = null;
    Rectangle previousRectDrawn = new Rectangle();
    SelectionDemo controller;

    public SelectionArea(ImageIcon image, SelectionDemo controller) {
        super(image); //This component displays an image.
        this.controller = controller;
        setOpaque(true);
        setMinimumSize(new Dimension(10,10)); //don't hog space

        MyListener myListener = new MyListener();
        addMouseListener(myListener);
        addMouseMotionListener(myListener);
    }

    class MyListener extends MouseInputAdapter {
        public void mousePressed(MouseEvent e) {
            int x = e.getX();
            int y = e.getY();
            currentRect = new Rectangle(x, y, 0, 0);
            updateDrawableRect(getWidth(), getHeight());
            repaint();
        }

        public void mouseDragged(MouseEvent e) {
            updateSize(e);
        }

        public void mouseReleased(MouseEvent e) {
            updateSize(e);
        }

        /*
         * Update the size of the current rectangle
         * and call repaint.  Because currentRect
         * always has the same origin, translate it
         * if the width or height is negative.
         *
         * For efficiency (though
         * that isn't an issue for this program),
         * specify the painting region using arguments
         * to the repaint() call.
         *
         */
        void updateSize(MouseEvent e) {
            int x = e.getX();
            int y = e.getY();
            currentRect.setSize(x - currentRect.x,
                                y - currentRect.y);
            updateDrawableRect(getWidth(), getHeight());
            Rectangle totalRepaint = rectToDraw.union(previousRectDrawn);
            repaint(totalRepaint.x, totalRepaint.y,
                    totalRepaint.width, totalRepaint.height);
        }
    }

    public void paintComponent(Graphics g) {
        super.paintComponent(g); //paints the background and image

        //If currentRect exists, paint a box on top.
        if (currentRect != null) {
            //Draw a rectangle on top of the image.
// XXX: We used to use XOR mode, but in 1.2, due to bugs 4188795
// XXX: and 4219548, that causes an off-by-one error.
            //g.setXORMode(Color.white); //Color of line varies
                                         //depending on image colors
            g.setColor(Color.white);
            g.drawRect(rectToDraw.x, rectToDraw.y,
                       rectToDraw.width - 1, rectToDraw.height - 1);

            controller.updateLabel(rectToDraw);
        }
    }

    void updateDrawableRect(int compWidth, int compHeight) {
        int x = currentRect.x;
        int y = currentRect.y;
        int width = currentRect.width;
        int height = currentRect.height;

        //Make the width and height positive, if necessary.
        if (width < 0) {
            width = 0 - width;
            x = x - width + 1;
            if (x < 0) {
                width += x;
                x = 0;
            }
        }
        if (height < 0) {
            height = 0 - height;
            y = y - height + 1;
            if (y < 0) {
                height += y;
                y = 0;
            }
        }

        //The rectangle shouldn't extend past the drawing area.
        if ((x + width) > compWidth) {
            width = compWidth - x;
        }
        if ((y + height) > compHeight) {
            height = compHeight - y;
        }

        //Update rectToDraw after saving old value.
        if (rectToDraw != null) {
            previousRectDrawn.setBounds(
                        rectToDraw.x, rectToDraw.y,
                        rectToDraw.width, rectToDraw.height);
            rectToDraw.setBounds(x, y, width, height);
        } else {
            rectToDraw = new Rectangle(x, y, width, height);
        }
    }
}
```

```java
/*
 * Swing version.
 */

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

/*
 * This is like the ShapesDemo applet, except that it
 * handles fonts more carefully.
 */
public class FontDemo extends JApplet {
    /** Executed only in applet. */
    public void init() {
        FontPanel fontPanel = new FontPanel();
        getContentPane().add(fontPanel, BorderLayout.CENTER);
    }

    /** Executed only in application.*/
    public static void main(String[] args) {
        JFrame f = new JFrame("FontDemo");
        f.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });
        FontPanel fontPanel = new FontPanel();
        f.getContentPane().add(fontPanel, BorderLayout.CENTER);
        f.setSize(550, 200);
        f.setVisible(true);
    }
}

class FontPanel extends JPanel {
    final int maxCharHeight = 17;
    final int minFontSize = 6;
    final int maxFontSize = 14;
    final Color bg = Color.lightGray;
    final Color fg = Color.black;

    Dimension totalSize;
    FontMetrics fontMetrics;
    Font biggestFont = new Font("SansSerif", Font.PLAIN, maxFontSize);

    public FontPanel() {
        //Initialize drawing colors, border, opacity.
        setBackground(bg);
        setForeground(fg);
        setBorder(BorderFactory.createCompoundBorder(
                        BorderFactory.createRaisedBevelBorder(),
                        BorderFactory.createLoweredBevelBorder()));
    }

    FontMetrics pickFont(Graphics g,
                         String longString,
                         int xSpace) {
        boolean fontFits = false;
        Font currentFont = biggestFont;
        FontMetrics currentMetrics = getFontMetrics(currentFont);
        int size = currentFont.getSize();
        String name = currentFont.getName();
        int style = currentFont.getStyle();

        while (!fontFits) {
            if ( (currentMetrics.getHeight() <= maxCharHeight)
              && (currentMetrics.stringWidth(longString)
                  <= xSpace)) {
                fontFits = true;
            } else {
                if (size <= minFontSize) {
                    fontFits = true;
                } else {
                    currentFont = new Font(name, style, --size);
                    currentMetrics = getFontMetrics(currentFont);
                }
            }
        }

        //Must set font in both component and Graphics object.
        g.setFont(currentFont);
        setFont(currentFont);
        return currentMetrics;
    }

    public void paintComponent(Graphics g) {
        super.paintComponent(g);      //clears the background

        Dimension d = getSize();
        Insets insets = getInsets();
        int currentWidth = d.width - insets.left - insets.right;
        int currentHeight = d.height - insets.top - insets.bottom;
        int gridWidth = currentWidth / 7;
        int gridHeight = currentHeight / 2;

        if ( (totalSize == null)
          || (totalSize.width != currentWidth)
          || (totalSize.height != currentHeight) ) {
            totalSize = new Dimension(currentWidth, currentHeight);
            fontMetrics = pickFont(g, "drawRoundRect",
                                   gridWidth);
        }

        Color fg3D = Color.lightGray;
        int firstX = insets.left + 3;
        int firstY = insets.top + 3;
        int x = firstX;
        int y = firstY;
        int rectWidth = gridWidth - 2*x;
        int stringY = gridHeight - 5 -
                      fontMetrics.getDescent();
        int rectHeight = stringY - fontMetrics.getMaxAscent()
                         - y - 2;

        // drawLine(x1, y1, x2, y2)
        g.drawLine(x, y+rectHeight-1, x + rectWidth, y);
        g.drawString("drawLine", x, stringY);
        x += gridWidth;

        // drawRect(x, y, w, h)
        g.drawRect(x, y, rectWidth, rectHeight);
        g.drawString("drawRect", x, stringY);
        x += gridWidth;
        // draw3DRect(x, y, w, h, raised)
        g.setColor(fg3D);
        g.draw3DRect(x, y, rectWidth, rectHeight, true);
        g.setColor(fg);
        g.drawString("draw3DRect", x, stringY);
        x += gridWidth;

        // drawRoundRect(x, y, w, h, arcw, arch)
        g.drawRoundRect(x, y, rectWidth, rectHeight, 10, 10);
        g.drawString("drawRoundRect", x, stringY);
        x += gridWidth;

        // drawOval(x, y, w, h)
        g.drawOval(x, y, rectWidth, rectHeight);
        g.drawString("drawOval", x, stringY);
        x += gridWidth;

        // drawArc(x, y, w, h)
        g.drawArc(x, y, rectWidth, rectHeight, 90, 135);
        g.drawString("drawArc", x, stringY);
        x += gridWidth;

        // drawPolygon(xPoints, yPoints, numPoints)
        int x1Points[] = {x, x+rectWidth, x, x+rectWidth};
        int y1Points[] = {y, y+rectHeight, y+rectHeight, y};
        g.drawPolygon(x1Points, y1Points, x1Points.length);
        g.drawString("drawPolygon", x, stringY);

        // NEW ROW
        x = firstX;
        y += gridHeight;
        stringY += gridHeight;

        // drawPolyline(xPoints, yPoints, numPoints)
        // Note: drawPolygon would close the polygon.
        int x2Points[] = {x, x+rectWidth, x, x+rectWidth};
        int y2Points[] = {y, y+rectHeight, y+rectHeight, y};
        g.drawPolyline(x2Points, y2Points, x2Points.length);
        g.drawString("drawPolyline", x, stringY);
        x += gridWidth;

        // fillRect(x, y, w, h)
        g.fillRect(x, y, rectWidth, rectHeight);
        g.drawString("fillRect", x, stringY);
        x += gridWidth;

        // fill3DRect(x, y, w, h, raised)
        g.setColor(fg3D);
        g.fill3DRect(x, y, rectWidth, rectHeight, true);
        g.setColor(fg);
        g.drawString("fill3DRect", x, stringY);
        x += gridWidth;

        // fillRoundRect(x, y, w, h, arcw, arch)
        g.fillRoundRect(x, y, rectWidth, rectHeight, 10, 10);
        g.drawString("fillRoundRect", x, stringY);
        x += gridWidth;

        // fillOval(x, y, w, h)
        g.fillOval(x, y, rectWidth, rectHeight);
        g.drawString("fillOval", x, stringY);
        x += gridWidth;
        // fillArc(x, y, w, h)
        g.fillArc(x, y, rectWidth, rectHeight, 90, 135);
        g.drawString("fillArc", x, stringY);
        x += gridWidth;

        // fillPolygon(xPoints, yPoints, numPoints)
        int x3Points[] = {x, x+rectWidth, x, x+rectWidth};
        int y3Points[] = {y, y+rectHeight, y+rectHeight, y};
        g.fillPolygon(x3Points, y3Points, x3Points.length);
        g.drawString("fillPolygon", x, stringY);
    }
}
```

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Trail: Creating a GUI with JFC/Swing
Lesson: Working with Graphics

Run FontDemo

Note: Because the preceding applet uses the Swing 1.1 API, it requires Java Plug-in 1.1.2 or Java Plug-in 1.2. It won't work with Java Plug-in 1.1.1 or uncustomized 1.1 browsers. For more information about running applets in the tutorial, refer to About Our Examples. That page includes a section about Downloading Java Plug-in.

```
<APPLET CODE="FontDemo.class"
        ARCHIVE="example-swing/fontDemo.jar"
        WIDTH="550" HEIGHT="100"
        ALT="Your browser understands the applet tag but isn't displaying any applet.">
</APPLET>
```

Trail: Creating a GUI with JFC/Swing
Lesson: Working with Graphics

Working with Text

Support for working with primitive text is spread between the AWT `Graphics`◆, `Font`, ◆, and `FontMetrics`◆ classes. Of course, you can save yourself a lot of trouble by using a text-drawing component instead -- a label◆ or text component◆, for instance.

Java^{TM} 2 Note: If you are using Java 2 (JDK^{TM} 1.2), you can use the full-featured text support in the Java^{TM} 2D API. See the 2D Graphics◆ section in the 2D Graphics trail for more information. However, we still recommend that you avoid drawing your own text, and use a standard Swing component instead.

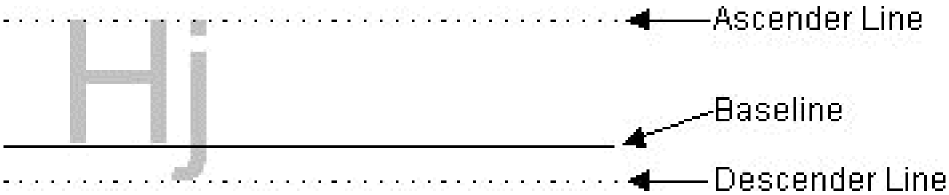
Painting Text

The `Graphics` class provides three methods for painting text: `drawBytes`, `drawChars`, and `drawString`. Here is an example of code that paints a string to the screen:

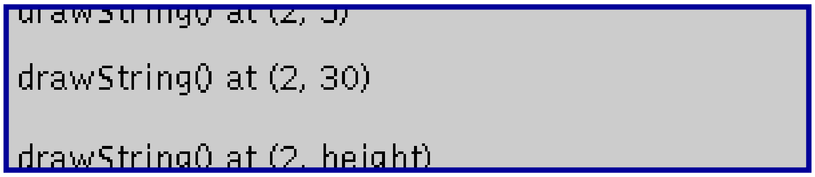
```
g.drawString("Hello World!", x, y);
```

For the text painting methods, `x` and `y` are integers that specify the position of the *lower left* corner of the text. To be precise, the `y` coordinate specifies the *baseline* of the text -- the line that most letters rest on -- which doesn't include room for the tails (*descenders*) on letters such as "y". Be sure to make `y` large enough to allow vertical space for the text, but small enough to allow room for descenders.

Here's a figure that shows the baseline, as well as the ascender and descender lines. You'll learn more about ascenders and descenders a bit later.



Here is a picture of a simple applet that illustrates what can happen when you're not careful about where you position your text:



drawString() at (2, 5)

drawString() at (2, 30)

drawString() at (2, height)

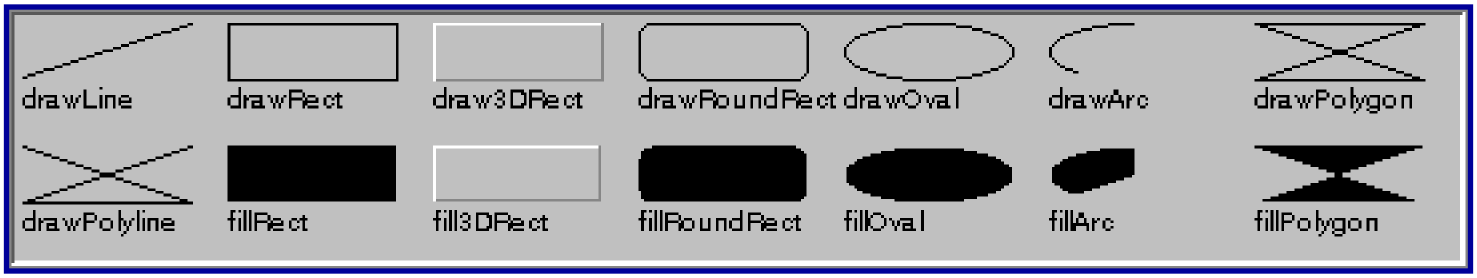
This is a picture of the applet's GUI. To run the applet, click the picture. The applet will appear in a new browser window.

The top string is probably cut off, since its `y` argument is `5`, which leaves only 5 pixels above the baseline for the string -- not enough for most fonts. The middle string probably shows up just fine, unless you have a huge default font. Most of the letters in the bottom string display fine, except for letters with descenders. All descenders in the bottom string are cut off, since the code that displays this string doesn't allow room for them. You can find the applet's source code in `TextXY.java`.

Note: The text-painting methods' interpretation of `x` and `y` is different from that of the shape-painting methods. When painting a shape (such as a rectangle), `x` and `y` specify the *upper* left corner of the shape's bounding rectangle, instead of the lower left corner.

Getting Information about a Font: FontMetrics

The shape-painting example from Example 2: A Shape Sampler could be improved by choosing a font that's smaller than the usual default font. The following example does this and also enlarges the shapes to take up the space freed by the font's smaller height. Here is a picture of the improved applet:



This is a picture of the applet's GUI. To run the applet, click the picture. The applet will appear in a new browser window.

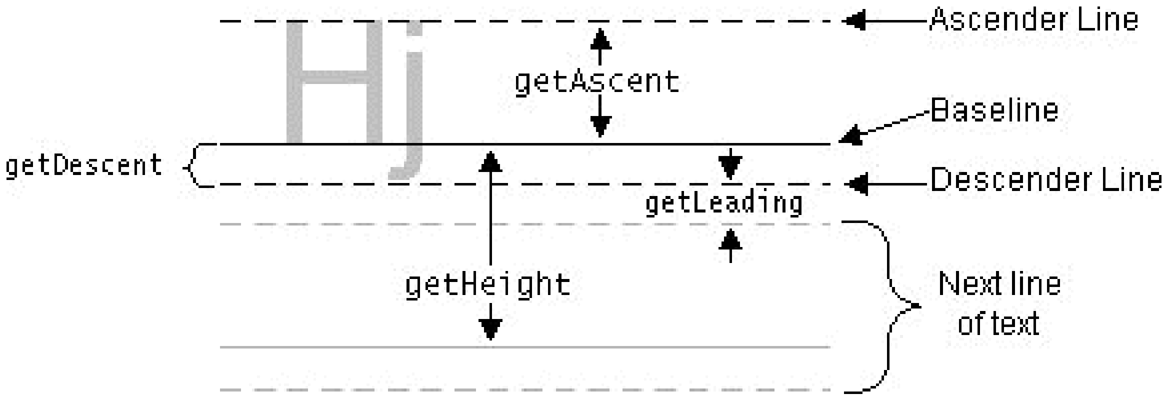
You can find its code in `FontDemo.java`◆. The example chooses the appropriate font by using a `FontMetrics` object to get details of the font's size. For example, the following loop ensures that the longest string displayed by the applet ("drawRoundRect") fits within the space each shape is allotted.

```
boolean fontFits = false;
Font currentFont = biggestFont;
FontMetrics currentMetrics = getFontMetrics(currentFont);
int size = currentFont.getSize();
String name = currentFont.getName();
int style = currentFont.getStyle();

while (!fontFits) {
    if ( (currentMetrics.getHeight() <= maxCharHeight)
      && (currentMetrics.stringWidth(longString)
          <= xSpace)) {
         fontFits = true;
    } else {
         if (size <= minFontSize) {
         fontFits = true;
    } else {
         currentFont = new Font(name, style, --size);
         currentMetrics = getFontMetrics(currentFont);
    }
}
```

The example code above uses the `Graphics` `getFont`, `setFont`, and `getFontMetrics` methods to get and set the current font and to get the `FontMetrics` object that corresponds to the font. From the `FontMetrics` `getHeight` and `stringWidth(String)` methods, the example code gets vertical and horizontal size information about the font.

The following figure shows some of the information that a `FontMetrics` object can provide about a font's size.



Here's a summary of the `FontMetrics` methods that return information about a font's vertical size:

`int getAscent()`, `int getMaxAscent()`

The `getAscent` method returns the number of pixels between the ascender line and the baseline. Generally, the ascender line represents the typical height of capital letters. Specifically, the ascent and descent values are chosen by the font's designer to represent the correct text "color", or density of ink, so that the text appears as the designer planned it. The ascent typically provides enough room for almost all of the characters in the font, except perhaps for accents on capital letters. The `getMaxAscent` method accounts for these exceptionally tall characters.

`int getDescent()`, `int getMaxDescent()`

The `getDescent` method returns the number of pixels between the baseline and the descender line. In most fonts, all characters fall within the descender line at their lowest point. Just in case, though, you can use the `getMaxDescent` method to get a distance guaranteed to encompass all characters.

`int getHeight()`

Returns the number of pixels normally found between the baseline of one line of text and the baseline of the next line of text. Note that this includes an allowance for leading.

`int getLeading()`

Returns the suggested distance (in pixels) between one line of text and the next. Specifically the leading is the distance between the descender line of one line of text and the ascender line of the next line of text. By the way, *leading* is pronounced *LEDDing.*

Note that the font size (returned by the `Font` class `getSize` method) is an abstract measurement. Theoretically, it corresponds to the ascent plus the descent. Practically, however, the font designer decides exactly how tall a "12 point" font (for example) is. For example, 12-point Times is often slightly shorter than 12-point Helvetica. Typically, font size is measured in *points*, which are approximately 1/72 of an inch.

The following list shows the methods that `FontMetrics` provides to return information about the horizontal size of a font's characters. These methods take into account the spacing around each character. More precisely, each method returns *not* the number of pixels taken up by a particular character (or characters), but the number of pixels by which the *current point* will be advanced when that character (or characters) is shown. We call this the *advance width* to distinguish it from the character or text width.

`int getMaxAdvance()`
: The advance width (in pixels) of the widest character in the font.

`int bytesWidth(byte[], int, int)`
: The advance width of the text represented by the specified array of bytes. The first integer argument specifies the starting offset of the data within the byte array. The second integer argument specifies the maximum number of bytes to check.

`int charWidth(int)`, `int charWidth(char)`
: The advance width of the specified character.

`int charsWidth(char[], int, int)`
: The advance width of the string represented by the specified character array.

`int stringWidth(String)`
: The advance width of the specified string.

`int[] getWidths()`
: The advance width of each of the first 256 characters in the font.

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Run TextXY

Note: Because the preceding applet uses the Swing 1.1 API, it requires Java Plug-in 1.1.2 or Java Plug-in 1.2. It won't work with Java Plug-in 1.1.1 or uncustomized 1.1 browsers. For more information about running applets in the tutorial, refer to About Our Examples. That page includes a section about Downloading Java Plug-in.

```java
/*
 * Swing version.
 */

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

/*
 * Very simple applet that illustrates parameters to text-drawing methods.
 */
public class TextXY extends JApplet {
    //Invoked only when executed as applet.
    public void init() {
        buildUI(getContentPane());
    }

    public void buildUI(Container container) {
        TextPanel textPanel = new TextPanel();
        container.add(textPanel, BorderLayout.CENTER);
    }

    class TextPanel extends JPanel {
        public TextPanel() {
            setPreferredSize(new Dimension(400, 100));
        }

        public void paintComponent(Graphics g) {
            super.paintComponent(g);
            g.drawString("drawString() at (2, 5)", 2, 5);
            g.drawString("drawString() at (2, 30)", 2, 30);
            g.drawString("drawString() at (2, height)", 2, getHeight());
        }
    }

    //Invoked only when executed as application.
    public static void main(String[] args) {
        JFrame f = new JFrame("TextXY");
        f.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });

        TextXY controller = new TextXY();
        controller.buildUI(f.getContentPane());
        f.pack();
        f.setVisible(true);
    }
}
```

S.S. JAVA

```
<APPLET CODE="ImageDisplayer.class"
        CODEBASE="example-swing"
        ARCHIVE="image.jar"
        WIDTH="400" HEIGHT="70">
</APPLET>
```

```
/*
 * Swing version.
 */

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

/*
 * This applet displays several images in a row.  However,
 * it doesn't wait for the images to fully load before drawing
 * them, which causes the weird effect of the animation appearing
 * from the top down.
 */

public class ImageSequenceTimer extends JApplet
                                implements ActionListener {
    ImageSQPanel imageSQPanel;
    static int frameNumber = -1;
    int delay;
    Thread animatorThread;
    static boolean frozen = false;
    Timer timer;

    //Invoked only when this is run as an applet.
    public void init() {
        //Get the images.
        Image[] images = new Image[10];
        for (int i = 1; i <= 10; i++) {
            images[i-1] = getImage(getCodeBase(), "images/T"+i+".gif");
        }
        buildUI(getContentPane(), images);
        startAnimation();
    }

    //Note: Container must use BorderLayout, which is the
    //default layout manager for content panes.
    void buildUI(Container container, Image[] dukes) {
        int fps = 10;

        //How many milliseconds between frames?
        delay = (fps > 0) ? (1000 / fps) : 100;

        //Set up a timer that calls this object's action handler
        timer = new Timer(delay, this);
        timer.setInitialDelay(0);
        timer.setCoalesce(true);

        imageSQPanel = new ImageSQPanel(dukes);
        container.add(imageSQPanel, BorderLayout.CENTER);

        imageSQPanel.addMouseListener(new MouseAdapter() {
            public void mousePressed(MouseEvent e) {
                if (frozen) {
                    frozen = false;
                    startAnimation();
                } else {
                    frozen = true;
                    stopAnimation();
                }
            }
       });
    }

    public void start() {
        startAnimation();
    }

    public void stop() {
        stopAnimation();
    }

    public synchronized void startAnimation() {
        if (frozen) {
            //Do nothing.  The user has requested that we
            //stop changing the image.
        } else {
            //Start animating!
            if (!timer.isRunning()) {
                timer.start();
            }
        }
    }

    public synchronized void stopAnimation() {
        //Stop the animating thread.
        if (timer.isRunning()) {
            timer.stop();
        }
    }

    public void actionPerformed(ActionEvent e) {
        //Advance the animation frame.
        frameNumber++;

        //Display it.
        imageSQPanel.repaint();
    }

    class ImageSQPanel extends JPanel{
        Image dukesWave[];

        public ImageSQPanel(Image[] dukesWave) {
            this.dukesWave = dukesWave;
        }

        //Draw the current frame of animation.
        public void paintComponent(Graphics g) {
            super.paintComponent(g); //paint background

            //Paint the frame into the image.
            try {
                g.drawImage(dukesWave[ImageSequenceTimer.frameNumber%10],
                            0, 0, this);

            } catch (ArrayIndexOutOfBoundsException e) {
                //On rare occasions, this method can be called
                //when frameNumber is still -1.  Do nothing.
                return;
            }
        }
    }

    //Invoked only when this is run as an application.
    public static void main(String[] args) {
        Image[] waving = new Image[10];

        for (int i = 1; i <= 10; i++) {
            waving[i-1] =
                Toolkit.getDefaultToolkit().getImage(
                    "images/T"+i+".gif");
        }

        JFrame f = new JFrame("ImageSequenceTimer");
        f.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });

        ImageSequenceTimer controller = new ImageSequenceTimer();
        controller.buildUI(f.getContentPane(), waving);
        controller.startAnimation();
        f.setSize(new Dimension(75, 100));
        f.setVisible(true);
    }
}
```

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Run ImageSequenceTimer

Note: Because the preceding applet uses the Swing 1.1 API, it requires Java Plug-in 1.1.2 or Java Plug-in 1.2. It won't work with Java Plug-in 1.1.1 or uncustomized 1.1 browsers. For more information about running applets in the tutorial, refer to About Our Examples. That page includes a section about Downloading Java Plug-in.

```
<APPLET CODE="ImageSequenceTimer.class"
        CODEBASE="example-swing"
        ARCHIVE="imageTimer.jar"
        WIDTH="55" HEIGHT="68"
        ALT="Your browser understands the applet tag but isn't displaying any applet.">
</APPLET>
```

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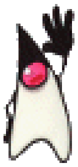
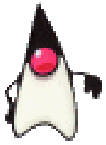
Trail: Creating a GUI with JFC/Swing
Lesson: Working with Graphics

Displaying a Sequence of Images

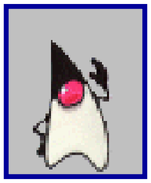
The example in this section gives you the basics of displaying an image sequence. The next section has hints for improving the appearance and performance of this animation. This section shows only applet code. The code for an application would be similar, except you would use different code to load the images, as described in Loading Images.

Below are the ten images this applet uses.

T1.gif:
T2.gif:
T3.gif:
T4.gif:
T5.gif: 

T6.gif:
T7.gif:
T8.gif:
T9.gif:
T10.gif: 

Here's a picture of what the applet looks like. Remember that you can click on the applet to stop or start the animation.



This is a picture of the applet's GUI. To run the applet, click the picture. The applet will appear in a new browser window.

The code for this example, in `ImageSequenceTimer.java`, is even simpler than for the previous example, which moved an image. Here is the code that differs significantly from the moving image example:

```
. . .//In initialization code:
Image[] images = new Image[10];
for (int i = 1; i <= 10; i++) {
    images[i-1] = getImage(getCodeBase(), "images/duke/T"+i+".gif");
}
```

```
. . .//In the paintComponent method:
g.drawImage(images[ImageSequenceTimer.frameNumber % 10],
            0, 0, this);
```

Another way to implement this example would be to use a label to display the image. Instead of having custom painting code, the program would use the `setIcon` method to change the image displayed.

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```java
/*
 * Swing version.
 */

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

/*
 * This applet displays several images in a row.  It preloads
 * the images using MediaTracker, which uses multiple background
 * threads to download the images.  The program displays a
 * "Please wait" message until all the images are fully loaded.
 * Note that the Swing ImageIcon class uses MediaTracker to
 * preload images, so you can often use it instead of using
 * Images and MediaTracker directly.
 */

public class MTImageSequenceTimer extends JApplet
                                  implements ActionListener {
    MTPanel mtPanel;
    static int frameNumber = -1;
    int delay;
    static boolean frozen = false;
    Timer timer;
    boolean error;
    MediaTracker tracker;

    //Invoked only when run as an applet.
    public void init() {
        //Load the images.
        Image images[] = new Image[10];
        for (int i = 1; i <= 10; i++) {
            images[i-1] = getImage(getCodeBase(), "images/T"+i+".gif");
        }
        buildUI(getContentPane(), images);
        startAnimation();
    }

    void buildUI(Container container, Image[] dukes) {
        tracker = new MediaTracker(this);
        for (int i = 1; i <= 10; i++) {
            tracker.addImage(dukes[i-1], 0);
            error = tracker.isErrorAny();
        }

        int fps = 10;

        //How many milliseconds between frames?
        delay = (fps > 0) ? (1000 / fps) : 100;

        //Set up a timer that calls this object's action handler.
        timer = new Timer(delay, this);
        timer.setInitialDelay(0);
        timer.setCoalesce(true);

        mtPanel = new MTPanel(dukes);
        container.add(mtPanel, BorderLayout.CENTER);

        mtPanel.addMouseListener(new MouseAdapter() {
            public void mousePressed(MouseEvent e) {
                if (frozen) {
                    frozen = false;
                    startAnimation();
                } else {
                    frozen = true;
                    stopAnimation();
                }
            }
       });
    }

    public void start() {
        startAnimation();
    }

    public void stop() {
        stopAnimation();
    }

    public synchronized void startAnimation() {
        if (frozen) {
            //Do nothing.  The user has requested that we
            //stop changing the image.
        } else {
            //Start animating!
            if (!timer.isRunning()) {
                timer.start();
            }
        }
    }

    public synchronized void stopAnimation() {
        //Stop the animating thread.
        if (timer.isRunning()) {
            timer.stop();
        }
    }

    public void actionPerformed(ActionEvent e) {
        //Start downloading the images. Wait until they're
        //loaded before requesting repaints.
        try {
            tracker.waitForAll();
        } catch (InterruptedException exc) {}

        //Advance the frame.
        frameNumber++;

        //Display it.
        mtPanel.repaint();
    }

    class MTPanel extends JPanel {
        Image dukesWave[];

        public MTPanel(Image[] dukesWave) {
            this.dukesWave = dukesWave;
        }

        //Draw the current frame of animation.
        public void paintComponent(Graphics g) {
            super.paintComponent(g); //paint the background
            int width = getWidth();
            int height = getHeight();

            //If not all the images are loaded,
            //just display a status string.
            if (!tracker.checkAll()) {
                g.drawString("Please wait...", 0, height/2);
                return;
            }

            //Paint the frame into the image.
            g.drawImage(dukesWave[MTImageSequenceTimer.frameNumber%10],
                        0, 0, this);
        }
    }

    //Invoked only when run as an application.
    public static void main(String[] args) {
        Image[] waving = new Image[10];
        for (int i = 1; i <= 10; i++) {
            waving[i-1] =
                Toolkit.getDefaultToolkit().getImage("images/T"+i+".gif");
        }

        JFrame f = new JFrame("MTImageSequenceTimer");
        f.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });

        MTImageSequenceTimer controller = new MTImageSequenceTimer();
        controller.buildUI(f.getContentPane(), waving);
        controller.startAnimation();
        f.setSize(new Dimension(75, 100));
        f.setVisible(true);
    }
}
```

Run MTImageSequenceTimer

Note: Because the preceding applet uses the Swing 1.1 API, it requires Java Plug-in 1.1.2 or Java Plug-in 1.2. It won't work with Java Plug-in 1.1.1 or uncustomized 1.1 browsers. For more information about running applets in the tutorial, refer to About Our Examples. That page includes a section about Downloading Java Plug-in.

```
<APPLET CODE="MTImageSequenceTimer.class"
        CODEBASE="example-swing"
        ARCHIVE="mtTimer.jar"
        WIDTH="55" HEIGHT="68"
        ALT="Your browser understands the applet tag but isn't displaying any applet.">
</APPLET>
```

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Improving the Appearance and Performance of Image Animation

You might have noticed two things about the animation on the previous page:

- While the images were loading, the program displayed some images partially and others not at all.
- Loading the images took a long time.

The problem of displaying partial images is easy to fix, using the `MediaTracker`◆ class. `MediaTracker` also can decrease the amount of time that loading images takes. Another way to deal with the problem of slow image loading is to change the image format somehow; this page gives you some suggestions for doing so.

Note: The `ImageIcon` class◆ provided by Swing automatically uses a `MediaTracker` to download image data as soon as an `ImageIcon` is created. For more information, see How to Use Icons◆.

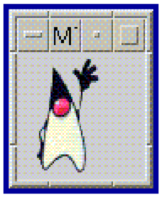
Using MediaTracker to Download Images and Delay Image Display

The `MediaTracker` class lets you easily download data for a group of images and find out when the images are fully loaded. Ordinarily, an image's data isn't downloaded until the image is painted for the first time. To request that the data for a group of images be preloaded asynchronously, use one of the following `MediaTracker` methods: `checkID(`*`anInt`*`, true)` or `checkAll(true)`. To load data synchronously (waiting for the data to arrive), use the `waitForID` or `waitForAll` method. The `MediaTracker` methods that load data use several background threads to download the data, which can speed up downloading.

To check on the status of image loading, you can use the `MediaTracker` `statusID` or `statusAll` method. To simply check whether any image data remains to be loaded, you can use the `checkID` or `checkAll` method.

In `MTImageSequenceTimer.java` is a modified version of the example applet that uses the `MediaTracker` `waitForAll` and `checkAll` methods. Until every image is fully loaded, this applet simply displays a "Please wait..." message. See the `MediaTracker` API documentation for an example that paints a background image immediately, but delays painting the animated images.

Here is a picture of the applet:



This is a picture of the applet's GUI. To run the applet, click the picture. The applet will appear in a new browser window.

Below is the changed code, which uses a `MediaTracker` to help delay image display. Differences are marked in a **bold** font.

```
...//Where instance variables are declared:
MediaTracker tracker;

tracker = new MediaTracker(this);

...//In the init method:
for (int i = 1; i <= 10; i++) {
    images[i-1] = getImage(getCodeBase(),
                           "images/duke/T"+i+".gif");
}

...//In the buildUI method,
   //which is called by init and main,
   //allowing us to run the sample
   //as an applet or an application:
for (int i = 1; i <= 10; i++) {
    tracker.addImage(images[i-1], 0);
}

...//At the beginning of the actionPerformed method:
try {
    //Start downloading the images. Wait until they're loaded.
    tracker.waitForAll();
} catch (InterruptedException e) {}
```

```
...//In the paintComponent method:
//If not all the images are loaded, just clear the background
//and display a status string.
if (!tracker.checkAll()) {
    g.clearRect(0, 0, d.width, d.height);
    g.drawString("Please wait...", 0, d.height/2);
}

//If all images are loaded, paint.
else {
    ...//same code as before...
}
```

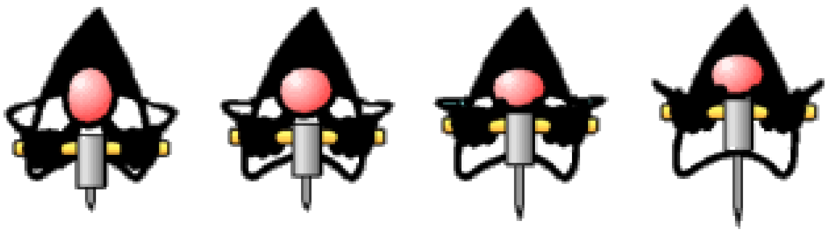
Speeding Up Image Loading

Whether or not you use `MediaTracker`, loading images using URLs (as applets usually do) usually takes a long time. Most of the time is taken up by initiating HTTP connections. Each image file requires a separate HTTP connection, and each connection can take several seconds to initiate.

The key to avoiding this performance hit is to put the images in a single file. You can do this using a JAR file, as described in Combining an Applet's Files into a Single File◆ and Using JAR Files: The Basics◆.

Another performance strategy that might help is to combine a group of images into a single image file. One simple way to do this is to create an image strip -- a file that contains several images in a row. Here's an example of an image strip:

jack.gif:



To paint an image from the strip, you first set the painting area to the size of one image. Then you paint the image strip, shifted to the left (if necessary) so that only the image you want appears within the painting area. For example:

```
//imageStrip is the Image object representing the image strip.
```

```
//imageWidth is the size of an individual image in the strip.
//imageNumber is the number (from 0 to numImages)
//    of the image to paint.
int stripWidth = imageStrip.getWidth(this);
int stripHeight = imageStrip.getHeight(this);
int imageWidth = stripWidth / numImages;
g.clipRect(0, 0, imageWidth, stripHeight);
g.drawImage(imageStrip, -imageNumber*imageWidth, 0, this);
```

If you want image loading to be faster still, you should look into image compression schemes, especially ones that perform interframe compression.

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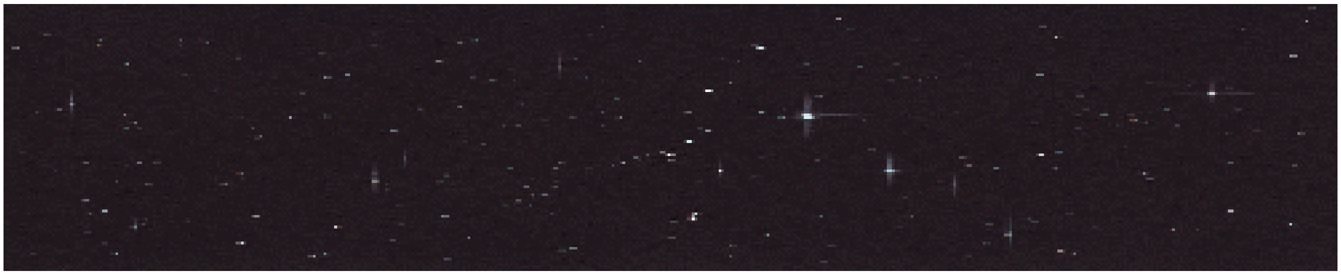
```
/*
 * Swing version.
 */

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

/*
 * Moves a foreground image in front of a background image.
 * See MovingLabels.java for an alternative implementation
 * that uses two labels instead of doing its own painting.
 */
public class MovingImageTimer extends JApplet
                              implements ActionListener {
    int frameNumber = -1;
    boolean frozen = false;
    Timer timer;
    AnimationPane animationPane;

    static String fgFile = "images/rocketship.gif";
    static String bgFile = "images/starfield.gif";

    //Invoked only when run as an applet.
    public void init() {
        //Get the images.
        Image bgImage = getImage(getCodeBase(), bgFile);
        Image fgImage = getImage(getCodeBase(), fgFile);
        buildUI(getContentPane(), bgImage, fgImage);
    }

    void buildUI(Container container, Image bgImage, Image fgImage) {
        int fps = 10;

        //How many milliseconds between frames?
        int delay = (fps > 0) ? (1000 / fps) : 100;

        //Set up a timer that calls this object's action handler.
        timer = new Timer(delay, this);
        timer.setInitialDelay(0);
        timer.setCoalesce(true);

        animationPane = new AnimationPane(bgImage, fgImage);
        container.add(animationPane, BorderLayout.CENTER);

        animationPane.addMouseListener(new MouseAdapter() {
            public void mousePressed(MouseEvent e) {
                if (frozen) {
                    frozen = false;
                    startAnimation();
                } else {
                    frozen = true;
                    stopAnimation();
                }
            }
       });
    }

    //Invoked by a browser only.
    public void start() {
        startAnimation();
    }
    //Invoked by a browser only.
    public void stop() {
        stopAnimation();
    }

    //Can be invoked from any thread.
    public synchronized void startAnimation() {
        if (frozen) {
            //Do nothing.  The user has requested that we
            //stop changing the image.
        } else {
            //Start animating!
            if (!timer.isRunning()) {
                timer.start();
            }
        }
    }

    //Can be invoked from any thread.
    public synchronized void stopAnimation() {
        //Stop the animating thread.
        if (timer.isRunning()) {
            timer.stop();
        }
    }

    public void actionPerformed(ActionEvent e) {
        //Advance animation frame.
        frameNumber++;

        //Display it.
        animationPane.repaint();
    }

    class AnimationPane extends JPanel {
        Image background, foreground;

        public AnimationPane(Image background, Image foreground) {
            this.background = background;
            this.foreground = foreground;
        }

        //Draw the current frame of animation.
        public void paintComponent(Graphics g) {
            super.paintComponent(g);  //paint any space not covered
                                      //by the background image
            int compWidth = getWidth();
            int compHeight = getHeight();
            int imageWidth, imageHeight;

            //If we have a valid width and height for the
            //background image, draw it.
            imageWidth = background.getWidth(this);
            imageHeight = background.getHeight(this);
            if ((imageWidth > 0) && (imageHeight > 0)) {
                g.drawImage(background,
                            (compWidth - imageWidth)/2,
                            (compHeight - imageHeight)/2, this);
            }

            //If we have a valid width and height for the
            //foreground image, draw it.
            imageWidth = foreground.getWidth(this);
            imageHeight = foreground.getHeight(this);
            if ((imageWidth > 0) && (imageHeight > 0)) {
                g.drawImage(foreground,
                            ((frameNumber*5)
                              % (imageWidth + compWidth))
                              - imageWidth,
                            (compHeight - imageHeight)/2,
                            this);
            }
        }
    }

    //Invoked only when run as an application.
    public static void main(String[] args) {
        Image bgImage = Toolkit.getDefaultToolkit().getImage(
                                MovingImageTimer.bgFile);
        Image fgImage = Toolkit.getDefaultToolkit().getImage(
                                MovingImageTimer.fgFile);

        JFrame f = new JFrame("MovingImageTimer");
        final MovingImageTimer controller = new MovingImageTimer();
        controller.buildUI(f.getContentPane(), bgImage, fgImage);

        f.addWindowListener(new WindowAdapter() {
            public void windowIconified(WindowEvent e) {
                controller.stopAnimation();
            }
            public void windowDeiconified(WindowEvent e) {
                controller.startAnimation();
            }
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });
        f.setSize(new Dimension(500, 125));
        f.setVisible(true);
        controller.startAnimation();
    }
}
```



Run MovingImageTimer

Note: Because the preceding applet uses the Swing 1.1 API, it requires Java Plug-in 1.1.2 or Java Plug-in 1.2. It won't work with Java Plug-in 1.1.1 or uncustomized 1.1 browsers. For more information about running applets in the tutorial, refer to About Our Examples. That page includes a section about Downloading Java Plug-in.

```
<APPLET CODE="MovingImageTimer.class"
        CODEBASE="example-swing"
        ARCHIVE="moveTimer.jar"
        WIDTH="500" HEIGHT="100"
        ALT="Your browser understands the applet tag but isn't displaying any applet.">
</APPLET>
```

```
/*
 * Swing version.
 */

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

public class MovingLabels extends JApplet
                          implements ActionListener {
    int frameNumber = -1;
    Timer timer;
    boolean frozen = false;

    JLayeredPane layeredPane;
    JLabel bgLabel, fgLabel;
    int fgHeight, fgWidth;
    int bgHeight, bgWidth;
    static String fgFile = "images/rocketship.gif";
    static String bgFile = "images/starfield.gif";

    //Invoked only when run as an applet.
    public void init() {
        Image bgImage = getImage(getCodeBase(), bgFile);
        Image fgImage = getImage(getCodeBase(), fgFile);
        buildUI(getContentPane(), bgImage, fgImage);
    }

    void buildUI(Container container, Image bgImage, Image fgImage) {
        final ImageIcon bgIcon = new ImageIcon(bgImage);
        final ImageIcon fgIcon = new ImageIcon(fgImage);
        bgWidth = bgIcon.getIconWidth();
        bgHeight = bgIcon.getIconHeight();
        fgWidth = fgIcon.getIconWidth();
        fgHeight = fgIcon.getIconHeight();

        //Set up a timer that calls this object's action handler
        timer = new Timer(100, this); //delay = 100 ms
        timer.setInitialDelay(0);
        timer.setCoalesce(true);

        //Create a label to display the background image.
        bgLabel = new JLabel(bgIcon);
        bgLabel.setOpaque(true);
        bgLabel.setBounds(0, 0, bgWidth, bgHeight);

        //Create a label to display the foreground image.
        fgLabel = new JLabel(fgIcon);
        fgLabel.setBounds(-fgWidth, -fgHeight, fgWidth, fgHeight);

        //Create the layered pane to hold the labels.
        layeredPane = new JLayeredPane();
        layeredPane.setPreferredSize(
                       new Dimension(bgWidth, bgHeight));
        layeredPane.addMouseListener(new MouseAdapter() {
            public void mousePressed(MouseEvent e) {
               if (frozen) {
                    frozen = false;
                    startAnimation();
                } else {
                    frozen = true;
                    stopAnimation();
                }
            }
        });

        layeredPane.add(bgLabel, new Integer(0));  //low layer
        layeredPane.add(fgLabel, new Integer(1));  //high layer
        container.add(layeredPane, BorderLayout.CENTER);
    }

    //Invoked by the applet browser only.
    public void start() {
        startAnimation();
    }

    //Invoked by the applet browser only.
    public void stop() {
        stopAnimation();
    }

    public synchronized void startAnimation() {
        if (frozen) {
            //Do nothing.  The user has requested that we
            //stop changing the image.
        } else {
            //Start animating!
            if (!timer.isRunning()) {
                timer.start();
            }
        }
    }

    public synchronized void stopAnimation() {
        //Stop the animating thread.
        if (timer.isRunning()) {
            timer.stop();
        }
    }

    public void actionPerformed(ActionEvent e) {
        //Advance animation frame.
        frameNumber++;

        //Display it.
        fgLabel.setLocation(
            ((frameNumber*5)
             % (fgWidth + bgWidth))
            - fgWidth,
            (bgHeight - fgHeight)/2);
    }

    //Invoked only when run as an application.
    public static void main(String[] args) {
        Image bgImage = Toolkit.getDefaultToolkit().getImage(
                                MovingLabels.bgFile);
        Image fgImage = Toolkit.getDefaultToolkit().getImage(
                                MovingLabels.fgFile);
        final MovingLabels movingLabels = new MovingLabels();
        JFrame f = new JFrame("MovingLabels");
        f.addWindowListener(new WindowAdapter() {
            public void windowIconified(WindowEvent e) {
                movingLabels.stopAnimation();
            }
            public void windowDeiconified(WindowEvent e) {
                movingLabels.startAnimation();
            }
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });
        movingLabels.buildUI(f.getContentPane(), bgImage, fgImage);
        f.setSize(500, 125);
        f.setVisible(true);
        movingLabels.startAnimation();
    }
}
```

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Run MovingLabels

Note: Because the preceding applet uses the Swing 1.1 API, it requires Java Plug-in 1.1.2 or Java Plug-in 1.2. It won't work with Java Plug-in 1.1.1 or uncustomized 1.1 browsers. For more information about running applets in the tutorial, refer to About Our Examples. That page includes a section about Downloading Java Plug-in.

```
<APPLET CODE="MovingLabels.class"
        CODEBASE="example-swing"
        ARCHIVE="moveLabels.jar"
        WIDTH="500" HEIGHT="100"
        ALT="Your browser understands the applet tag but isn't displaying any applet.">
</APPLET>
```

```
/*
 * Swing version.
 */

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

/*
 * Displays a framed area.  When the user clicks within
 * the area, this program displays a filled rectangle
 * and a string indicating the coordinates where the
 * click occurred.
 */

public class RectangleDemo extends JApplet {
    JLabel label;

    //Called only when this is run as an applet.
    public void init() {
        buildUI(getContentPane());
    }

    void buildUI(Container container) {
        container.setLayout(new BoxLayout(container,
                                          BoxLayout.Y_AXIS));

        RectangleArea rectangleArea = new RectangleArea(this);
        container.add(rectangleArea);

        label = new JLabel("Click within the framed area.");
        container.add(label);

        //Align the left edges of the components.
        rectangleArea.setAlignmentX(LEFT_ALIGNMENT);
        label.setAlignmentX(LEFT_ALIGNMENT); //unnecessary, but doesn't hurt
    }

    public void updateLabel(Point point) {
        label.setText("Click occurred at coordinate ("
                      + point.x + ", " + point.y + ").");
    }

    //Called only when this is run as an application.
    public static void main(String[] args) {
        JFrame f = new JFrame("RectangleDemo");
        f.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });
        RectangleDemo controller = new RectangleDemo();
        controller.buildUI(f.getContentPane());
        f.pack();
        f.setVisible(true);
    }
}

class RectangleArea extends JPanel {
    Point point = null;
    RectangleDemo controller;
    Dimension preferredSize = new Dimension(300,100);
    int rectWidth = 50;
    int rectHeight = 50;

    public RectangleArea(RectangleDemo controller) {
        this.controller = controller;

        Border raisedBevel = BorderFactory.createRaisedBevelBorder();
        Border loweredBevel = BorderFactory.createLoweredBevelBorder();
        Border compound = BorderFactory.createCompoundBorder
                              (raisedBevel, loweredBevel);
        setBorder(compound);

        addMouseListener(new MouseAdapter() {
            public void mousePressed(MouseEvent e) {
                int x = e.getX();
                int y = e.getY();
                if (point == null) {
                    point = new Point(x, y);
                } else {
                    point.x = x;
                    point.y = y;
                }
                repaint();
            }
        });
    }

    public Dimension getPreferredSize() {
        return preferredSize;
    }

    public void paintComponent(Graphics g) {
        super.paintComponent(g);  //paint background

        //Paint a filled rectangle at user's chosen point.
        if (point != null) {
            g.drawRect(point.x, point.y,
                       rectWidth - 1, rectHeight - 1);
            g.setColor(Color.yellow);
            g.fillRect(point.x + 1, point.y + 1,
                       rectWidth - 2, rectHeight - 2);

            controller.updateLabel(point);
        }
    }
}
```

The Java^{TM} Tutorial

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Run RectangleDemo

Note: Because the preceding applet uses the Swing 1.1 API, it requires Java Plug-in 1.1.2 or Java Plug-in 1.2. It won't work with Java Plug-in 1.1.1 or uncustomized 1.1 browsers. For more information about running applets in the tutorial, refer to About Our Examples. That page includes a section about Downloading Java Plug-in.

```
<APPLET CODE = "RectangleDemo.class"
        ARCHIVE="example-swing/rectangleDemo.jar"
        WIDTH = "400" HEIGHT = "150" >
</APPLET>
```

```
<APPLET CODE = "SelectionDemo.class"
        CODEBASE="example-swing"
        ARCHIVE="selectionDemo.jar"
        WIDTH = "400" HEIGHT = "100" >
</APPLET>
```

```
/*
 * Swing version.
 */

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

/*
 * This displays a framed area containing one of
 * each shape you can draw.
 */
public class ShapesDemo extends JApplet {

    //Executed only when this program is run as an applet.
    public void init() {
        ShapesPanel shapesPanel = new ShapesPanel();
        getContentPane().add(shapesPanel, BorderLayout.CENTER);
    }

    //Executed only when this program is run as an applicaiton.
    public static void main(String[] args) {
        JFrame f = new JFrame("ShapesDemo");
        f.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });

        ShapesPanel shapesPanel = new ShapesPanel();
        f.getContentPane().add(shapesPanel, BorderLayout.CENTER);
        f.setSize(new Dimension(550, 200));
        f.setVisible(true);
    }
}

class ShapesPanel extends JPanel {
    final int maxCharHeight = 15;
    final Color bg = Color.lightGray;
    final Color fg = Color.black;

    public ShapesPanel() {
        //Initialize drawing colors, border, opacity.
        setBackground(bg);
        setForeground(fg);
        setBorder(BorderFactory.createCompoundBorder(
                BorderFactory.createRaisedBevelBorder(),
                BorderFactory.createLoweredBevelBorder()));
    }

    public void paintComponent(Graphics g) {
        super.paintComponent(g);      //clears the background

        Insets insets = getInsets();
        int currentWidth = getWidth() - insets.left - insets.right;
        int currentHeight = getHeight() - insets.top - insets.bottom;
        int gridWidth = currentWidth / 7;
        int gridHeight = currentHeight / 2;

        Color fg3D = Color.lightGray;
        int firstX = insets.left + 3;
        int firstY = insets.top + 3;
        int x = firstX;
        int y = firstY;
        int stringY = gridHeight - 7;
        int rectWidth = gridWidth - 2*x;
        int rectHeight = stringY - maxCharHeight - y;

        // drawLine(x1, y1, x2, y2)
        g.drawLine(x, y+rectHeight-1, x + rectWidth, y);
        g.drawString("drawLine", x, stringY);
        x += gridWidth;

        // drawRect(x, y, w, h)
        g.drawRect(x, y, rectWidth, rectHeight);
        g.drawString("drawRect", x, stringY);
        x += gridWidth;

        // draw3DRect(x, y, w, h, raised)
        g.setColor(fg3D);
        g.draw3DRect(x, y, rectWidth, rectHeight, true);
        g.setColor(fg);
        g.drawString("draw3DRect", x, stringY);
        x += gridWidth;

        // drawRoundRect(x, y, w, h, arcw, arch)
        g.drawRoundRect(x, y, rectWidth, rectHeight, 10, 10);
        g.drawString("drawRoundRect", x, stringY);
        x += gridWidth;

        // drawOval(x, y, w, h)
        g.drawOval(x, y, rectWidth, rectHeight);
        g.drawString("drawOval", x, stringY);
        x += gridWidth;

        // drawArc(x, y, w, h)
        g.drawArc(x, y, rectWidth, rectHeight, 90, 135);
        g.drawString("drawArc", x, stringY);
        x += gridWidth;

        // drawPolygon(xPoints, yPoints, numPoints)
        int x1Points[] = {x, x+rectWidth, x, x+rectWidth};
        int y1Points[] = {y, y+rectHeight, y+rectHeight, y};
        g.drawPolygon(x1Points, y1Points, x1Points.length);
        g.drawString("drawPolygon", x, stringY);

        // NEW ROW
        x = firstX;
        y += gridHeight;
        stringY += gridHeight;

        // drawPolyline(xPoints, yPoints, numPoints)
        // Note: drawPolygon would close the polygon.
        int x2Points[] = {x, x+rectWidth, x, x+rectWidth};
        int y2Points[] = {y, y+rectHeight, y+rectHeight, y};
        g.drawPolyline(x2Points, y2Points, x2Points.length);
        g.drawString("drawPolyline", x, stringY);
        x += gridWidth;

        // fillRect(x, y, w, h)
        g.fillRect(x, y, rectWidth, rectHeight);
        g.drawString("fillRect", x, stringY);
        x += gridWidth;
        // fill3DRect(x, y, w, h, raised)
        g.setColor(fg3D);
        g.fill3DRect(x, y, rectWidth, rectHeight, true);
        g.setColor(fg);
        g.drawString("fill3DRect", x, stringY);
        x += gridWidth;

        // fillRoundRect(x, y, w, h, arcw, arch)
        g.fillRoundRect(x, y, rectWidth, rectHeight, 10, 10);
        g.drawString("fillRoundRect", x, stringY);
        x += gridWidth;

        // fillOval(x, y, w, h)
        g.fillOval(x, y, rectWidth, rectHeight);
        g.drawString("fillOval", x, stringY);
        x += gridWidth;

        // fillArc(x, y, w, h)
        g.fillArc(x, y, rectWidth, rectHeight, 90, 135);
        g.drawString("fillArc", x, stringY);
        x += gridWidth;

        // fillPolygon(xPoints, yPoints, numPoints)
        int x3Points[] = {x, x+rectWidth, x, x+rectWidth};
        int y3Points[] = {y, y+rectHeight, y+rectHeight, y};
        g.fillPolygon(x3Points, y3Points, x3Points.length);
        g.drawString("fillPolygon", x, stringY);
    }
}
```

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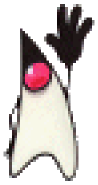
Run ShapesDemo

Note: Because the preceding applet uses the Swing 1.1 API, it requires Java Plug-in 1.1.2 or Java Plug-in 1.2. It won't work with Java Plug-in 1.1.1 or uncustomized 1.1 browsers. For more information about running applets in the tutorial, refer to About Our Examples. That page includes a section about Downloading Java Plug-in.

```
<APPLET CODE="ShapesDemo.class"
        ARCHIVE="example-swing/shapesDemo.jar"
        WIDTH="550" HEIGHT="100"
        ALT="Your browser understands the applet tag but isn't displaying any applet.">
</APPLET>
```

```
<APPLET CODE="TextXY.class"
        ARCHIVE="example-swing/textXY.jar"
        WIDTH="300" HEIGHT="60"
        ALT="Your browser understands the applet tag but isn't displaying any applet.">
</APPLET>
```



Trail: Creating a GUI with JFC/Swing
Lesson: Working with Graphics

Loading Images

This section describes how to get the `Image` object corresponding to an image. As long as the image data is in GIF or JPEG format and you know its filename or URL, it's easy to get an `Image` object for it: just use one of the `Applet` or `Toolkit` `getImage` methods. The `getImage` methods return immediately, without checking whether the image data exists. The actual loading of image data normally doesn't start until the first time the program tries to paint the image.

For many programs, this invisible background loading works well. Others, though, need to keep track of the progress of the image loading. This section explains how to do so using the `MediaTracker` class and the `ImageObserver` interface.

Note: The `ImageIcon`◆ class automatically uses a `MediaTracker` to load its image.

Finally, this section tells you how to create images on the fly, using a class such as `MemoryImageSource`.

Using the getImage Methods

This section discusses first the `Toolkit` `getImage` methods and then the `Applet` `getImage` methods.

The `Toolkit` class declares two `getImage` methods:

- `Image getImage(URL url)`
- `Image getImage(String filename)`

Here are examples of using the `Toolkit` `getImage` methods. Although every Java application and applet can use these methods, applets are subject to the usual security restrictions. In particular, untrusted applets can't successfully specify a filename to `getImage` because untrusted applets can't load data from the local file system. You can find information about restrictions on untrusted applets in Security Restrictions◆.

```
Toolkit toolkit = Toolkit.getDefaultToolkit();
Image image1 = toolkit.getImage("imageFile.gif");
Image image2 = toolkit.getImage(
    new URL("http://java.sun.com/graphics/people.gif"));
```

The `Applet` class supplies two `getImage` methods:

- `Image getImage(URL url)`
- `Image getImage(URL url, String name)`

Only applets can use the `Applet getImage` methods. Moreover, the `Applet getImage` methods don't work until the applet has a full context (`AppletContext`). For this reason, these methods *do not work* if called in a constructor or in a statement that declares an instance variable. You should instead call `getImage` from a method such as `init`.

This following code examples show you how to use the `Applet getImage` methods. See Using the AWT to Create a GUI◆ for an explanation of the `getCodeBase` and `getDocumentBase` methods.

```
//In a method in an Applet subclass:
Image image1 = getImage(getCodeBase(), "imageFile.gif");
Image image2 = getImage(getDocumentBase(), "anImageFile.jpeg");
Image image3 = getImage(
    new URL("http://java.sun.com/graphics/people.gif"));
```

Requesting and Tracking Image Loading: MediaTracker and ImageObserver

You can track image loading in two ways: the `MediaTracker`◆ class and the `ImageObserver`◆ interface. The `MediaTracker` class is sufficient for many programs. You just create a `MediaTracker` instance, tell it to track one or more images, and then ask the `MediaTracker` the status of those images, as needed. An example is explained in Improving the Appearance and Performance of Image Animation.

The animation example shows two particularly useful `MediaTracker` features: requesting that the data for a group of images be loaded, and waiting for a group of images to be loaded. To request that the image data for a group of images be loaded, you can use the forms of `checkID` and `checkAll` that take a boolean argument. Setting the boolean argument to `true` starts loading the data for any images that aren't yet being loaded. Or you can request that the image data be loaded and wait for it using the `waitForID` and `waitForAll` methods.

The ImageObserver interface lets you keep even closer track of image loading than MediaTracker allows. The Component class uses it so that components are repainted as the images they display are loaded. To use the ImageObserver interface, you implement the ImageObserver imageUpdate method and make sure the implementing object is registered as the image observer. Usually, this registration happens when you specify an ImageObserver to the drawImage method, as described in a later section. The imageUpdate method is called whenever information about an image becomes available.

If you browse the MediaTracker API documentation, you might notice that the Component class defines two useful-looking methods: checkImage and prepareImage. The MediaTracker class has made these methods largely unnecessary.

Creating Images with MemoryImageSource

With the help of an image producer such as the MemoryImageSource class, you can construct images from scratch. The following code example calculates a 100x100 image representing a fade from black to blue along the X axis and a fade from black to red along the Y axis.

```
int w = 100;
int h = 100;
int[] pix = new int[w * h];
int index = 0;
for (int y = 0; y < h; y++) {
    int red = (y * 255) / (h - 1);
    for (int x = 0; x < w; x++) {
          int blue = (x * 255) / (w - 1);
          pix[index++] = (255 << 24) | (red << 16) | blue;
    }
}
Image img = createImage(new MemoryImageSource(w, h, pix, 0, w));
```

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Trail: Creating a GUI with JFC/Swing

Lesson: Laying Out Components Within a Container

This lesson tells you how to use layout managers that the Java platform provides. It also tells you how to use absolute positioning (no layout manager) and gives an example of writing a custom layout manager. For each layout manager (or lack thereof), this section has an example that can run either as an applet or as an application. By resizing the window the example brings up, you can see how size changes affect the layout.

Before reading this section, you should understand basic layout management concepts, which you can find in Layout Management◆.

Note: This lesson assumes you're using the Swing components. If you're using the AWT components instead, then you should read the old version of this lesson, which is available by download as part of the Creating a User Interface (AWT Only) archive.

Using Layout Managers

This section gives both general rules and detailed instructions on using each of the layout managers that the Java platform provides.

Creating a Custom Layout Manager

Instead of using one of the Java platform's layout managers, you can write your own. Layout managers must implement the `LayoutManager` interface, which specifies the five methods every layout manager must define. Optionally, layout managers can implement `LayoutManager2`, which is a subinterface of `LayoutManager`.

Doing Without a Layout Manager (Absolute Positioning)

If necessary, you can position components without using a layout manager. Generally, this solution is used to specify absolute sizes and positions for components.

Solving Common Layout Problems

Some of the most common layout problems are that components are displayed too small -- or not at all. This section tells you how to fix these and other common layout problems.

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Trail: Creating a GUI with JFC/Swing

Lesson: Using Other Swing Features

This lesson contains a collection of how-to pages to help you use miscellaneous Swing features.

How to Use Actions

With `Action` objects, you can coordinate the state and event handling of two or more components that generate action events. For example, you can use a single `Action` to create and coordinate a tool-bar button and a menu item that perform the same function.

How to Support Assistive Technologies

Swing components have built-in support for assistive technologies. Your program can provide even better support by following a few rules.

How to Use Borders

Borders are very handy for drawing lines, titles, and empty space around the edges of components.. (You might have noticed that the examples in this trail use a lot of borders.) This section tells you how to add a border to any `JComponent`.

How to Use Icons

Many Swing components can display icons. Usually, icons are implemented as instances of the `ImageIcon` class.

How to Set the Look and Feel

You can specify the look and feel of your Swing components.

How to Use Threads

Read this section if you need access to the GUI from any thread except the event-dispatching thread. This section explains how to use methods such as `invokeLater` and classes such as `SwingWorker`. It also tells you when you might want to use the `Timer` class.

How to Use Swing Timers

With the Swing `Timer` class, you can implement a thread that performs an action after a delay, and optionally continues to repeat the action. The action executes in the event-dispatching thread.

Solving Common Problems Using Other Swing Features

This section tells you how to fix problems you might encounter while trying to use the information in this lesson.

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Trail: Creating a GUI with JFC/Swing
Lesson: Laying Out Components Within a Container

Using Layout Managers

Every container, by default, has a layout manager -- an object that implements the `LayoutManager` interface.* If a container's default layout manager doesn't suit your needs, you can easily replace it with another one. The Java platform supplies layout managers that range from the very simple (`FlowLayout` and `GridLayout`) to the special purpose (`BorderLayout` and `CardLayout`) to the very flexible (`GridBagLayout` and `BoxLayout`).

This section gives you an overview of some layout managers that the Java platform provides, gives you some general rules for using layout managers, and then tells you how to use each of the provided layout managers. It also points to examples of using each layout manager.

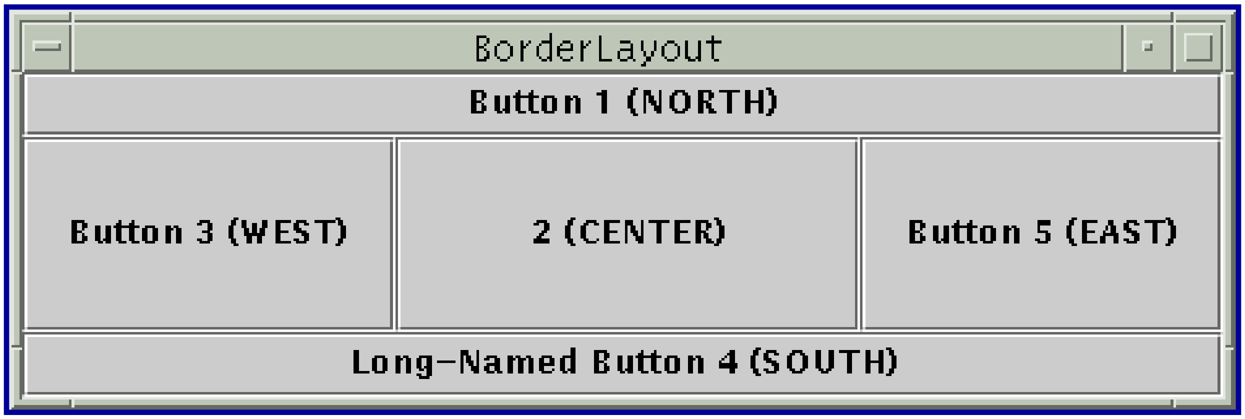
General Rules for Using Layout Managers

This section answers some common questions about layout managers:

- How do you choose a layout manager?
- How do you create a layout manager, associate it with a container, and tell it to start working?
- How does the layout manager know what components it manages?

How to Use BorderLayout

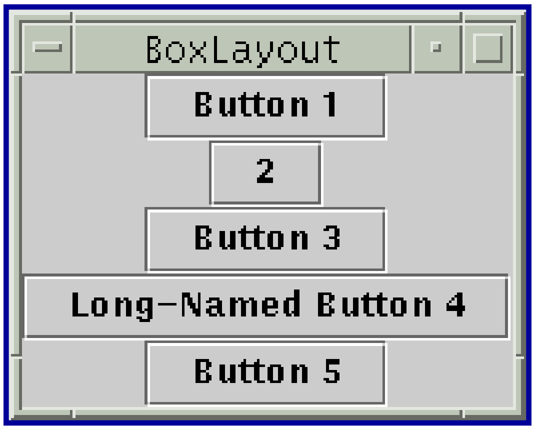
`BorderLayout` is the default layout manager for every content pane. (As described in Using Top-Level Containers◆, the content pane is the main container in all frames, applets, and dialogs.) A `BorderLayout` has five areas available to hold components: north, south, east, west, and center. All extra space is placed in the center area. Here's an applet that puts one button in each area:



This is a picture of the applet's GUI. To run the applet, click the picture. The applet will appear in a new browser window.

How to Use BoxLayout

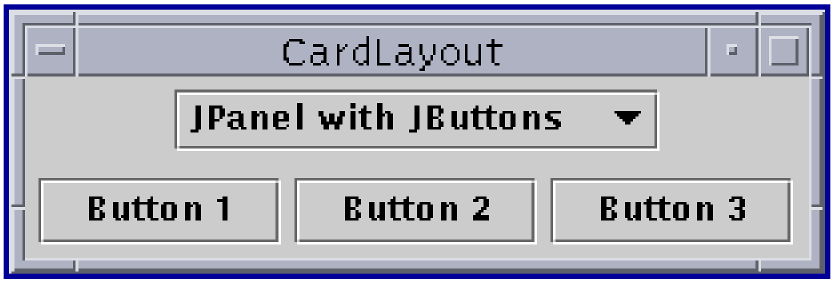
The `BoxLayout` class puts components in a single row or column. It respects the components' requested maximum sizes, and also lets you align components. Here's an applet that uses a `BoxLayout` to put a bunch of buttons in a centered column:



This is a picture of the applet's GUI. To run the applet, click the picture. The applet will appear in a new browser window.

How to Use CardLayout

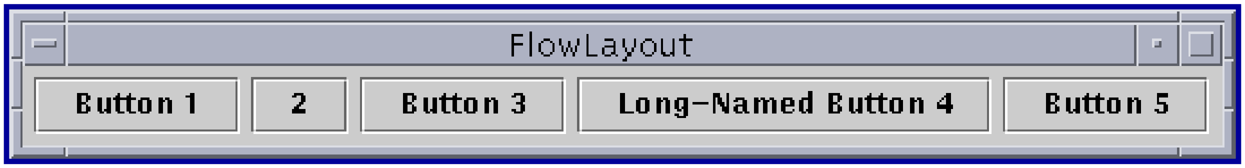
The `CardLayout` class lets you implement an area that contains different components at different times. Tabbed panes◆ are intermediate Swing containers that provide similar functionality, but with a pre-defined GUI. A `CardLayout` is often controlled by a combo box , with the state of the combo box determining which panel (group of components) the `CardLayout` displays. Here's an applet that uses a combo box and `CardLayout` in this way:



This is a picture of the applet's GUI. To run the applet, click the picture. The applet will appear in a new browser window.

How to Use FlowLayout

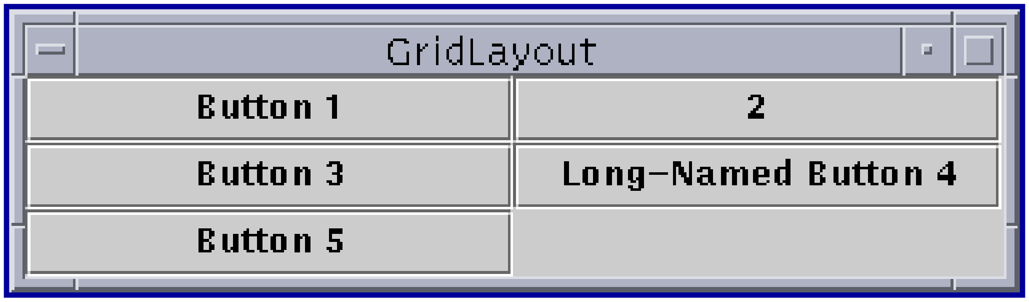
`FlowLayout` is the default layout manager for every `JPanel`. It simply lays out components from left to right, starting new rows if necessary. Both panels in the `CardLayout` applet above use `FlowLayout`. Here's another example of an applet that uses a `FlowLayout`:



This is a picture of the applet's GUI. To run the applet, click the picture. The applet will appear in a new browser window.

How to Use GridLayout

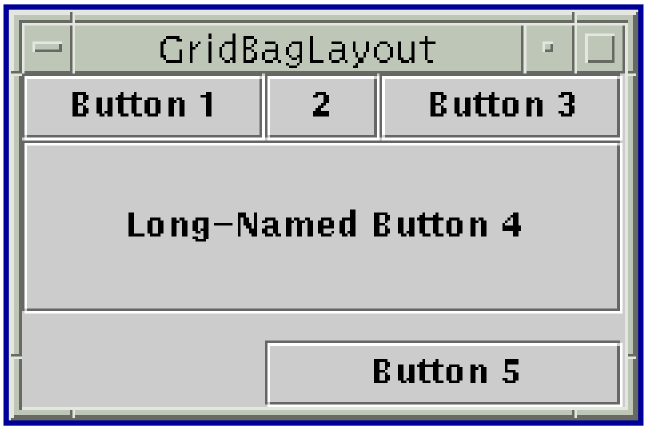
`GridLayout` simply makes a bunch of components equal in size and displays them in the requested number of rows and columns. Here's an applet that uses a `GridLayout` to control the display of five buttons:



This is a picture of the applet's GUI. To run the applet, click the picture. The applet will appear in a new browser window.

How to Use GridBagLayout

`GridBagLayout` is the most sophisticated, flexible layout manager the Java platform provides. It aligns components by placing them within a grid of cells, allowing some components to span more than one cell. The rows in the grid aren't necessarily all the same height; similarly, grid columns can have different widths. Here's an applet that uses a `GridBagLayout` to manage five buttons:



This is a picture of the applet's GUI. To run the applet, click the picture. The applet will appear in a new browser window.

---

* In JDK 1.1 a second interface, `LayoutManager2`, was introduced. `LayoutManager2` extends `LayoutManager`, providing support for maximum size and alignment. Currently, only `BoxLayout` implements `LayoutManager2`. All the other layout managers that we discuss implement only `LayoutManager`.

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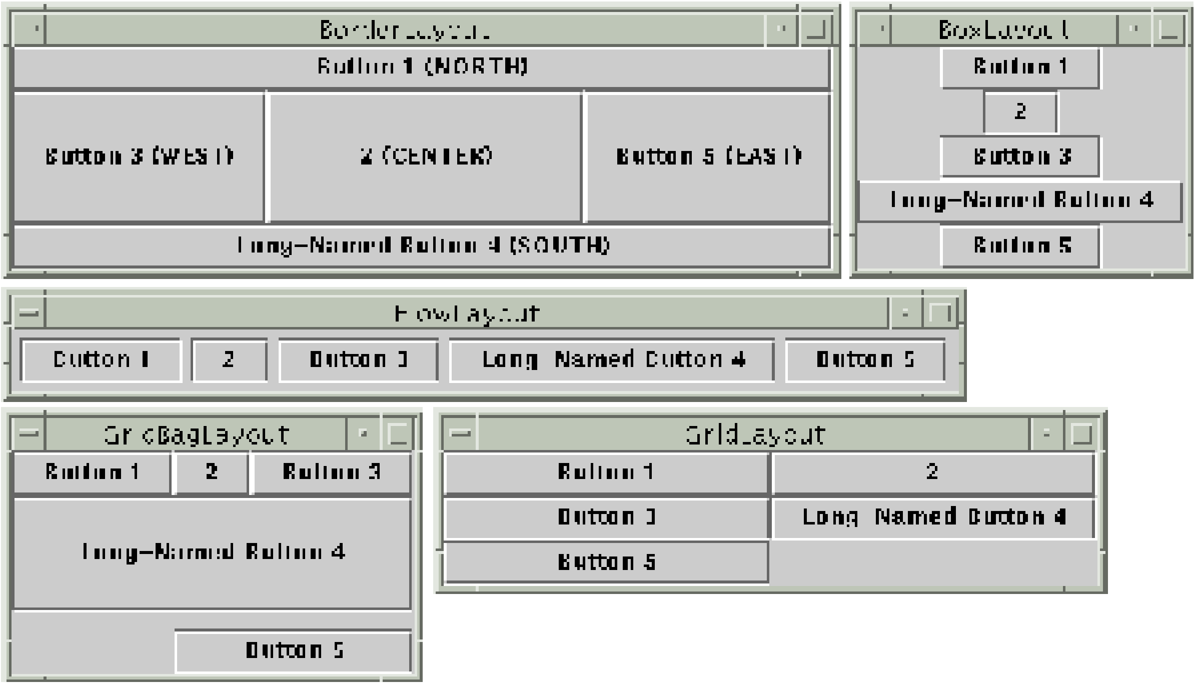
Layout Management

The following figures show the GUIs of five programs, each of which displays five buttons. The buttons are identical, and the code for the programs is almost identical. So why do they look so different? Because they use different layout managers to control the size and position of the buttons.



Layout management is the process of determining the size and position of components. By default, each container has a *layout manager* -- an object that performs layout management for the components within the container. Components can provide size and alignment hints to layout managers, but layout managers have the final say on the size and position of those components.

The Java platform supplies five commonly used layout managers: `BorderLayout`, `BoxLayout`, `FlowLayout`, `GridBagLayout`, and `GridLayout`. These layout managers are designed for displaying multiple components at once, and are shown in the preceding figure. A sixth provided class, `CardLayout`, is a special-purpose layout manager used in combination with other layout managers. You can find details about each of these six layout managers, including hints for choosing the appropriate one, in Using

Layout Managers.

Whenever you use the `add` method to put a component in a container, you must take the container's layout manager into account. Some layout managers, such as `BorderLayout`, require you to specify the component's relative position in the container, using an additional argument with the `add` method. Occasionally, a layout manager such as `GridBagLayout` requires elaborate setup procedures. Many layout managers, however, simply place components based on the order they were added to their container.

All this probably sounds more complicated than it is. You can usually either copy code from our examples in Using Swing Components or look up the individual layout manager in Using Layout Managers. Generally, you only ever set the layout manager of two types of containers: content panes (which use `BorderLayout` by default) and `JPanel`s (which use `FlowLayout` by default).

The rest of this section discusses some of the common layout tasks:

- Setting the layout manager
- Providing hints about a component
- Putting space between components
- How layout management occurs

Setting the Layout Manager

You can easily change the layout manager that a container uses. Just invoke the container's `setLayout` method. For example, here's the code that makes a panel use `BorderLayout`:

```
JPanel pane = new JPanel();
pane.setLayout(new BorderLayout());
```

Although we recommend that you use layout managers, you can perform layout without them. By setting a container's layout property to null, you make the container use no layout manager. With this strategy, called *absolute positioning*, you must specify the size and position of every component within that container. One drawback of absolute positioning is that it doesn't adjust well when the top-level container is resized, nor does it adjust well to differences between users and systems, such as different font sizes.

Providing Hints about a Component

Sometimes you need to customize the size hints that a component provides to its container's layout manager, so that the component will be laid out well. You do this by specifying the minimum, preferred, and maximum sizes of the component. You can either invoke the component's methods for setting size hints -- `setMinimumSize`, `setPreferredSize`, and `setMaximumSize` -- or you can create a subclass of the component that overrides the appropriate getter methods -- `getMinimumSize`, `getPreferredSize`, and `getMaximumSize`. Currently, the only layout manager in the Java platform that pays attention to a component's requested maximum size is `BoxLayout`.

Besides providing size hints, you can also provide alignment hints. For example, you can specify that the top edges of two components should be aligned. You set alignment hints either by invoking the component's `setAlignmentX` and `setAlignmentY` methods, or by overriding the component's `getAlignmentX` and `getAlignmentY` methods. Currently, `BoxLayout` is the only layout manager that pays attention to alignment hints.

Putting Space Between Components

Three factors influence the amount of space between visible components in a container:

The layout manager

Some layout managers automatically put space between components; others don't. Some let you specify the amount of space between components. See Laying Out Components Within a Container◆ for information about spacing support in each layout manager.

Invisible components

You can create lightweight components that perform no painting, but that can take up space in the GUI. Often, you use invisible components in containers controlled by `BoxLayout`. See How to Use BoxLayout◆ for examples of using invisible components.

Empty borders

No matter what the layout manager, you can affect the apparent amount of space between components by adding empty borders to components. The best candidates for empty borders are components that typically have no default border, such as panels and labels. Some other components might not work well with borders in some look-and-feel implementations, because of the way their painting code is implemented. For information about borders, see How to Use Borders◆.

How Layout Management Occurs

Here's an example of a layout management sequence for a frame (`JFrame`).

1. After the GUI is constructed, the `pack` method is invoked on the `JFrame`. This specifies that the frame should be at its preferred size.

2. To find the frame's preferred size, the frame's layout manager adds the size of the frame's edges to the preferred size of the component directly contained by the frame. This is the sum of the preferred size of the frame's content pane, plus the size of the frame's menu bar, if any.

3. The content pane's layout manager is responsible for figuring out the content pane's preferred size. By default, this layout manager is a `BorderLayout` object. However, let's assume that we replace it with a `GridLayout` object that's set up to create two columns, as in the bottom right of the preceding snapshot. The interesting thing about grid layout is that it forces all components to be the same size, and it tries to make them as wide as the widest component's preferred width and as high as highest one's preferred height.

   First, the grid layout manager queries the content pane for its insets -- the size of the content pane's border, if any. Next, the grid layout manager queries each component in the content pane for its preferred size, noting the largest preferred width and largest preferred height. Then it calculates the content pane's preferred size.

4. When each button is asked for its preferred size, the button first checks whether the user specified a preferred size. If so, it reports that size. If not, it queries its look and feel for the preferred size.

The end result is that to determine the best size for the frame, the system determines the sizes of the containers at the bottom of the containment hierarchy. These sizes then percolate up the containment hierarchy, eventually determining the frame's total size. Similar calculations occur when the frame is resized.

For more information about layout, see Laying Out Components Within a Container◆.

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Creating a Custom Layout Manager

Note: Before you start creating a custom layout manager, make sure that no existing layout manager will work. In particular, `GridBagLayout` and `BoxLayout` are flexible enough to work in many cases. You can also find layout managers from other sources, such as from the Internet. Finally, you can simplify layout by grouping components into containers such as invisible panels◆.

To create a custom layout manager, you must create a class that implements the `LayoutManager`◆ interface. You can either implement it directly, or implement its subinterface, `LayoutManager2`◆.

Every layout manager must implement at least the following five methods, which are required by the `LayoutManager` interface:

`void addLayoutComponent(String, Component)`
Called by the `Container` `add` methods. Layout managers that don't associate strings with their components generally do nothing in this method.

`void removeLayoutComponent(Component)`
Called by the `Container` `remove` and `removeAll` methods. Many layout managers do nothing in this method, relying instead on querying the container for its components, using the `Container` `getComponents` method.

`Dimension preferredLayoutSize(Container)`
Called by the `Container` `getPreferredSize` method, which is itself called under a variety of circumstances. This method should calculate and return the ideal size of the container, assuming that the components it contains will be at or above their preferred sizes. This method must take into account the container's internal borders, which are returned by the `getInsets` method.

`Dimension minimumLayoutSize(Container)`

Called by the `Container` `getMinimumSize` method, which is itself called under a variety of circumstances. This method should calculate and return the minimum size of the container, assuming that the components it contains will be at or above their minimum sizes. This method must take into account the container's internal borders, which are returned by the `getInsets` method.

`void layoutContainer(Container)`

Called when the container is first displayed, and each time its size changes. A layout manager's `layoutContainer` method doesn't actually draw components. It simply invokes each component's `resize`, `move`, and `reshape` methods to set the component's size and position. This method must take into account the container's internal borders, which are returned by the `getInsets` method. You can't assume that the `preferredLayoutSize` or `minimumLayoutSize` method will be called before `layoutContainer` is called.

Besides implementing the preceding five methods, layout managers generally implement at least one public constructor and the `toString` method.

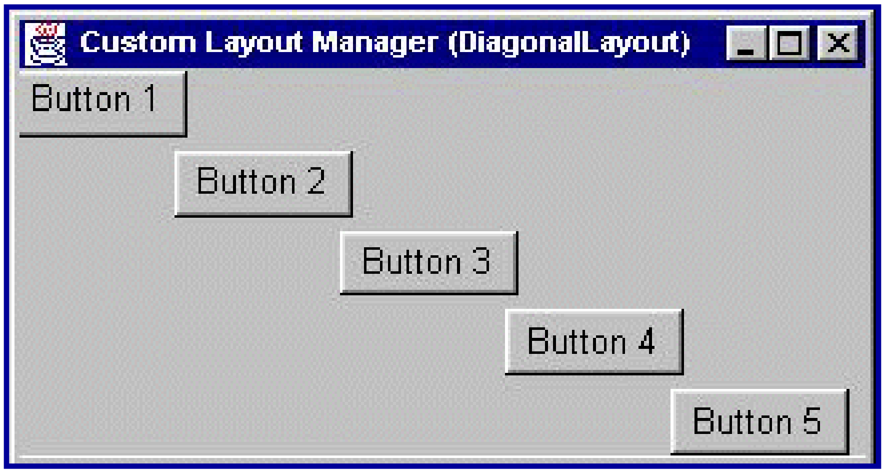
If you wish to support component constraints, maximum sizes, or alignment, then your layout manager should implement the `LayoutManager2` interface. That interface adds five methods to those required by `LayoutManager`:

- `addLayoutComponent(Component, Object)`
- `getLayoutAlignmentX(Container)`
- `getLayoutAlignmentY(Container)`
- `invalidateLayout(Container)`
- `maximumLayoutSize(Container)`

For more information about these methods, see the `LayoutManager2` API documentation. Also see the source code for `BoxLayout`, to see how it implements the `LayoutManager2` interface.

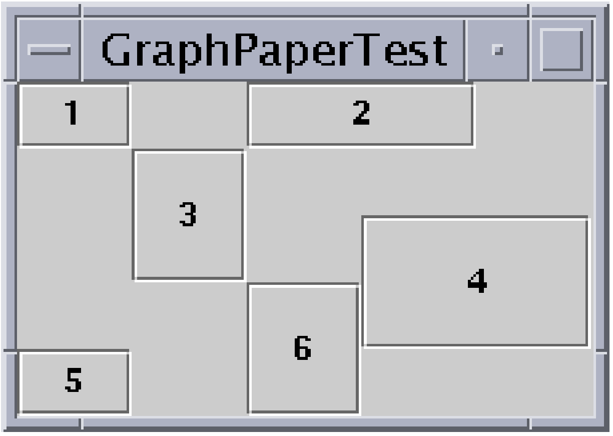
When implementing a layout manager, you might want to use `SizeRequirements` objects to help you determine the size and position of components. See the source code for `BoxLayout` for an example of using `SizeRequirements`.

In `DiagonalLayout.java`, you can find the source code for a custom layout manager. `DialogLayout` lays out components diagonally, from left to right, with one component per row. Here's an example of `DiagonalLayout` in action:



This is a picture of the applet's GUI. To run the applet, click the picture. The applet will appear in a new browser window.

You can find another example of a custom layout manager in GraphPaperLayout.java. `GraphPaperLayout`, written by Michael Martak, lays out components in a grid. Each component's size and location are specified, using grid units rather than absolute locations, when the component is added to its container. You can set the relative grid size, horizontal space between components, and vertical space between components when initializing the layout manager. You can also change component locations and the grid size dynamically. For an example of using `GraphPaperLayout`, see GraphPaperTest.java. Here's a snapshot of `GraphPaperTest` that shows `GraphPaperLayout` in action:



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Lesson: Laying Out Components Within a Container

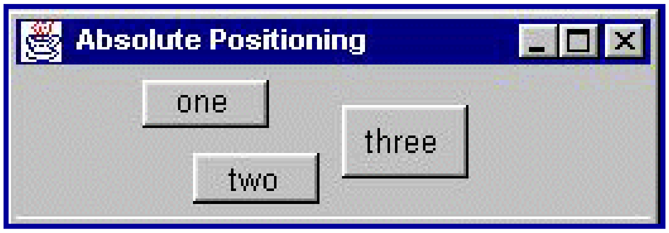
Doing Without a Layout Manager (Absolute Positioning)

Although it's possible to do without a layout manager, you should use a layout manager if at all possible. A layout manager makes it easy to adjust to look-and-feel-dependent component appearances, to different font sizes, and to a container's changing size. Layout managers also can be reused easily by other containers as well as other programs.

If a container holds components whose size isn't affected by the container's size or by font and look-and-feel changes, then absolute positioning might make sense. Desktop panes, which contain internal frames◆, are in this category. The size and position of internal frames doesn't depend directly on the desktop pane's size. The programmer determines the initial size and placement of internal frames within the desktop pane, and then the user can move or resize the frames. A layout manager is unnecessary in this situation.

Another situation in which absolute positioning might make sense is that of a custom container that performs size and position calculations that are particular to the container, and perhaps require knowledge of the container's specialized state. This is the situation with split panes◆.

Here's an applet that brings up a window whose content pane uses absolute positioning.



This is a picture of the applet's GUI. To run the applet, click the picture. The applet will appear in a new browser window.

Below are the instance variable declarations and constructor implementation of the window class. Here's a link to `the whole program`◆. The program runs either within an applet, with the help of `AppletButton`◆, or as an application.

```
public class NoneWindow extends JFrame {
    . . .
    private boolean laidOut = false;
    private JButton b1, b2, b3;

    public NoneWindow() {
        Container contentPane = getContentPane();
        contentPane.setLayout(null);

        b1 = new JButton("one");
        contentPane.add(b1);
        b2 = new JButton("two");
        contentPane.add(b2);
        b3 = new JButton("three");
        contentPane.add(b3);

        Insets insets = contentPane.getInsets();
        b1.setBounds(25 + insets.left, 5 + insets.top, 75, 20);
        b2.setBounds(55 + insets.left, 35 + insets.top, 75, 20);
        b3.setBounds(150 + insets.left, 15 + insets.top, 75, 30);
        . . .
    }
    . . .
}
```

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Trail: Creating a GUI with JFC/Swing
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Solving Common Layout Problems

Problem: How do I specify a component's exact size?

- First, make sure that you really need to set the component's exact size. Each Swing component has a different preferred size, depending on the font it uses and the look and feel. For this reason, it often doesn't make sense to specify a Swing component's exact size.

- If the component isn't controlled by a layout manager, you can set its size by invoking the `setSize` or `setBounds` method on it. Otherwise, you need to provide size hints and then make sure you're using a layout manager that respects the size hints.

- If you extend a Swing component class, you can give size hints by overriding the component's `getMinimumSize`, `getPreferredSize`, and `getMaximumSize` methods. What's nice about this approach is that each `get`*`Xxxx`*`Size` method can get the component's default size hints by invoking `super.get`*`Xxxx`*`Size()`. Then it can adjust the size, if necessary, before returning it.

- Another way to give size hints is to invoke the component's `setMinimumSize`, `setPreferredSize`, and `setMaximumSize` methods.

Note: No matter how you specify your component's size, be sure that your component's container uses a layout manager that respects the requested size of the component. The `FlowLayout` and `GridBagLayout` managers use the component's preferred size (the latter depending on the constraints that you set), but `BorderLayout` and `GridLayout` usually don't. The `BoxLayout` manager generally uses a component's preferred size (although components can be larger), and is the only layout manager that respects the component's maximum size.

If you specify new size hints for a component that's already visible, you then need to invoke the `revalidate` method on it, to make sure that its containment hierarchy is laid out again. Then invoke the `repaint` method.

Problem: My custom component is being sized too small.

- Does the component implement the `getPreferredSize` and `getMinimumSize` methods? If so, do they return the right values?
- Are you using a layout manager that can use as much space as is available? See General Rules for Using Layout Managers for some tips on choosing a layout manager and specifying that it use the maximum available space for a particular component.

If you don't see your problem in this list, see Solving Common Component Problems◆.

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Some Simple Event-Handling Examples

Here is a bare-bones applet that illustrates event handling. It contains a single button that beeps when you click it.

This is a picture of the applet's GUI. To run the applet, click the picture. The applet will appear in a new browser window.

You can find the entire program in `Beeper.java`◆. Here's the code that implements the event handling for the button:

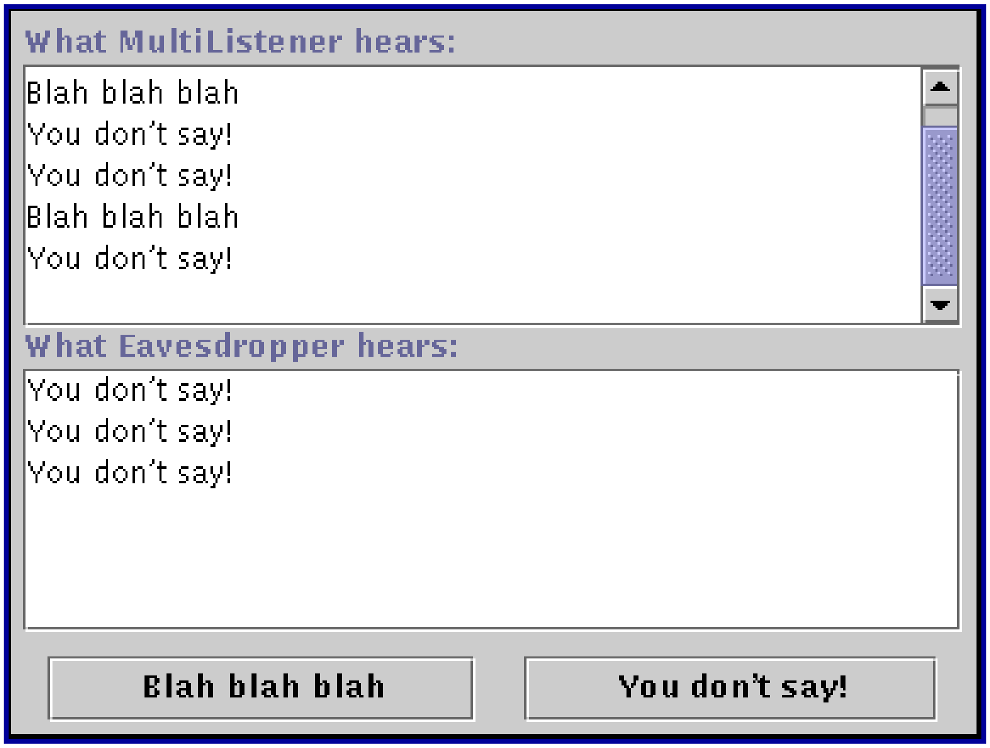
```
public class Beeper ... implements ActionListener {
    ...
    //where initialization occurs:
        button.addActionListener(this);
    ...
    public void actionPerformed(ActionEvent e) {
        ...//Make a beep sound...
    }
}
```

Isn't that simple? The `Beeper` class implements the `ActionListener` interface, which contains one method: `actionPerformed`. Since `Beeper` implements `ActionListener`, a `Beeper` object can register as a listener for the action events that buttons fire. Once the `Beeper` has been registered using the `Button` `addActionListener` method, the `Beeper`'s `actionPerformed` method is called every time the button is clicked.

A More Complex Example

The event model, which you saw at its simplest in the above example, is quite powerful and flexible. Any number of event listener objects can listen for all kinds of events from any number of event source objects. For example, a program might create one listener per event source. Or a program might have a single listener for all events from all sources. A program can even have more than one listener for a single kind of event from a single event source.

The following applet gives an example of using multiple listeners per object. The applet contains two event sources (`JButton` instances) and two event listeners. One of the event listeners (an instance of a class called `MultiListener`) listens for events from both buttons. When it receives an event, it adds the event's "action command" (the text on the button's label) to the top text area. The second event listener (an instance of a class called `Eavesdropper`) listens for events on only one of the buttons. When it receives an event, it adds the action command to the bottom text area.



```
Blah blah blah
You don't say!
You don't say!
Blah blah blah
You don't say!
```

```
You don't say!
You don't say!
You don't say!
```

This is a picture of the applet's GUI. To run the applet, click the picture. The applet will appear in a new browser window.

You can find the entire program in `MultiListener.java`. Here's the code that implements the event handling for the button:

```
public class MultiListener ... implements ActionListener {
    ...
    //where initialization occurs:
        button1.addActionListener(this);
        button2.addActionListener(this);

        button2.addActionListener(new Eavesdropper(bottomTextArea));
    }

    public void actionPerformed(ActionEvent e) {
        topTextArea.append(e.getActionCommand() + newline);
    }
}
```

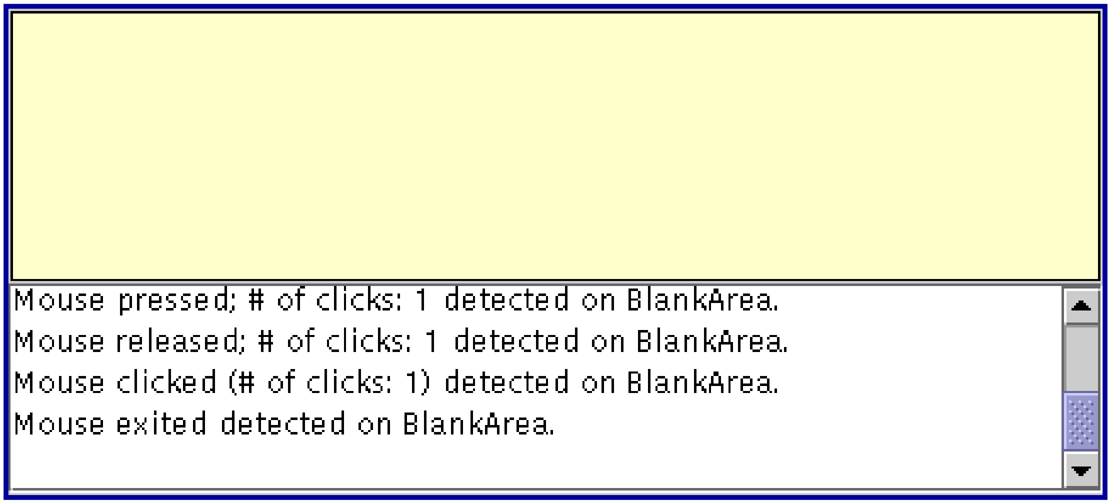
```
class Eavesdropper implements ActionListener {
    ...
    public void actionPerformed(ActionEvent e) {
        myTextArea.append(e.getActionCommand() + newline);
    }
}
```

In the above code, both `MultiListener` and `Eavesdropper` implement the `ActionListener` interface and register as action listeners using the `JButton` `addActionListener` method. Both classes' implementations of the `actionPerformed` method are similar: they simply add the event's action command to a text area.

An Example of Handling Another Event Type

So far, the only kind of event you've seen has been action events. Let's take a look at a program that handles another kind of event: mouse events.

The following applet displays a rectangle-edged area and a text area. Whenever a mouse event -- a click, press, release, enter, or exit -- occurs on either the rectangle-edged area (`BlankAreaMouseEventDemo`), the text area displays a string describing the event.



```
Mouse pressed; # of clicks: 1 detected on BlankArea.
Mouse released; # of clicks: 1 detected on BlankArea.
Mouse clicked (# of clicks: 1) detected on BlankArea.
Mouse exited detected on BlankArea.
```

This is a picture of the applet's GUI. To run the applet, click the picture. The applet will appear in a new browser window.

You can find the entire program in `MouseEventDemo.java` and `BlankArea.java`. Here's the code that implements the event handling:

```
public class MouseEventDemo ...  implements MouseListener {
    ...
    //where initialization occurs:
        //Register for mouse events on blankArea and applet
        blankArea.addMouseListener(this);
        addMouseListener(this);
    }

    public void mousePressed(MouseEvent e) {
       saySomething("Mouse pressed; # of clicks: "
                    + e.getClickCount(), e);
    }

    public void mouseReleased(MouseEvent e) {
       saySomething("Mouse released; # of clicks: "
                    + e.getClickCount(), e);
    }

    public void mouseEntered(MouseEvent e) {
       saySomething("Mouse entered", e);
    }

    public void mouseExited(MouseEvent e) {
       saySomething("Mouse exited", e);
    }

    public void mouseClicked(MouseEvent e) {
       saySomething("Mouse clicked (# of clicks: "
                    + e.getClickCount() + ")", e);
    }

    void saySomething(String eventDescription, MouseEvent e) {
        textArea.append(eventDescription + " detected on "
                        + e.getComponent().getClass().getName()
                        + "." + newline);
    }
}
```

You'll see the code explained in How to Write a Mouse Listener, later in this section.

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Trail: Creating a GUI with JFC/Swing
Lesson: Writing Event Listeners

General Information about Writing Event Listeners

From Event Handling◆, you should already know the basics of event listeners. For example, you can attach multiple listeners to a single event source. Most importantly, event-listener methods should execute quickly. Because all event-handling and drawing methods are executed in the same thread, a slow event-listener method can make the program seem unresponsive and slow to repaint itself.

First, this section introduces you to event objects -- small objects that describe each event. In particular, we talk about `EventObject`, the superclass for all AWT and Swing events. After that this section describes two major categories of events, then gives you hints for avoiding clutter in your code.

- Getting Event Information: Event Objects
- Concepts: Low-Level Events and Semantic Events
- Using Adapters and Inner Classes to Handle Events

Getting Event Information: Event Objects

Every event-listener method has a single argument -- an object that inherits from the `EventObject`◆ class. Although the argument always descends from `EventObject`, its type is generally specified more precisely. For example, the argument for methods that handle mouse events is an instance of `MouseEvent`, where `MouseEvent` is an indirect subclass of `EventObject`.

The `EventObject` class defines one very useful method:

`Object getSource()`
    Returns the object that fired the event.

Note that the `getSource` method returns an `Object`. Event classes sometimes define methods similar to `getSource`, but that have more restricted return types. For example, the `ComponentEvent` class defines a `getComponent` method that -- just like `getSource` -- returns the object that fired the event. The difference is that `getComponent` always returns a `Component`. Each how-to page in this lesson describes whether you should use `getSource` or another method to get the event source.

Often, an event class defines methods that return information about the event. For example, you can query a `MouseEvent` object for information about where the event occurred, how many clicks the user made, which modifier keys were pressed, and so on.

Concepts: Low-Level Events and Semantic Events

Events can be divided into two groups: *low-level* events and *semantic* events. Low-level events represent window-system occurrences or low-level input. Everything else is a semantic event.

Mouse and key events -- both of which result directly from user input -- are low-level events. Other low-level events include component, container, focus, and window events. Component events let you track changes to a component's position, size, and visibility. Container events let you know when any component is added to or removed from a particular container. Focus events tell you when a component gains or loses the *keyboard focus* -- the ability to receive characters typed at the keyboard. Window events keep you informed of the basic status of any kind of `Window`, such as a `Dialog` or a `Frame`.

Examples of semantic events include action events, item events, and list selection events. The trigger for a semantic event can differ by component. For example, a button customarily fires an action event when the user clicks it, but a text field fires an action event when the user presses Return. The trigger can also vary by look and feel. For example, an audio look and feel might implement a button that fires an action event when the user says a certain phrase. Some semantic events aren't triggered by low-level events, at all. For example, a table-model event might be fired when a table model receives new data from a database.

Whenever possible, you should listen for semantic events rather than low-level events. That way, you can make your code as robust and portable as possible. For example, listening for action events on buttons, rather than mouse events, means that the button will react appropriately when the user tries to activate the button using a keyboard alternative or a look-and-feel-specific gesture. When dealing with a compound component such as a combo box, it's imperative that you stick to semantic events, since you have no reliable way of registering listeners on all the look-and-feel-specific components that might be used to form the compound component.

Using Adapters and Inner Classes to Handle Events

This subsection tells you how to use adapters and inner classes to reduce clutter in your code. If you don't care about this subject, feel free to skip to the next section.

Most listener interfaces contain more than one method. For example, the `MouseListener` interface contains five methods: `mousePressed`, `mouseReleased`, `mouseEntered`, `mouseExited`, and `mouseClicked`. Even if you care only about mouse clicks, if your class directly implements `MouseListener`, then you must implement all five `MouseListener` methods. Methods for those events you don't care about can have empty bodies. Here's an example:

```
//An example with cluttered but valid code.
public class MyClass implements MouseListener {
    ...
        someObject.addMouseListener(this);
    ...
    /* Empty method definition. */
    public void mousePressed(MouseEvent e) {
    }

    /* Empty method definition. */
    public void mouseReleased(MouseEvent e) {
    }

    /* Empty method definition. */
    public void mouseEntered(MouseEvent e) {
    }

    /* Empty method definition. */
    public void mouseExited(MouseEvent e) {
    }

    public void mouseClicked(MouseEvent e) {
        ...//Event handler implementation goes here...
    }
}
```

Unfortunately, the resulting collection of empty method bodies can make code harder to read and maintain. To help you avoid cluttering your code with empty method bodies, the API generally includes an *adapter* class for each listener interface with more than one method. (Handling Common Events lists all the listeners and their adapters.) For example, the `MouseAdapter` class implements the `MouseListener` interface. An adapter class implements empty versions of all its interface's methods.

To use an adapter, you create a subclass of it, instead of directly implementing a listener interface. For example, by extending `MouseAdapter`, your class inherits empty definitions of all five of the methods that `MouseListener` contains.

```
/*
 * An example of extending an adapter class instead of
 * directly implementing a listener interface.
 */
public class MyClass extends MouseAdapter {
    ...
        someObject.addMouseListener(this);
    ...
    public void mouseClicked(MouseEvent e) {
        ...//Event handler implementation goes here...
    }
}
```

What if you don't want your event-handling class to inherit from an adapter class? For example, suppose you write an applet, and you want your `Applet` subclass to contain some code to handle mouse events. Since the Java language doesn't permit multiple inheritance, your class can't extend both the `Applet` and `MouseAdapter` classes. The solution is to define an *inner class* -- a class inside of your `Applet` subclass -- that extends the `MouseAdapter` class,

```
//An example of using an inner class.
public class MyClass extends Applet {
    ...
        someObject.addMouseListener(new MyAdapter());
    ...
    class MyAdapter extends MouseAdapter {
        public void mouseClicked(MouseEvent e) {
            ...//Event handler implementation goes here...
        }
    }
}
```

Here's an example of using an anonymous inner class:

```
//An example of using an anonymous inner class.
public class MyClass extends Applet {
    ...
        someObject.addMouseListener(new MouseAdapter() {
            public void mouseClicked(MouseEvent e) {
                ...//Event handler implementation goes here...
            }
        });
    ...
```

```
            }
        }
```

Inner classes work well even if your event handler needs access to private instance variables from the enclosing class. As long as you don't declare an inner class to be `static`, an inner class can refer to instance variables and methods just as if its code is in the containing class. To make a local variable available to an inner class, just save a copy of the variable as a `final` local variable.

Note: Some 1.1 compilers don't let an inner class use private instance variables of the enclosing class. A workaround is to remove the `private` specifier from the instance variable's declaration.

To refer to the enclosing instance, you can use `EnclosingClass.this`. For more information about inner classes, see Implementing Nested Classes◆.

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The Java^{TM} Tutorial

Trail: Creating a GUI with JFC/Swing
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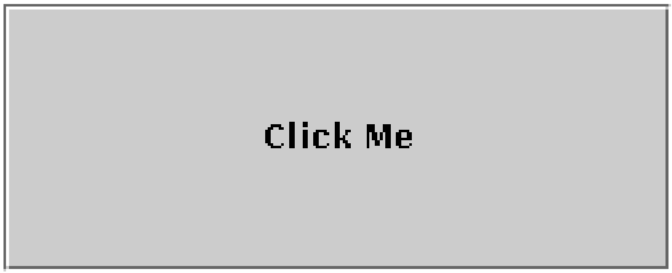
Run Beeper

Since you can't run the applet, here's a picture of it:



Note: Because the preceding applet uses the Swing 1.1 API, it requires Java Plug-in 1.1.2 or Java Plug-in 1.2. It won't work with Java Plug-in 1.1.1 or uncustomized 1.1 browsers. For more information about running applets in the tutorial, refer to About Our Examples. That page includes a section about Downloading Java Plug-in.

```
/*
 * Swing version.
 */

import javax.swing.JApplet;
import javax.swing.JButton;

import java.awt.Toolkit;
import java.awt.BorderLayout;
import java.awt.event.ActionListener;
import java.awt.event.ActionEvent;

public class Beeper extends JApplet
                    implements ActionListener {
    JButton button;

    public void init() {
        button = new JButton("Click Me");
        getContentPane().add(button, BorderLayout.CENTER);
        button.addActionListener(this);
    }

    public void actionPerformed(ActionEvent e) {
        Toolkit.getDefaultToolkit().beep();
    }
}
```

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Trail: Creating a GUI with JFC/Swing
Lesson: Writing Event Listeners

How to Write an Action Listener

Action listeners are probably the easiest -- and most common -- event handlers to implement. You implement an action listener to respond to the user's indication that some implementation-dependent action should occur.

When the user clicks a button◆, chooses a menu item◆ or presses Return in a text field◆, an action event occurs. The result is that an `actionPerformed` message is sent to all action listeners that are registered on the relevant component.

Here is the action event handling code from an applet named `Beeper`:

```
public class Beeper ...  implements ActionListener {
    ...
    //where initialization occurs:
        button.addActionListener(this);
    ...
    public void actionPerformed(ActionEvent e) {
        Toolkit.getDefaultToolkit().beep();
    }
}
```

The `Beeper` applet is described in this trail's introduction to events, Some Simple Event-Handling Examples. You can find the entire program in `Beeper.java`◆. The other example described in that section, `MultiListener.java`◆, has two action sources and two action listeners, with one listener listening to both sources and the other listening to just one.

The Action Event API

The `ActionListener`◆ interface contains a single method, and thus has no corresponding adapter class. Here is the lone `ActionListener` method:

`void actionPerformed(ActionEvent)`
: Called just after the user informs the listened-to component that an action should occur.

The `actionPerformed` method has a single parameter: an `ActionEvent`◆ object. The `ActionEvent` class defines two useful methods:

`String getActionCommand()`
: Returns the string associated with this action. Most objects that can fire action events support a method called `setActionCommand` that lets you set this string. If you don't set the action command explicitly, then it's generally the text displayed in the component. For objects with multiple items, and thus multiple possible actions, the action command is generally the name of the selected item.

`int getModifiers()`
: Returns an integer representing the modifier keys the user was pressing when the action event occurred. You can use the `ActionEvent`-defined constants `SHIFT_MASK`, `CTRL_MASK`, `META_MASK`, and `ALT_MASK` to determine which keys were pressed. For example, if the user Shift-selects a menu item, then the following expression is nonzero:

```
actionEvent.getModifiers() & ActionEvent.SHIFT_MASK
```

Also useful is the `getSource` method, which `ActionEvent` inherits from `EventObject`◆.

Examples that Use Action Listeners

The following table lists some of the many examples that use action listeners.

Example	Where Described	Notes
`Beeper`	This section and Some Simple Event-Handling Examples	Contains one button with one action listener that beeps when you click the button.
`MultiListener`	Some Simple Event-Handling Examples	Registers two different action listeners on one button. Also registers the same action listener on two different buttons.

`RadioButtonDemo.java`	How to Use Radio Buttons◆	Registers the same action listener on five radio buttons. The listener uses the `getActionCommand` method to determine which radio button fired the event.
`MenuDemo`	How to Use Menus◆	Shows how to listen for action events on menu items.
`TextDemo`	How to Use Text Fields◆	An applet that registers an action listener on a text field.
`ActionDemo`	How to Use Actions◆	Uses actions to bind buttons and menu items to the same function.
`IconDemoApplet`	How to Use Icons◆	Loads an image in an action listener. Because loading an image can take a while, this program uses a `SwingWorker` to load the image in a background thread.
`TableDialogEditDemo`	How to Use Tables◆	Registers an action listener through a factory method on the OK button of a color chooser dialog.
`SliderDemo`	How to Use Sliders◆	Registers an action listener on a timer that controls an animation loop.

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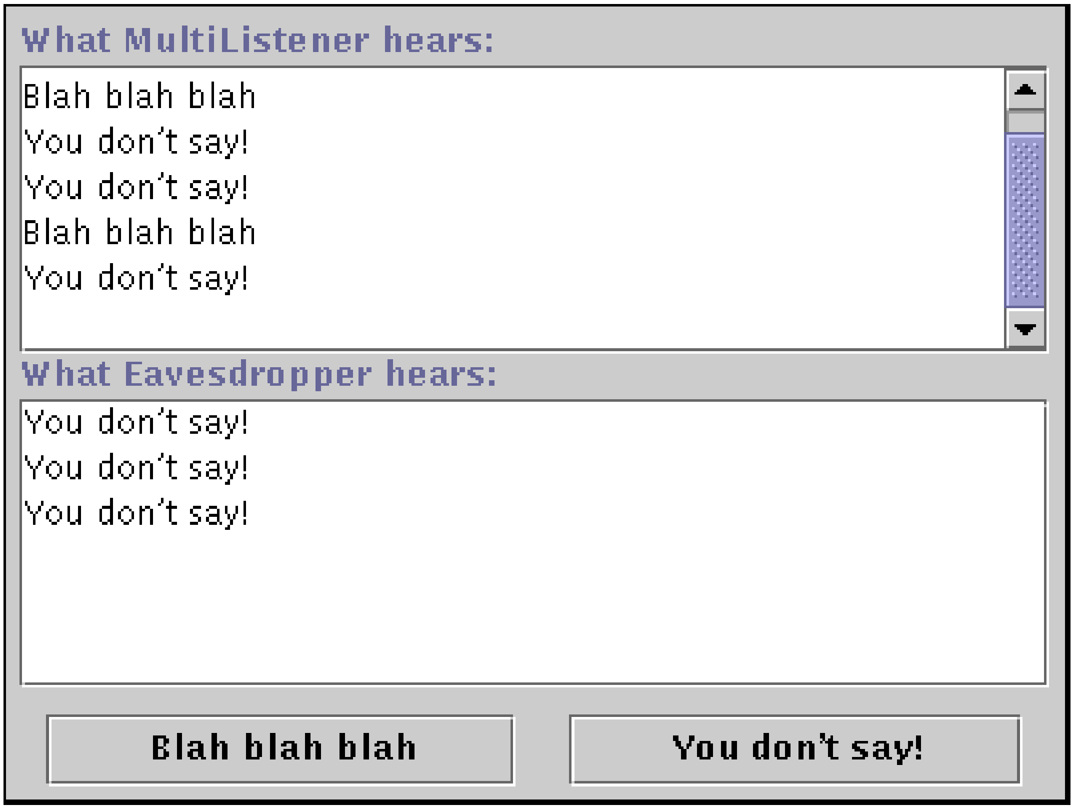
Run MultiListener

Since you can't run the applet, here's a picture of it:



```
Blah blah blah
You don't say!
You don't say!
Blah blah blah
You don't say!
```

```
You don't say!
You don't say!
You don't say!
```

Note: Because the preceding applet uses the Swing 1.1 API, it requires Java Plug-in 1.1.2 or Java Plug-in 1.2. It won't work with Java Plug-in 1.1.1 or uncustomized 1.1 browsers. For more information about running applets in the tutorial, refer to About Our Examples. That page includes a section about Downloading Java Plug-in.

```java
/*
 * Swing version
 */

import javax.swing.*;

import java.awt.GridBagLayout;
import java.awt.GridBagConstraints;
import java.awt.Insets;
import java.awt.Dimension;
import java.awt.Color;

import java.awt.event.ActionListener;
import java.awt.event.ActionEvent;

public class MultiListener extends JApplet
                           implements ActionListener {
    JTextArea topTextArea;
    JTextArea bottomTextArea;
    JButton button1, button2;
    final static String newline = "\n";

    public void init() {
        JLabel l = null;

        GridBagLayout gridbag = new GridBagLayout();
        GridBagConstraints c = new GridBagConstraints();
        JPanel contentPane = new JPanel();
        contentPane.setLayout(gridbag);
        contentPane.setBorder(BorderFactory.createCompoundBorder(
                                BorderFactory.createMatteBorder(
                                                1,1,2,2,Color.black),
                                BorderFactory.createEmptyBorder(5,5,5,5)));

        c.fill = GridBagConstraints.BOTH;
        c.gridwidth = GridBagConstraints.REMAINDER;
        l = new JLabel("What MultiListener hears:");
        gridbag.setConstraints(l, c);
        contentPane.add(l);

        c.weighty = 1.0;
        topTextArea = new JTextArea();
        topTextArea.setEditable(false);
        JScrollPane topScrollPane = new JScrollPane(topTextArea);
        Dimension preferredSize = new Dimension(200, 75);
        topScrollPane.setPreferredSize(preferredSize);
        gridbag.setConstraints(topScrollPane, c);
        contentPane.add(topScrollPane);

        c.weightx = 0.0;
        c.weighty = 0.0;
        l = new JLabel("What Eavesdropper hears:");
        gridbag.setConstraints(l, c);
        contentPane.add(l);

        c.weighty = 1.0;
        bottomTextArea = new JTextArea();
        bottomTextArea.setEditable(false);
        JScrollPane bottomScrollPane = new JScrollPane(bottomTextArea);
        bottomScrollPane.setPreferredSize(preferredSize);
        gridbag.setConstraints(bottomScrollPane, c);
        contentPane.add(bottomScrollPane);
        c.weightx = 1.0;
        c.weighty = 0.0;
        c.gridwidth = 1;
        c.insets = new Insets(10, 10, 0, 10);
        button1 = new JButton("Blah blah blah");
        gridbag.setConstraints(button1, c);
        contentPane.add(button1);

        c.gridwidth = GridBagConstraints.REMAINDER;
        button2 = new JButton("You don't say!");
        gridbag.setConstraints(button2, c);
        contentPane.add(button2);

        button1.addActionListener(this);
        button2.addActionListener(this);

        button2.addActionListener(new Eavesdropper(bottomTextArea));

        setContentPane(contentPane);
    }

    public void actionPerformed(ActionEvent e) {
        topTextArea.append(e.getActionCommand() + newline);
    }
}

class Eavesdropper implements ActionListener {
    JTextArea myTextArea;
    public Eavesdropper(JTextArea ta) {
        myTextArea = ta;
    }

    public void actionPerformed(ActionEvent e) {
        myTextArea.append(e.getActionCommand()
                        + MultiListener.newline);
    }
}
```

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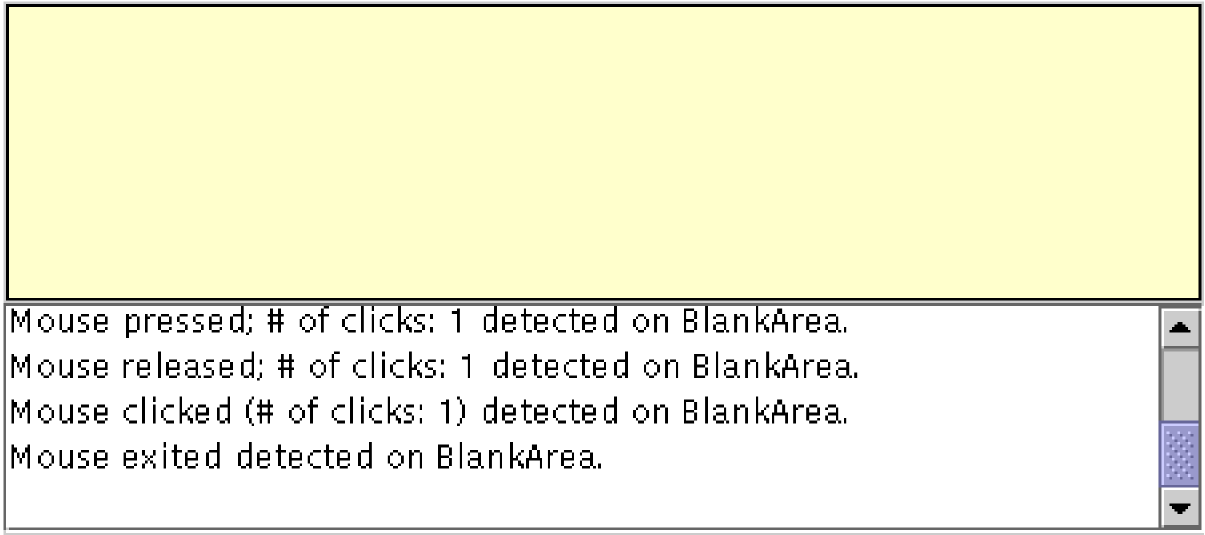
Run MouseEventDemo

Since you can't run the applet, here's a picture of it:



```
Mouse pressed; # of clicks: 1 detected on BlankArea.
Mouse released; # of clicks: 1 detected on BlankArea.
Mouse clicked (# of clicks: 1) detected on BlankArea.
Mouse exited detected on BlankArea.
```

Note: Because the preceding applet uses the Swing 1.1 API, it requires Java Plug-in 1.1.2 or Java Plug-in 1.2. It won't work with Java Plug-in 1.1.1 or uncustomized 1.1 browsers. For more information about running applets in the tutorial, refer to About Our Examples. That page includes a section about Downloading Java Plug-in.

```
/*
 * Swing version
 */

import javax.swing.*;

import java.awt.GridBagLayout;
import java.awt.GridBagConstraints;
import java.awt.Insets;
import java.awt.Color;
import java.awt.Dimension;

import java.awt.event.MouseListener;
import java.awt.event.MouseEvent;

public class MouseEventDemo extends JApplet
                            implements MouseListener {
    BlankArea blankArea;
    JTextArea textArea;
    final static String newline = "\n";

    public void init() {
        GridBagLayout gridbag = new GridBagLayout();
        GridBagConstraints c = new GridBagConstraints();
        JPanel contentPane = new JPanel();
        contentPane.setLayout(gridbag);

        c.fill = GridBagConstraints.BOTH;
        c.gridwidth = GridBagConstraints.REMAINDER;
        c.weightx = 1.0;
        c.weighty = 1.0;

        c.insets = new Insets(1, 1, 1, 1);
        blankArea = new BlankArea(new Color(0.98f, 0.97f, 0.85f));
        gridbag.setConstraints(blankArea, c);
        contentPane.add(blankArea);

        c.insets = new Insets(0, 0, 0, 0);
        textArea = new JTextArea();
        textArea.setEditable(false);
        JScrollPane scrollPane = new JScrollPane(textArea);
        scrollPane.setVerticalScrollBarPolicy(
                JScrollPane.VERTICAL_SCROLLBAR_ALWAYS);
        scrollPane.setPreferredSize(new Dimension(200, 75));
        gridbag.setConstraints(scrollPane, c);
        contentPane.add(scrollPane);

        //Register for mouse events on blankArea and applet.
        blankArea.addMouseListener(this);
        addMouseListener(this);

        setContentPane(contentPane);
    }

    public void mousePressed(MouseEvent e) {
       saySomething("Mouse pressed (# of clicks: "
                    + e.getClickCount() + ")", e);
    }

    public void mouseReleased(MouseEvent e) {
       saySomething("Mouse released (# of clicks: "
                    + e.getClickCount() + ")", e);
    }
    public void mouseEntered(MouseEvent e) {
       saySomething("Mouse entered", e);
    }

    public void mouseExited(MouseEvent e) {
       saySomething("Mouse exited", e);
    }

    public void mouseClicked(MouseEvent e) {
       saySomething("Mouse clicked (# of clicks: "
                    + e.getClickCount() + ")", e);
    }

    void saySomething(String eventDescription, MouseEvent e) {
        textArea.append(eventDescription + " detected on "
                        + e.getComponent().getClass().getName()
                        + "." + newline);
    }
}
```

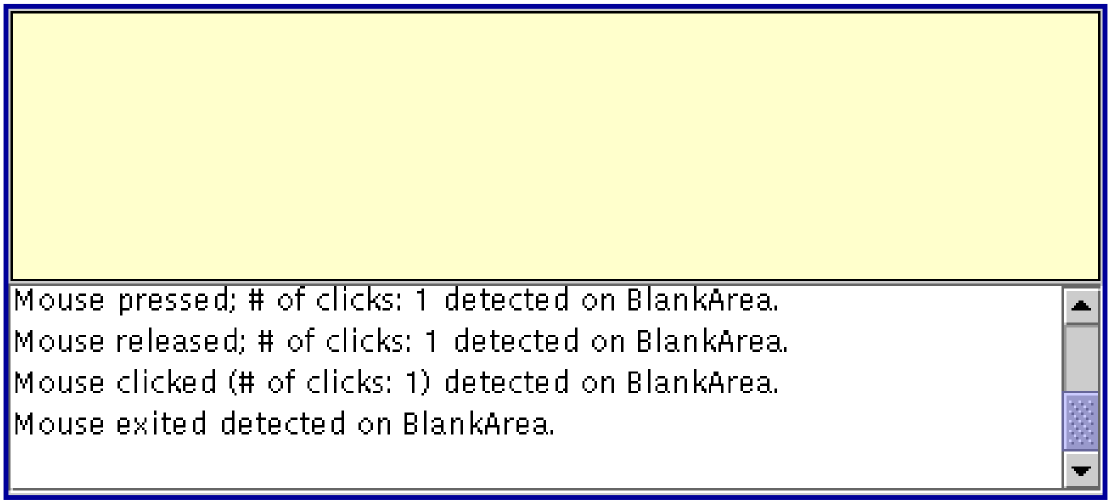
```
/*
 * Swing version
 */

import javax.swing.*;
import java.awt.Dimension;
import java.awt.Color;
import java.awt.Graphics;

public class BlankArea extends JLabel {
    Dimension minSize = new Dimension(100, 100);

    public BlankArea(Color color) {
        setBackground(color);
        setOpaque(true);
        setBorder(BorderFactory.createLineBorder(Color.black));
    }

    public Dimension getMinimumSize() {
        return minSize;
    }

    public Dimension getPreferredSize() {
        return minSize;
    }
}
```

Trail: Creating a GUI with JFC/Swing
Lesson: Writing Event Listeners

How to Write a Mouse Listener

Mouse events tell you when the user uses the mouse (or similar input device) to interact with a component. Mouse events occur when the cursor enters or exits a component's on-screen area and when the user presses or releases the mouse button. Because tracking the cursor's motion involves significantly more system overhead than tracking other mouse events, mouse-motion events are separated into a separate listener type (see How to Write a Mouse Motion Listener). If your program needs to detect both mouse events and mouse-motion events, you can use Swing's convenient `MouseInputAdapter` class, which implements both `MouseListener` and `MouseMotionListener`.

The following applet contains a mouse listener. At the top of the applet is a blank area (implemented, strangely enough, by a class named `BlankArea`). The mouse listener listens for events both on the `BlankArea` and on its container, which is an instance of `MouseEventDemo`. Each time a mouse event occurs, a descriptive message is displayed under the blank area. By moving the cursor on top of the blank area and occasionally pressing mouse buttons, you can fire mouse events.



```
Mouse pressed; # of clicks: 1 detected on BlankArea.
Mouse released; # of clicks: 1 detected on BlankArea.
Mouse clicked (# of clicks: 1) detected on BlankArea.
Mouse exited detected on BlankArea.
```

This is a picture of the applet's GUI. To run the applet, click the picture. The applet will appear in a new browser window.

Try this:

1. Move the cursor into the yellow rectangle at the top of the applet.
   You'll see one or more mouse-entered events.
2. Press and hold the mouse button.
   You'll see a mouse-pressed event. You might see some extra mouse events,

such as mouse-exited and then mouse-entered.

3. Release the mouse button.
   You'll see a mouse-released event. If you didn't move the mouse, a mouse-clicked event will follow.
4. Press and hold the mouse button, and then drag the mouse so that the cursor ends up outside the applet's area. Release the mouse button.
   You'll see a mouse-pressed event, followed by a mouse-exited event, followed by a mouse-released event. You are *not* notified of the cursor's motion. To get mouse-motion events, you need to implement a mouse-motion listener.

You can find the applet's code in `MouseEventDemo.java` and `BlankArea.java`. Here is the applet's mouse event handling code:

```
public class MouseEventDemo ... implements MouseListener {
        ...//where initialization occurs:
        //Register for mouse events on blankArea and applet (panel).
        blankArea.addMouseListener(this);
        addMouseListener(this);
    ...

    public void mousePressed(MouseEvent e) {
       saySomething("Mouse pressed; # of clicks: "
                    + e.getClickCount(), e);
    }

    public void mouseReleased(MouseEvent e) {
       saySomething("Mouse released; # of clicks: "
                    + e.getClickCount(), e);
    }

    public void mouseEntered(MouseEvent e) {
       saySomething("Mouse entered", e);
    }

    public void mouseExited(MouseEvent e) {
       saySomething("Mouse exited", e);
    }

    public void mouseClicked(MouseEvent e) {
       saySomething("Mouse clicked (# of clicks: "
                    + e.getClickCount() + ")", e);
    }

    void saySomething(String eventDescription, MouseEvent e) {
        textArea.append(eventDescription + " detected on "
                        + e.getComponent().getClass().getName()
```

```
                                        + "." + newline);
        }
    }
```

The Mouse Event API

The `MouseListener` interface and its corresponding adapter class, `MouseAdapter`, contain these methods:

`void mouseClicked(MouseEvent)`
Called just after the user clicks the listened-to component.

`void mouseEntered(MouseEvent)`
Called just after the cursor enters the bounds of the listened-to component.

`void mouseExited(MouseEvent)`
Called just after the cursor exits the bounds of the listened-to component.

`void mousePressed(MouseEvent)`
Called just after the user presses a mouse button while the cursor is over the listened-to component.

`void mouseReleased(MouseEvent)`
Called just after the user releases a mouse button after a mouse press over the listened-to component.

One complication affects mouse-entered, mouse-exited, and mouse-released events. When the user drags (presses and holds the mouse button and then moves the mouse), then the component that the cursor was over when the drag started is the one that receives all subsequent mouse and mouse-motion events up to and including the mouse button release. That means that no other component will receive a single mouse event -- not even a mouse-released event -- while the drag is occurring.

Each mouse event method has a single parameter: a `MouseEvent` object. The `MouseEvent` class defines the following useful methods:

`int getClickCount()`
Returns the number of quick, consecutive clicks the user has made (including this event). For example, returns 2 for a double click.

`int getX()`
`int getY()`
`Point getPoint()`
Return the (x,y) position at which the event occurred, relative to the component that fired the event.

`boolean isPopupTrigger()`
Returns `true` if the mouse event should cause a popup menu to appear. Because popup triggers are platform dependent, if your program uses popup menus, you should call `isPopupTrigger` for all mouse-pressed and mouse-released events fired by components over which the popup can appear. See Bringing Up a Popup Menu for more information about popup menus.

The `MouseEvent` class inherits the following handy method from `ComponentEvent`.

`Component getComponent`

Returns the component that fired the event. You can use this method instead of the `getSource` method.

The `MouseEvent` class inherits many useful methods from `InputEvent`:

`int getWhen()`

Returns the timestamp of when this event occurred. The higher the timestamp, the more recently the event occurred.

`boolean isAltDown()`
`boolean isControlDown()`
`boolean isMetaDown()`
`boolean isShiftDown()`

Returns the state of individual modifier keys at the time the event was fired.

`int getModifiers()`

Returns the state of all the modifier keys and mouse buttons when the event was fired. You can use this method to determine which mouse button was pressed (or newly released) when a mouse event was fired. The `InputEvent` class defines these constants for use with the `getModifiers` method: `ALT_MASK`, `BUTTON1_MASK`, `BUTTON2__MASK`, `BUTTON3_MASK`, `CTRL_MASK`, `META_MASK`, and `SHIFT_MASK`. For example, the following expression is true if the right button was pressed:

```
(mouseEvent.getModifiers() & InputEvent.BUTTON3_MASK)
== InputEvent.BUTTON3_MASK
```

The `SwingUtilities` class contains convenience methods for determining whether a particular mouse button has been pressed:

```
static boolean isLeftMouseButton(MouseEvent)
static boolean isMiddleMouseButton(MouseEvent)
static boolean isRightMouseButton(MouseEvent)
```

Examples that Use Mouse Listeners

The following table lists the examples that use mouse listeners.

Example	Where Described	Notes
`MouseEventDemo`	This section	Reports all mouse events that occur within a blank panel to demonstrate the circumstances under which mouse events are fired.

`CoordinatesDemo`	Overview of Custom Painting◆	An applet that draws a small circle where the user clicks the mouse. The applet also reports the x, y location of the mouse click.
`SelectionDemo`	Overview of Custom Painting◆	An applet that lets the user drag a rectangle to select a portion of an image. Uses a subclass of `MouseInputAdapter` to listen to both mouse events and mouse-motion events.
`GlassPaneDemo`	How to Use Root Panes◆	Uses a subclass of `MouseInputAdapter` to listen to mouse events and mouse-motion events on the root pane's glass pane. Redispatches the events to underlying components.
`TableSorter`	How to Use Tables◆	Listens to mouse events on a table header. Sorts data in the selected column.
`MovingLabels`	Moving an Image Across the Screen◆	Stops and starts an animation in response to mouse clicks.
`PopupMenuDemo`	How to Use Menus◆	Displays a popup menu in response to mouse clicks.
`ListDemo`	How to Use Lists◆	Listens for double mouse clicks on a list. Double clicks act as an accelerator for selecting an item in the list and pressing a button.

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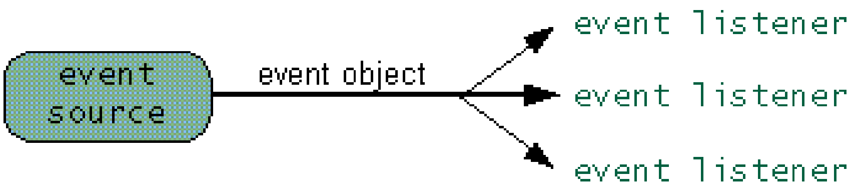
Trail: Creating a GUI with JFC/Swing
Lesson: Swing Features and Concepts

Event Handling

Every time the user types a character or pushes a mouse button, an event occurs. Any object can be notified of the event. All it has to do is implement the appropriate interface and be registered as an *event listener* on the appropriate *event source*. Swing components can generate many kinds of events. Here are a few examples:

Act that results in the event	Listener type
User clicks a button, presses Return while typing in a text field, or chooses a menu item	`ActionListener`
User closes a frame (main window)	`WindowListener`
User presses a mouse button while the cursor is over a component	`MouseListener`
User moves the mouse over a component	`MouseMotionListener`
Component becomes visible	`ComponentListener`
Component gets the keyboard focus	`FocusListener`
Table or list selection changes	`ListSelectionListener`

Each event is represented by an object that gives information about the event and identifies the event source. Event sources are typically components, but other kinds of objects can also be event sources. As the following figure shows, each event source can have multiple listeners registered on it. Conversely, a single listener can register with multiple event sources.



Caption: **Multiple listeners can register to be notified of events of a particular type from a particular source.**

Whenever you want to detect events from a particular component, first check the how-to section for that component. All of the component how-to sections can be found in the Using Swing Components◆ lesson. The how-to sections give examples of handling the events that you're most likely to care about. In How to Make Frames (Main Windows)◆, for instance, you'll find an example of writing a window listener that exits the application when the frame closes.

How to Implement an Event Handler

Every event handler requires three bits of code:

1. In the declaration for the event handler class, code that specifies that the class either implements a listener interface or extends a class that implements a listener interface. For example:

   ```
   public class MyClass implements ActionListener {
   ```

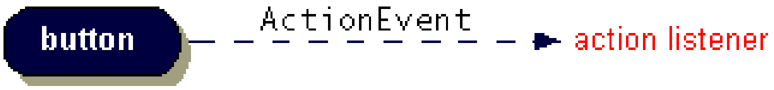
2. Code that registers an instance of the event handler class as a listener upon one or more components. For example:

   ```
   someComponent.addActionListener(instanceOfMyClass);
   ```

3. Code that implements the methods in the listener interface. For example:

   ```
   public void actionPerformed(ActionEvent e) {
       ...//code that reacts to the action...
   }
   ```

Let's investigate a typical event-handling scenario by looking at how buttons (`JButton`) handle mouse clicks. To detect when the user clicks an on-screen button (or does the keyboard equivalent), a program must have an object that implements the `ActionListener` interface. The program must register this object as an action listener on the button (the event source), using the `addActionListener` method. When the user clicks the on-screen button, the button fires an action event. This results in the invocation of the action listener's `actionPerformed` method (the only method in the `ActionListener` interface). The single argument to the method is an `ActionEvent` object that gives information about the event and its source.



Caption: **When the user clicks a button, the button's action listeners are notified.**

Event handlers can be instances of any class. Often, an event handler that has only a few lines of code is implemented using an *anonymous inner class* -- an unnamed class defined inside of another class. Anonymous inner classes can be somewhat confusing at first, but once you're used to them they make code clearer by keeping the implementation of an event handler close to where the event handler is registered. For information about using inner classes, see Using Adapters and Inner Classes to Handle

Events◆.

For more information about implementing event handlers, see Writing Event Listeners◆.

Threads and Event Handling

Event-handling code executes in a single thread, the *event-dispatching thread*. This ensures that each event handler will finish executing before the next one executes. For instance, the `actionPerformed` method in the preceding example executes in the event-dispatching thread. Painting code also executes in the event-dispatching thread. This means that while the `actionPerformed` method is executing, the program's GUI is frozen -- it won't repaint or respond to mouse clicks, for example.

Important: The code in event handlers should execute very quickly! Otherwise, your program's perceived performance will be poor. If you need to perform some lengthy operation as the result of an event, do it by starting up another thread (or somehow sending a request to another thread) to perform the operation. For help on using threads, see How to Use Threads◆.

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Trail: Creating a GUI with JFC/Swing

Lesson: Swing Features and Concepts

This lesson introduces Swing's features and explains all the concepts you need to be able to use Swing components effectively. At the end of this lesson we dissect a Swing program, as a means of reviewing everything you've learned.

Swing Components and the Containment Hierarchy

Swing provides many standard GUI components such as buttons, lists, menus, and text areas, which you combine to create your program's GUI. It also includes containers such as windows and tool bars.

Layout Management

Containers use *layout managers* to determine the size and position of the components they contain. Borders affect the layout of Swing GUIs by making Swing components larger. You can also use invisible components to affect layout.

Event Handling

Event handling is how programs respond to external events, such as the user pressing a mouse button. Swing programs perform all their painting and event handling in the event-dispatching thread.

Painting

Painting means drawing the component on-screen. Although it's easy to customize a component's painting, most programs don't do anything more complicated than customizing a component's border.

Threads and Swing

If you do something to a visible component that might depend on or affect its state, then you need to do it from the event-dispatching thread. This isn't an issue for many simple programs, which generally refer to components only in event-handling code. However, other programs need to use the `invokeLater` method to execute component-related calls in the event-dispatching thread.

More Swing Features and Concepts

Swing offers many features, many of which rely on support provided by the `JComponent` class. Some of the interesting features this lesson hasn't discussed yet include support for icons, actions, Pluggable Look & Feel technology, assistive technologies, and separate models.

The Anatomy of a Swing-Based Program

A sample Swing application named `Converter` shows how Swing programs work and how the code hangs together.

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Trail: Creating a GUI with JFC/Swing

Lesson: Using Swing Components

This lesson describes every Swing component. All of these sections assume that you've successfully compiled and run a program that uses Swing components, and that you're familiar with Swing concepts. These prerequisites are covered in Getting Started with Swing◆ and Swing Features and Concepts◆.

A Visual Index to the Swing Components

This section has a picture of each Swing component, from top-level containers to intermediate containers to atomic components. To find the section that discusses a particular component, just click the component's picture.

The JComponent Class

Almost all Swing components inherit from the `JComponent` class. This section tells you about the features `JComponent` provides, and gives tips on how to take advantage of those features.

Using Top-Level Containers

Discusses how to create windows and applets.

Using Intermediate Swing Containers

Discusses how to use intermediate containers to group or add features to other components.

Using Atomic Components

Discusses the rest of the Swing components, which are generally the components that users interact with when using your GUI.

Solving Common Component Problems

This section discusses solutions to common component-related problems.

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Lesson: Using Swing Components

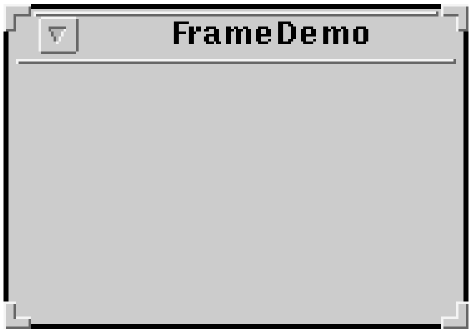
How to Make Frames (Main Windows)

A frame, implemented as an instance of the `JFrame` class, is a window that has decorations such as a border, a title, and buttons for closing and iconifying the window. Applications with a GUI typically use at least one frame. Applets sometimes use frames, as well.

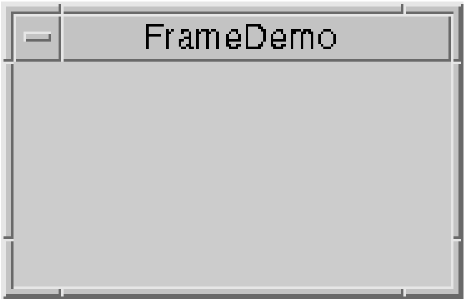
To make a window that's dependent on another window -- disappearing when the other window is iconified, for example -- use a dialog instead of a frame. To make a window that appears within another window, use an internal frame.

Here are two pictures of an empty-looking frame, each taken on a different platform.

Solaris



Windows



Note: The decorations on a frame are platform-dependent. You cannot change the decorations on a frame.

The Example Explained

The following code creates and sets up the frame from the previous figure and makes it visible onscreen. You can find the whole program in `FrameDemo.java`.

```
public static void main(String s[]) {
    JFrame frame = new JFrame("FrameDemo");
```

```
        frame.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {System.exit(0);}
        });

        //...create a blank label, set its preferred size...

        frame.getContentPane().add(emptyLabel, BorderLayout.CENTER);

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

The first line of code creates a frame with the constructor that lets you set the frame's title. The only other constructor provided by `JFrame` is a no-argument constructor.

Next the code adds a window listener to the frame. The listener's implementation makes the program exit when the user closes the frame. This behavior is appropriate for this program because the program has only one frame, and closing the frame makes the program useless. If the program didn't exit, then it would continue to run but have no visible GUI and no way of making any GUI visible. See Responding to Window-Closing Events for more information.

The bold line in the code segment adds a blank label to the frame's content pane. If you're not already familiar with content panes and how to add components to them, please read Adding Components to the Content Pane.

The next line gives the frame a size, using the `pack` method. The `pack` method sizes the frame so that all its contents are at or above their preferred sizes. An alternative to `pack` is to establish a frame's size explicitly by calling `setSize`. In general, using `pack` is preferable to calling `setSize`, since `pack` leaves the frame's layout manager in charge of the frame's size, and layout managers are good at adjusting to platform dependencies and other factors that affect component size.

The last line uses the `setVisible` method to make the frame appear onscreen. Sometimes you might see the `show` method used instead of `setVisible(true)`. The two usages are equivalent, but we use `setVisible(true)` for consistency's sake.

Note: If any part of the frame has been realized you should invoke `setVisible` from the event dispatching thread. For a definition of the term "realized" and information about the event dispatching thread, refer to Threads and Swing◆.

Responding to Window-Closing Events

By default, when the user closes a frame onscreen, the frame is hidden. Although invisible, the frame still exists and the program can make it visible again. If you want different behavior, then you need to either register a window listener that handles window-closing events, or you need to specify default close behavior using the `setDefaultCloseOperation` method. You can even do both.

The argument to `setDefaultCloseOperation` must be one of the following values, which are defined in the `WindowConstants`◆ interface (which `JFrame` implements):

- `DO_NOTHING_ON_CLOSE` -- Don't do anything when the user's requests that the frame close. Instead, the program should probably use a window listener that performs some other action in its `windowClosing` method.
- `HIDE_ON_CLOSE` (the default) -- Hide the frame when the user closes it. This removes the frame from the screen.
- `DISPOSE_ON_CLOSE` -- Hide and dispose of the frame when the user closes it. This removes the frame from the screen and frees up any resources used by it.

The default close operation is executed after the frame's window listeners (if any) handle the window-closing event. So, for example, assume that you specify that the default close operation is to dispose of the frame. You also implement a window listener that tests whether the frame is the last one and, if so, exits the application. Under these conditions, when the user closes a frame, the window listener will be called first. If it doesn't exit the application, then the default close operation -- disposing of the frame -- will then be performed.

For more information about handling window-closing events, see How to Write a Window Listener◆. Besides handling window-closing events, window listeners can also react to other window state changes, such as iconification and activation.

The Frame API

The following tables list the commonly used `JFrame` constructors and methods. Other methods you're likely to call are defined by the `java.awt.Frame`◆ and `java.awt.Window`◆ classes, from which `JFrame` descends. These methods include `pack`, `setSize`, `setVisible`, `setTitle`, and `getTitle`.

Because each `JFrame` object has a root pane, frames have support for interposing input and painting behavior in front of the frame's children, placing children on different "layers", and for Swing menu bars. These topics are introduced in Using Top-Level Containers. and explained in detail in How to Use Root Panes.

The API for using frames falls into these categories:

- Creating and Setting Up a Frame
- Methods Related to the Root Pane

Creating and Setting Up a Frame

Method	Purpose

`JFrame()`
`JFrame(String)`
	Create a frame that is initially invisible. Call `setVisible(true)` on the frame to make it visible. The `String` argument provides a title for the frame. You can also use `setTitle` to set a frame's title.

`void setDefaultCloseOperation(int)`
`int getDefaultCloseOperation()`
	Set or get the operation that occurs when the user pushes the close button on this frame. Possible choices are:
	• `DO_NOTHING_ON_CLOSE`
	• `HIDE_ON_CLOSE` (the default)
	• `DISPOSE_ON_CLOSE`
	These constants are defined in the `WindowConstants` interface, which `JFrame` implements.

Methods Related to the Root Pane

Method	Purpose

`void setContentPane(Container)`
`Container getContentPane()`
	Set or get the frame's content pane. The content pane contains the frame's visible GUI components and should be opaque.

`JRootPane createRootPane()`
`void setRootPane(JRootPane)`
`JRootPane getRootPane()`
	Create, set, or get the frame's root pane. The root pane manages the interior of the frame including the content pane, the glass pane, and so on.

`void setJMenuBar(JMenuBar)`
`JMenuBar getJMenuBar()`
	Set or get the frame's menu bar to manage a set of menus for the frame.

`void setGlassPane(Component)`
`Component getGlassPane()`
	Set or get the frame's glass pane. You can use the glass pane to intercept mouse events.

`void setLayeredPane(JLayeredPane)`
`JLayeredPane getLayeredPane()`
	Set or get the frame's layered pane. You can use the frame's layered pane to put components on top of or behind other components.

Examples that Use Frames

All of the examples in this trail that are standalone applications use `JFrame`. The following table lists a few and tells you where each is discussed.

Example	Where Described	Notes
`FrameDemo`	The Example Explained	Displays a basic frame with one component.
`Framework`	--	A study in creating and destroying windows, in implementing a menu bar, and in exiting an application.
`ColorChooserDemo`	How to Use Color Choosers	A subclass of `JFrame` that adds components to the default content pane.
`TableDemo`	How to Use Tables	A subclass of `JFrame` that sets the frame's content pane.
`LayeredPaneDemo`	How to Use Layered Panes	Illustrates how to use a layered pane (but not the frame's layered pane).
`GlassPaneDemo`	The Glass Pane	Illustrates the use of a frame's glass pane.
`MenuDemo`	How to Use Menus	Shows how to put a `JMenuBar` in a `JFrame`.

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Trail: Creating a GUI with JFC/Swing
Lesson: Using Other Swing Features

How to Use Threads

The first rule of using threads is this: avoid them when you can. Threads can be difficult to use, and they tend to make programs harder to debug. To avoid the possibility of deadlock, you must take extreme care that any threads you create don't invoke any methods on Swing components. Remember, once a Swing component has been realized, only the event-dispatching thread should affect or query the component. If you aren't familiar with the role of the event-dispatching thread, please read Threads and Swing◆ and Threads and Event Handling◆.

Despite the dangers, threads can be invaluable. You can use them to improve your program's perceived performance. And sometimes threads can simplify a program's code or architecture. Here are some typical situations where threads are used:

- To move a time-consuming initialization task out of the main thread, so that the GUI comes up faster. Examples of time-consuming tasks include making extensive calculations and blocking for network or disk I/O (loading images, for example).

- To move a time-consuming task out of the event-dispatching thread, so that the GUI remains responsive.

- To perform an operation repeatedly, usually with some predetermined period of time between operations.

- To wait for messages from other programs.

If you need to create a thread, you can avoid some common pitfalls by implementing the thread with a utility class such as `SwingWorker` or one of the `Timer` classes. A `SwingWorker` object creates a thread to execute a time-consuming operation. After the operation is finished, `SwingWorker` gives you the option of executing some additional code in the event-dispatching thread. Timers are useful for performing a task either repeatedly or after a specified delay. If you need to implement your own threads, you can find information on doing so in Threads: Doing Two or More Tasks At Once◆.

You can use several techniques to make multi-threaded Swing programs work well:

- If you need to update a component but your code isn't executing in an event handler, use one of these two `SwingUtilities` methods: `invokeLater` (preferred) or invokeAndWait. These methods let you specify that some code be executed in the event-dispatching thread.

- If you aren't sure whether your code is executing in an event handler, then you should analyze your program's code and document which thread each method is (and can be) called from. Failing that, you can use the `SwingUtilities.isEventDispatchThread()` method, which returns true if your code is executing in the event-dispatching thread. You can safely call `invokeLater` from any thread, but `invokeAndWait` throws an exception if it's called from the event-dispatching thread.

- If you need to update a component after a delay (whether or not your code is currently executing in an event handler), use a timer to do so.

- If you need to update a component at a regular interval, use a timer.

The rest of this section discusses `SwingWorker` and the `SwingUtilities` invoke methods. For information and examples of using timers, see How to Use Swing Timers.

Using the SwingWorker Class

Note: The implementation of the SwingWorker class has been updated twice, most recently in February 2000. The first update (in January 1999) allowed programs to safely interrupt the worker thread. The most recent update (called "SwingWorker 3") was to fix a subtle threading bug that could cause a `NullPointerException`.

The `SwingWorker` class is implemented in `SwingWorker.java`, which is *not* in the Swing release. To use the `SwingWorker` class, you first create a subclass of it. The subclass must implement the `construct` method so that it contains the code to perform your lengthy operation. When you instantiate your `SwingWorker` subclass, the `SwingWorker` creates a thread but does not (as of SwingWorker 3) start it. You then invoke `start` on your `SwingWorker` object to start the thread, which then calls your `construct` method.

Here is an example of using a `SwingWorker` to move a time-consuming task from an action event handler into a background thread, so that the GUI remains responsive.

```
//OLD CODE:
public void actionPerformed(ActionEvent e) {
    ...
    //...code that might take a while to execute is here...
    ...
}

//BETTER CODE:
```

```
public void actionPerformed(ActionEvent e) {
    ...
    final SwingWorker worker = new SwingWorker() {
        public Object construct() {
            //...code that might take a while to execute is here...
            return someValue;
        }
    };
    worker.start();  //required for SwingWorker 3
    ...
}
```

The value that `construct` returns can be any object. If you need to get the value, you can do so by invoking the `get` method on your `SwingWorker` object. Be careful about using `get`. Because it blocks, it can cause deadlock. If necessary, you can interrupt the thread (causing `get` to return) by invoking `interrupt` on the `SwingWorker`.

If you need to detect when the time-consuming operation completes, you can do so either by using `get` (which is dangerous, as we noted) or by overriding the `finished` method in your `SwingWorker` subclass. The `finished` method runs after the `construct` method returns. Because the `finished` method executes in the event-dispatching thread, you can safely use it to update Swing components. Of course, you shouldn't put time-consuming operations in your `finished` implementation.

The following example of implementing `finished` is taken from `IconDemoApplet.java`. For a full discussion of this applet, including how it improves perceived performance by using background threads to load images, see How to Use Icons.

```
public void actionPerformed(ActionEvent e) {
    ...
    if (icon == null) {     //haven't viewed this photo before
        loadImage(imagedir + pic.filename, current);
    } else {
        updatePhotograph(current, pic);
    }
}
...
//Load an image in a separate thread.
private void loadImage(final String imagePath, final int index) {
    final SwingWorker worker = new SwingWorker() {
        ImageIcon icon = null;

        public Object construct() {
            icon = new ImageIcon(getURL(imagePath));
            return icon; //return value not used by this program
        }
```

```
                //Runs on the event-dispatching thread.
                public void finished() {
                    Photo pic = (Photo)pictures.elementAt(index);
                    pic.setIcon(icon);
                    if (index == current)
                        updatePhotograph(index, pic);
                }
            };
            worker.start();  //required for SwingWorker 3
        }
```

For more examples of using `SwingWorker`, go to How to Monitor Progress. Also, `TumbleItem.java`, which is discussed in How to Make Applets, uses both a `SwingWorker` and a `Timer`.

Using the invokeLater Method

You can call `invokeLater` from any thread to request the event-dispatching thread to run certain code. You must put this code in the `run` method of a `Runnable` object and specify the `Runnable` object as the argument to `invokeLater`. The `invokeLater` method returns immediately, without waiting for the event-dispatching thread to execute the code. Here's an example of using `invokeLater`:

```
    Runnable updateAComponent = new Runnable() {
        public void run() { component.doSomething(); }
    };
    SwingUtilities.invokeLater(updateAComponent);
```

Using the invokeAndWait Method

The `invokeAndWait` method is just like `invokeLater`, except that `invokeAndWait` doesn't return until the event-dispatching thread has executed the specified code. Whenever possible, you should use `invokeLater` instead of `invokeAndWait`. If you use `invokeAndWait`, make sure that the thread that calls `invokeAndWait` does not hold any locks that other threads might need while the call is occurring.

Here's an example of using `invokeAndWait`:

```
    void showHelloThereDialog() throws Exception {
        Runnable showModalDialog = new Runnable() {
            public void run() {
                JOptionPane.showMessageDialog(myMainFrame,
                                              "Hello There");
            }
        };
        SwingUtilities.invokeAndWait(showModalDialog);
    }
```

Similarly, a thread that needs access to GUI state, such as the contents of a pair of text fields, might have the following code:

```
    void printTextField() throws Exception {
        final String[] myStrings = new String[2];

        Runnable getTextFieldText = new Runnable() {
            public void run() {
                myStrings[0] = textField0.getText();
                myStrings[1] = textField1.getText();
            }
        };
        SwingUtilities.invokeAndWait(getTextFieldText);

        System.out.println(myStrings[0] + " " + myStrings[1]);
    }
```

For more examples of using the invoke methods, see the BINGO example, especially the following classes: `CardWindow`, `ControlPane`, `Player`, and `OverallStatusPane`.

For more information about Swing thread issues, see the article index in *The Swing Connection*.

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Trail: Creating a GUI with JFC/Swing
Lesson: Using Swing Components

A Visual Index to the Swing Components

Top-Level Containers
The components at the top of any Swing containment hierarchy.

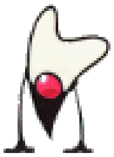
General-Purpose Containers
Intermediate containers that can be used under many different circumstances.

Special-Purpose Containers
Intermediate containers that play specific roles in the UI.

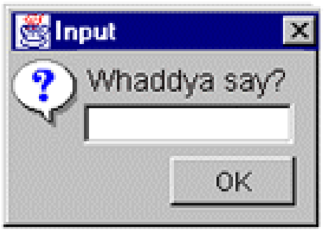
Basic Controls
Atomic components that exist primarily to get input from the user; they generally also show simple state.

Uneditable Information Displays
Atomic components that

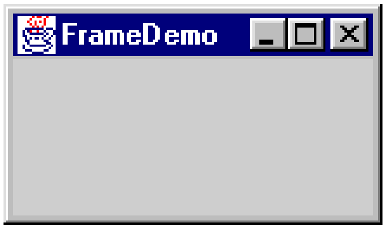
Top-Level Containers



Applet

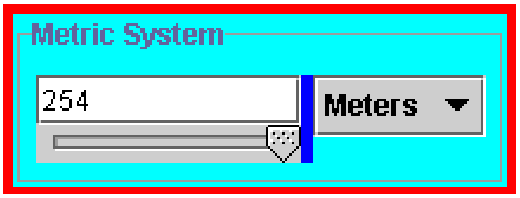


Dialog

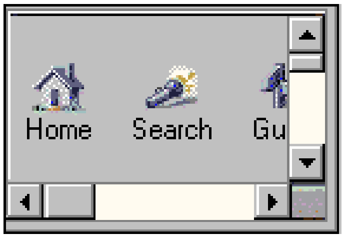


Frame

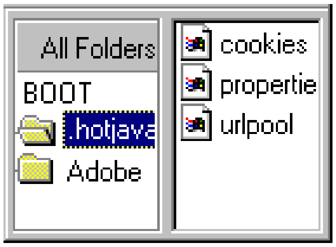
General-Purpose Containers



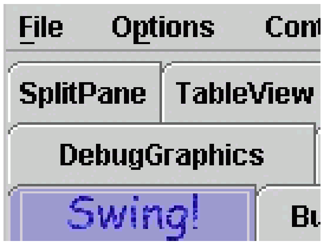
Panel



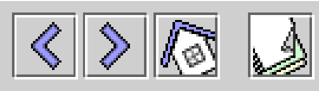
Scroll pane



Split pane



Tabbed pane



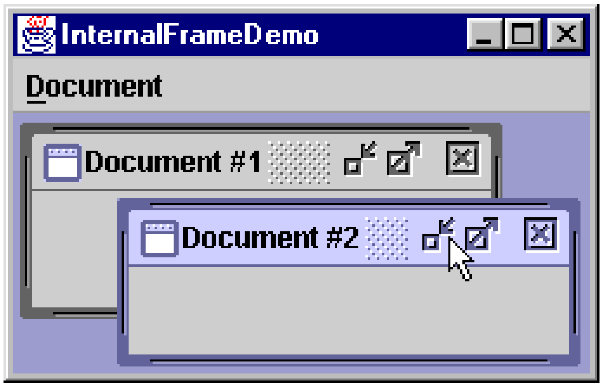
Tool bar

exist solely to give the user information.

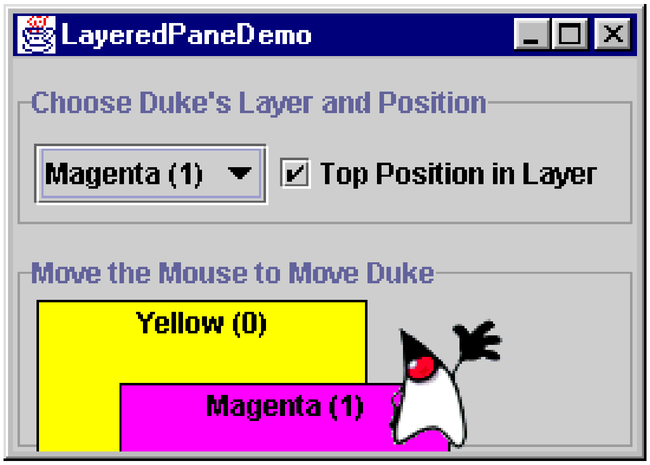
Editable Displays of Formatted Information

Atomic components that display highly formatted information that (if you choose) can be edited by the user.

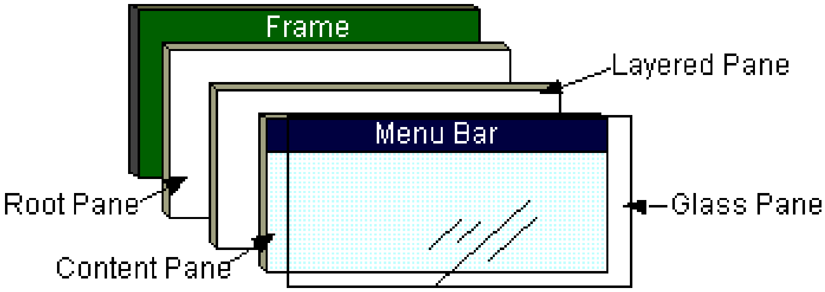
Special-Purpose Containers



Internal frame

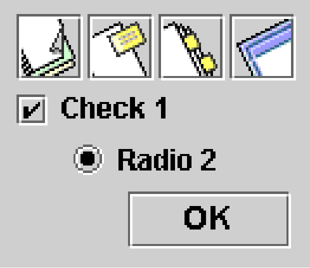


Layered pane

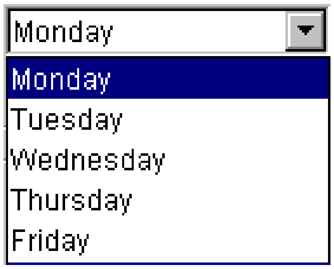


Root pane

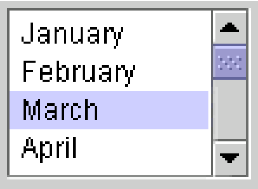
Basic Controls



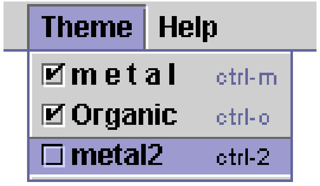
Buttons



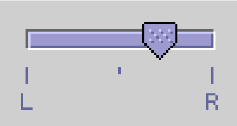
Combo box



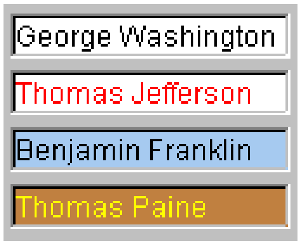
List



Menu

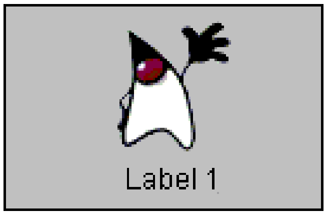


Slider

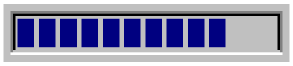


Text fields

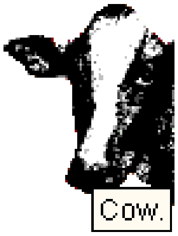
Uneditable Information Displays



Label

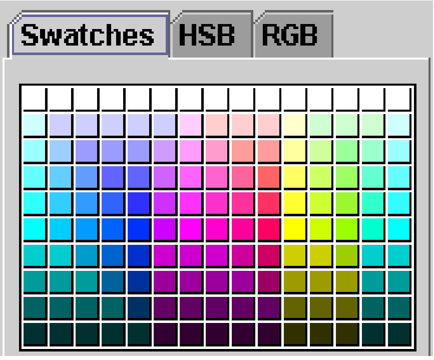


Progress bar

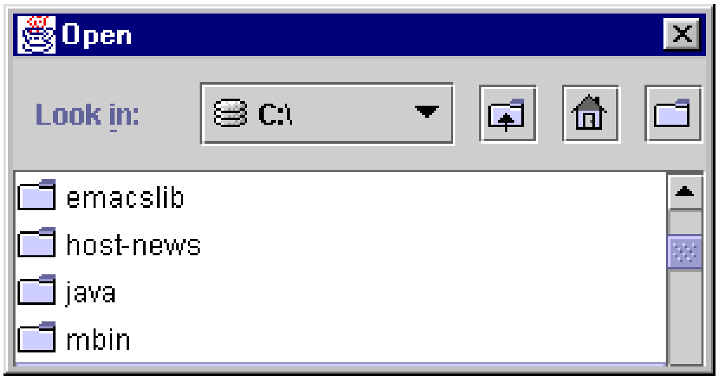


Tool tip

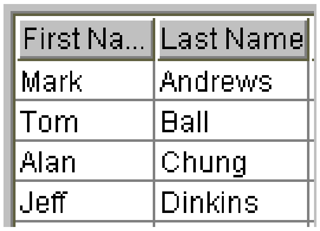
Editable Displays of Formatted Information



Color chooser

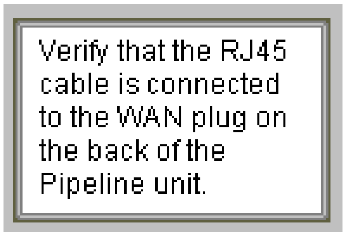


File chooser



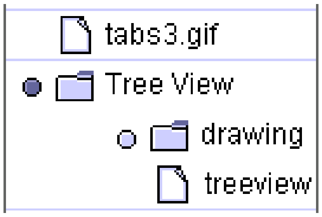
First Na...	Last Name
Mark	Andrews
Tom	Ball
Alan	Chung
Jeff	Dinkins

Table



Verify that the RJ45 cable is connected to the WAN plug on the back of the Pipeline unit.

Text



Tree

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Trail: Creating a GUI with JFC/Swing
Lesson: Using Swing Components

The JComponent Class

With the exception of top-level containers, all Swing components whose names begin with "J" descend from the `JComponent`◆ class. For example, `JPanel`, `JScrollPane`, `JButton`, and `JTable` all inherit from `JComponent`. However, `JFrame` doesn't because it implements a top-level container.

Note: A few Swing components aren't top-level containers and yet don't inherit from `JComponent`. The one you're most likely to need is the `Box.Filler` class, which is a non-painting component designed for use with `BoxLayout`◆. The `Box.Filler` class doesn't inherit from `JComponent` because it is so specialized that it needs no `JComponent` features, and because it is instantiated so often that it should be as small and fast as possible.

The `JComponent` class extends the `Container`◆ class, which itself extends `Component`◆. The `Component` class includes everything from providing layout hints to supporting painting and events. The `Container` class has support for adding components to the container and laying them out. This section's API tables summarize the most often used methods of `Component` and `Container`. Information about how to use the methods is scattered throughout this trail.

JComponent Features

The `JComponent` class provides the following functionality to its descendants:

- Tool tips
- Borders
- Keyboard-generated actions
- Application-wide pluggable look and feel
- Properties

- Support for layout
- Support for accessibility
- Double buffering
- Methods to increase efficiency

Tool tips

By specifying a string with the `setToolTipText` method, you can provide help to users of a component. When the cursor pauses over the component, the specified string is displayed in a small window that appears near the component. See How to Use Tool Tips for more information.

Borders

The `setBorder` method allows you to specify the border that a component displays around its edges. See How to Use Borders◆ for details.

Keyboard-generated actions

Using the `registerKeyboardAction` method, you can enable the user to use the keyboard, instead of the mouse, to operate the GUI.

Note: Some classes provide convenience methods for keyboard actions. For example, `AbstractButton` provides `setMnemonic`, which lets you specify the key that, in combination with a look-and-feel-specific modifier key, causes the button's action to be performed. See How to Use Buttons, Check Boxes, and Radio Buttons for an example of using mnemonics in buttons.

The combination of character and modifier keys that the user must press to start an action is represented by a `KeyStroke`◆ object. The resulting action event must be handled by an action listener◆. Each keyboard action works under exactly one of three conditions: only when the actual component has the focus, only when the component or one of its containers has the focus, or any time that anything in the component's window has the focus.

Application-wide pluggable look and feel

Behind the scenes, each `JComponent` object has a corresponding `ComponentUI` object that performs all the drawing, event handling, size determination, and so on for that `JComponent`. Exactly which `ComponentUI` object is used depends on the current look and feel, which you can set using the `UIManager.setLookAndFeel` method. See How to Set the Look and Feel◆

for details.

Properties

You can associate one or more properties (name/object pairs) with any `JComponent`. For example, a layout manager might use properties to associate a constraints object with each `JComponent` it manages. You put and get properties using the `putClientProperty` and `getClientProperty` methods. For general information about properties, see Using Properties to Manage Program Attributes◆.

Support for layout

Although the `Component` class provides layout hint methods such as `getPreferredSize` and `getAlignmentX`, it doesn't provide any way to set these layout hints, short of creating a subclass and overriding the methods. To give you another way to set layout hints, the `JComponent` class adds setter methods -- `setPreferredSize`, `setMinimumSize`, `setMaximumSize`, `setAlignmentX`, and `setAlignmentY`. See Layout Management◆ for more information.

Support for accessibility

The `JComponent` class provides API and basic functionality to help assistive technologies such as screen readers get information from Swing components, For more information about accessibility, see How to Support Assistive Technologies◆.

Double buffering

Double buffering smooths on-screen painting. For details, see Painting◆.

Methods to increase efficiency

`JComponent` has a few methods that provide more efficient ways to get information than the JDK 1.1 API allowed. The methods include `getX` and `getY`, which you can use instead of `getLocation`; and `getWidth` and `getHeight`, which you can use instead of `getSize`. It also adds one-argument forms of `getBounds`, `getLocation`, and `getSize` for which you specify the object to be modified and returned, letting you avoid unnecessary object creation. These methods have been added to `Component` for Java 2 (JDK 1.2).

The JComponent API

The `JComponent` class provides many new methods and inherits many methods from `Component` and `Container`. The following tables summarize the methods we use the most. The table is for reference only. Wherever possible, we provide links to where the

API is discussed in more detail.

- Customizing Component Appearance
- Setting Component State
- Handling Events
- Painting Components
- Dealing with the Containment Hierarchy
- Laying Out Components
- Getting Size and Position Information
- Specifying Absolute Size and Position

Customizing Component Appearance

Method	Purpose

`void setBorder(Border)`
`Border getBorder()`
(in `JComponent`)
	Set or get the border of the component. See How to Use Borders◆ for details.

`void setForeground(Color)`
`Color getForeground()`
`void setBackground(Color)`
`Color getBackground()`
(in `java.awt.Component`)
	Set or get the foreground or background color for the component. The foreground is generally the color used to draw the text in a component. The background is (not surprisingly) the color of the background areas of the component, assuming that the component is opaque.

`void setOpaque(boolean)` *(in `JComponent`)*	Set whether the component is opaque. An opaque component fills its background with its background color.
`boolean isOpaque` *(in `JComponent`)*	Get whether the component is opaque. This method (but not `setOpaque`) was added to `Component` in 1.2.

`void setFont(Font)`
`Font getFont()`
(in `java.awt.Component`)
	Set or get the component's font. If a font has not been set for the component, the font of its parent is returned.

`FontMetrics getFontMetrics(Font)` *(in `java.awt.Component`)*	Get the font metrics for the specified font.

Setting Component State

Method	Purpose
`void setToolTipText(String)` *(in `JComponent`)*	Set the text to display in a tool tip. See How to Use Tool Tips for more information.

`void setEnabled(boolean b)`
`boolean isEnabled()`
(in `java.awt.Component`)
	Set or get whether the component is enabled. An enabled component can respond to user input and generate events.

`void setLocale(Locale l)`
`Locale getLocale()`
(in `java.awt.Component`)
	Set or get the component's locale. If the component does not have a locale, the locale of its parent is returned. See Internationalization◆ for information about locales.

`void setCursor(Cursor)`
`Cursor getCursor()`
(in `java.awt.Component`)
	Set or get the cursor image to display when the mouse is over the component.

`void setVisible(boolean)`
`boolean isVisible()`
(in `java.awt.Component`)
	Set or get whether the component is visible. Components are initially visible, with the exception of top-level components.

Handling Events

(see Event Handling◆for details)

Method	**Purpose**

`void addComponentListener(ComponentListener)`
`void removeComponentListener(ComponentListener)`
(in `java.awt.Component`)
	Add or remove a component listener◆ to or from the component. Component listeners are notified when the listened-to component is hidden, shown, moved, or resized.

`void addKeyListener(KeyListener)`
`void removeKeyListener(KeyListener l)`
(in `java.awt.Component`)
	Add or remove a key listener◆ to or from the component. Key listeners are notified when the user types at the keyboard and the listened-to component has the keyboard focus.

`addMouseListener(MouseListener l)`
`void removeMouseListener(MouseListener)`
(in `java.awt.Component`)
	Add or remove a mouse listener◆ to or from the component. Mouse listeners are notified when the user uses the mouse to interact with the listened-to component.

`void addMouseMotionListener(MouseMotionListener)`
`void removeMouseMotionListener(MouseMotionListener)`
(in `java.awt.Component`)
	Add or remove a mouse motion listener◆ to or from the component. Mouse motion listeners are notified when the user moves the mouse within the listened-to component's bounds.

`void addContainerListener(ContainerListener)`
`void removeContainerListener(ContainerListener)`
(in `java.awt.Container`)
	Add or remove a container listener◆ to or from the container. Container listeners are notified when a component is added to or removed from the listened-to container.

`void addFocusListener(FocusListener)`
`void removeFocusListener(FocusListener)`
(in `java.awt.Component`)
	Add or remove a focus listener◆ to or from the component. Focus listeners are notified when the listened-to component gains or loses keyboard focus.

`Component getNextFocusableComponent()`
`void setNextFocusableComponent(Component)`
(in `JComponent`)
	Set or get the next focusable component. `null` indicates that the focus manager should choose the next focusable component automatically.

`void requestFocus()`
`boolean hasFocus()`
(in `java.awt.Component`)
	Request that the component get the keyboard focus, or detect whether it has the focus.

`boolean contains(int, int)`
`boolean contains(Point p)`
(in `java.awt.Component`)
	Determine whether the specified point is within the component. The argument should be specified in terms of the component's coordinate system. The two `int` arguments specify x and y coordinates, respectively.

`Component getComponentAt(int, int)` *(in `java.awt.Container`)*	Return the component that contains the specified x, y position. The top-most child component is returned in the case where components overlap. This is determined by finding the component closest to the index 0 that claims to contain the given point via `Component.contains()`.

Painting Components

(see Painting◆for details)

Method	**Purpose**

`void repaint()`
`void repaint(int, int, int, int)`
(in `java.awt.Component`)
	Request that all or part of the component be repainted. The four `int` arguments specify the bounds (x, y, width, height, in that order) of the rectangle to be painted.

`void repaint(Rectangle)` *(in `JComponent`)*	Request that the specified area within the component be repainted.
`void revalidate()` *(in `JComponent`)*	Request that the component and its affected containers be laid out again. You shouldn't generally need to invoke this method unless you explicitly change a component's size/alignment hints after it's visible, change a containment hierarchy after it's visible, or perhaps change the data in a component's model directly (without going through the component's API). You might need to invoke `repaint` after `revalidate`.
`void paintComponent(Graphics)` *(in `JComponent`)*	Paint the component. Override this method to implement painting for custom components.

Dealing with the Containment Hierarchy

(see Swing Components and the Containment Hierarchy◆for more information)

Method	**Purpose**

`Component add(Component)`
`Component add(Component, int)`
`void add(Component, Object)`
(in java.awt.Container)
	Add the specified component to the container. The one-argument version of this method adds the component to the end of the container. When present, the `int` argument indicates the new component's position within the container. When present, the `Object` argument provides layout constraints to the current layout manager.

`void remove(int)`
`void remove(Component comp)`
`void removeAll()`
(in java.awt.Container)
	Remove one of or all of the components from the container. When present, the `int` argument indicates the position within the container of the component to remove.

`JRootPane getRootPane()` *(in JComponent)*	Get the root pane ancestor for the component.
`Container getParent()` *(in java.awt.Component)*	Get the component's parent.
`int getComponentCount()` *(in java.awt.Container)*	Get the number of components in the container.

`Component getComponent(int)`
`Component[] getComponents()`
(in java.awt.Container)
	Get the one of or all of the components in the container. The `int` argument indicates the position of the component to get.

Laying Out Components

(see Laying Out Components Within a Container◆for more information)

Method	**Purpose**

`void setPreferredSize(Dimension)`
`void setMaximumSize(Dimension)`
`void setMinimumSize(Dimension)`
(in JComponent)
	Set the component's preferred, maximum, or minimum size, measured in pixels. The preferred size indicates the best size for the component. The component should be no larger than its maximum size and no smaller than its minimum size. Be aware that these are hints only and might be ignored by certain layout managers.

`Dimension getPreferredSize()`
`Dimension getMaximumSize()`
`Dimension getMinimumSize()`
(in java.awt.Component)
	Get the preferred, maximum, or minimum size of the component, measured in pixels. For non-`JComponent` subclasses, which don't have the corresponding setter methods, you can set a component's preferred, maximum, or minimum size by creating a subclass and overriding these methods.

`void setAlignmentX(float)`
`void setAlignmentY(float)`
(in `JComponent`)
	Set the alignment along the *x*- or *y*- axis. These values indicate how the component would like to be aligned relative to other components. The value should be a number between 0 and 1 where 0 represents alignment along the origin, 1 is aligned the furthest away from the origin, and 0.5 is centered, and so on. Be aware that these are hints only and might be ignored by certain layout managers.

`float getAlignmentX()`
`float getAlignmentY()`
(in `java.awt.Component`)
	Get the alignment of the component along the *x*- or *y*- axis. For non-`JComponent` subclasses, which don't have the corresponding setter methods, you can set a component's alignment by creating a subclass and overriding these methods.

`void setLayout(LayoutManager)`
`LayoutManager getLayout()`
(in `java.awt.Container`)
	Set or get the component's layout manager. The layout manager is responsible for sizing and positioning the components within a container.

Getting Size and Position Information

Method	**Purpose**

`int getWidth()`
`int getHeight()`
(in `java.awt.Component`)
	Get the current width or height of the component measured in pixels.

`Dimension getSize()`
`Dimension getSize(Dimension)`
(in `java.awt.Component`)
	Get the component's current size measured in pixels. When using the one-argument version of this method, the caller is responsible for creating the `Dimension` instance in which the result is returned.

`int getX()`
`int getY()`
(in `java.awt.Component`)
	Get the current x or y coordinate of the component's origin relative to the parent's upper left corner measured in pixels.

`Rectangle getBounds()`
`Rectangle getBounds(Rectangle)`
(in `java.awt.Component`)
	Get the bounds of the component measured in pixels. The bounds specify the component's width, height, and origin relative to its parent. When using the one-argument version of this method, the caller is responsible for creating the `Rectangle` instance in which the result is returned.

`Point getLocation()`
`Point getLocation(Point)`
`Point getLocationOnScreen()`
(in `java.awt.Component`)
	Gets the current location of the component relative to the parent's upper left corner measured in pixels. When using the one-argument version of `getLocation` method, the caller is responsible for creating the `Point` instance in which the result is returned. The `getLocationOnScreen` method returns the position relative to the upper left corner of the screen.

`Insets getInsets()` (in `java.awt.Container`)	Get the insets of the component.

Specifying Absolute Size and Position

(see Doing Without a Layout Manager (Absolute Positioning)◆for more information)

Method	**Purpose**

`void setLocation(int, int)`
`void setLocation(Point)`
(in `java.awt.Component`)
	Set the location of the component, in pixels, relative to the parent's upper left corner. The two `int` arguments specify x and y, in that order. Use these methods to position a component when you aren't using layout manager.

`void setSize(int, int)`
`void setSize(Dimension)`
(in `java.awt.Component`)
	Set the size of the component measured in pixels. The two `int` arguments specify width and height, in that order. Use these methods to size a component when you aren't using layout manager.

`void setBounds(int, int, int, int)`
`void setBounds(Rectangle)`
(in `java.awt.Component`)
	Set the size and location relative to the parent's upper left corner, in pixels, of the component. The four `int` arguments specify x, y, width, and height, in that order. Use these methods to position and size a component when you aren't using layout manager.

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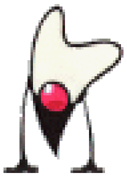
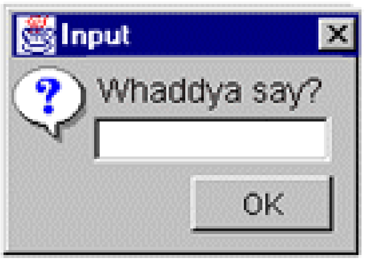
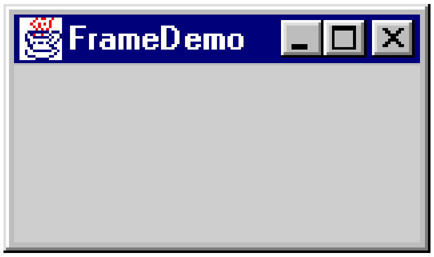
Top-Level Containers



Applet

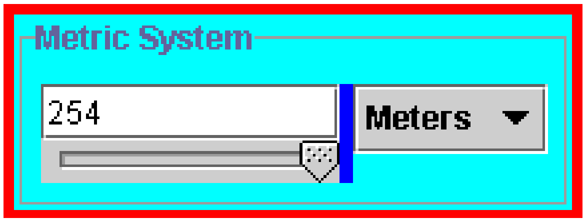


Dialog

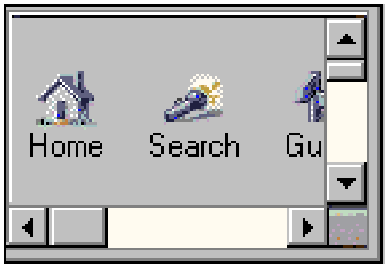


Frame

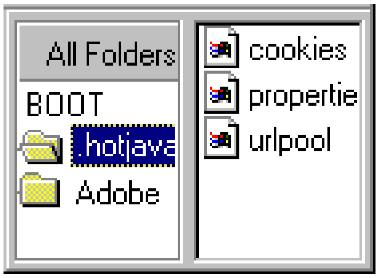
General-Purpose Containers



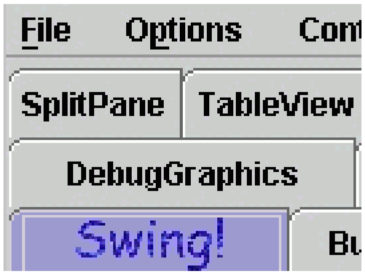
Panel



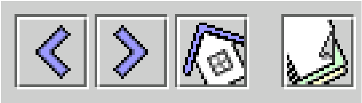
Scroll pane



Split pane

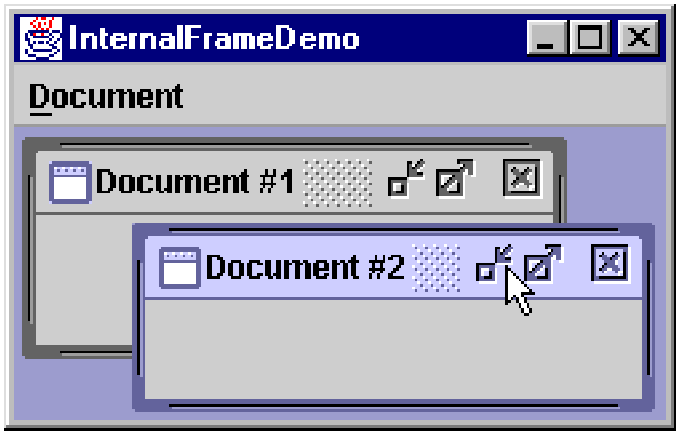


Tabbed pane

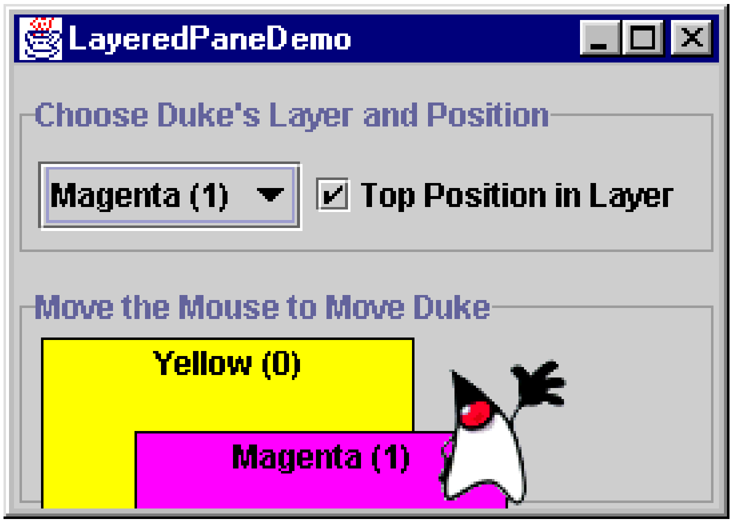


Tool bar

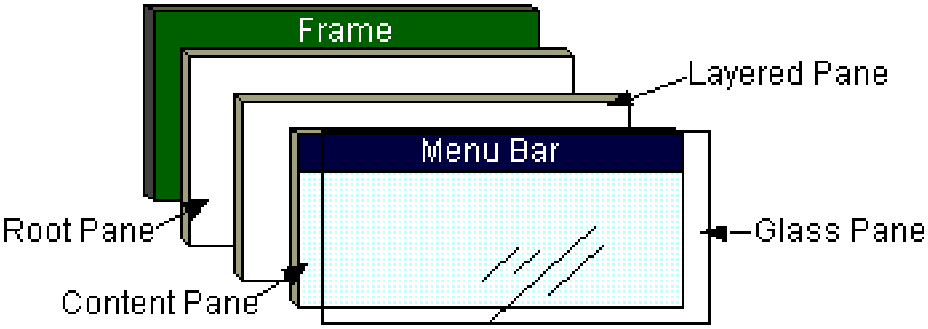
Special-Purpose Containers



Internal frame

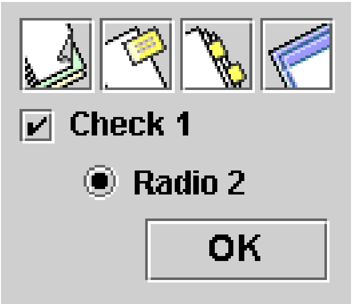


Layered pane

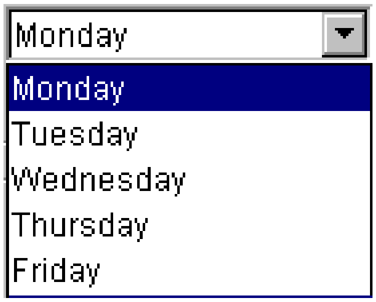


Root pane

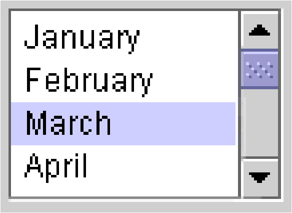
Basic Controls



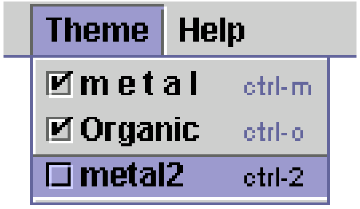
Buttons

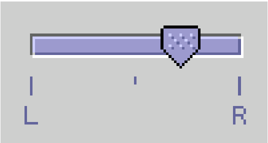


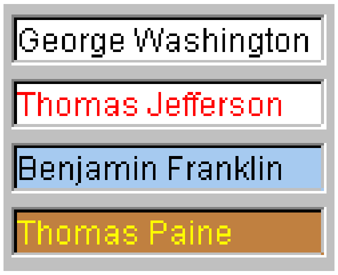
Combo box



List

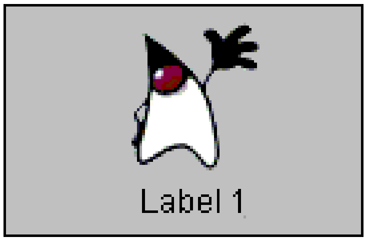




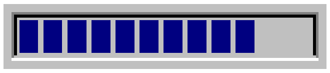


Menu Slider Text fields

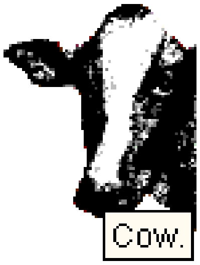
Uneditable Information Displays



Label

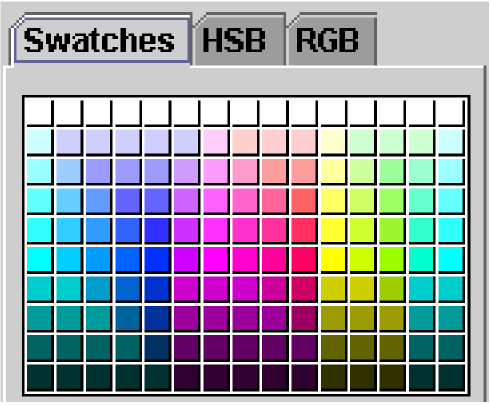


Progress bar

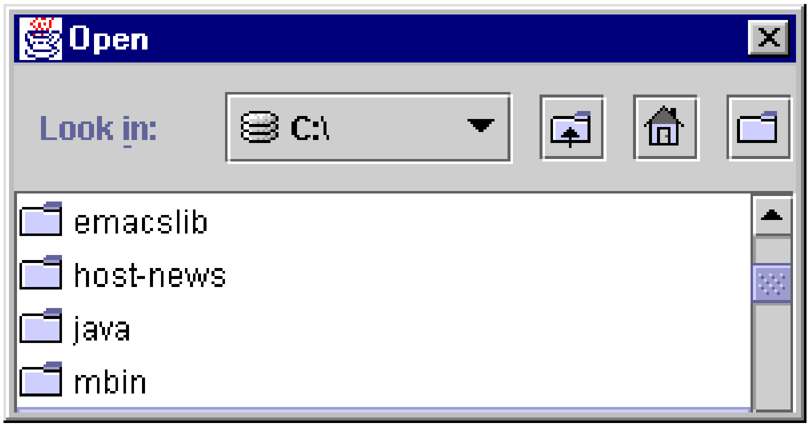


Tool tip

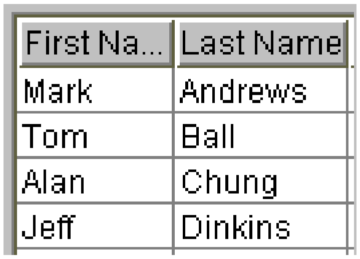
Editable Displays of Formatted Information



Color chooser

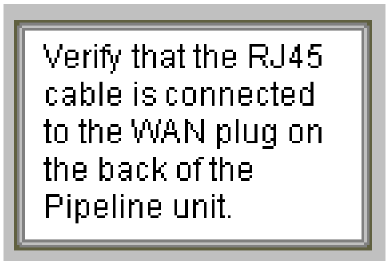


File chooser



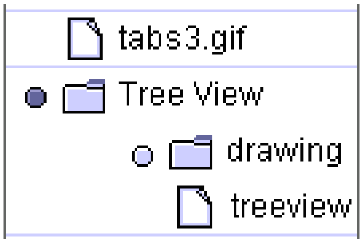
First Na...	Last Name
Mark	Andrews
Tom	Ball
Alan	Chung
Jeff	Dinkins

Table



Verify that the RJ45
cable is connected
to the WAN plug on
the back of the
Pipeline unit.

Text



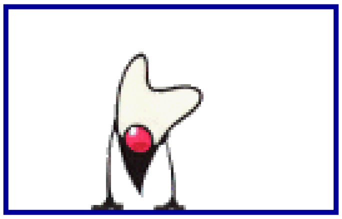
Tree

Trail: Creating a GUI with JFC/Swing
Lesson: Using Swing Components

How to Make Applets

This section covers `JApplet` -- a class that enables applets to use Swing components. `JApplet` is a subclass of `java.applet.Applet`, which is covered in the Writing Applets trail. If you've never written a regular applet before, we urge you to read that trail before proceeding with this section. The information provided in that trail applies to Swing applets, with a few exceptions that this section explains.

Any applet that contains Swing components must be implemented with a subclass of `JApplet`. Here's a Swing version of one of the applets that helped make Java famous -- an applet that animates our mascot, Duke, doing cartwheels:



This is a picture of the applet's GUI. To run the applet, click the picture. The applet will appear in a new browser window.

You can find the main source code for this applet in `TumbleItem.java`. You will also need one other source file and the image files that compose the animation. See the examples index for links to all the files required by this example.

This section discusses the following topics:

- Features Provided by JApplet
- Threads in Applets
- Using Images in a Swing Applet
- Providing an OBJECT/EMBED Tag for Java Plug-in
- The JApplet API
- Applet Examples

Features Provided by JApplet

`JApplet` adds two major features to the functionality that it inherits from `java.applet.Applet`. First, Swing applets provide support for assistive technologies◆. Second, because `JApplet` is a top-level Swing container, each Swing applet has a root pane. The most noticeable results of the root pane's presence are support for adding a menu bar and the need to use a content pane.

As described in Using Top-Level Containers, each top-level container such as a `JApplet` has a single content pane. The content pane makes Swing applets different from regular applets in the following ways:

- You add components to a Swing applet's content pane, not directly to the applet. Adding Components to the Content Pane shows you how.
- You set the layout manager on a Swing applet's content pane, not directly on the applet.
- The default layout manager for a Swing applet's content pane is `BorderLayout`. This differs from the default layout manager for `Applet`, which is `FlowLayout`.
- You should not put painting code directly in a `JApplet` object. See Converting to Swing◆ for information on converting applet painting code, and Working with Graphics◆ for examples of how to perform custom painting in applets.

JDK 1.1 Note: If you run a Swing applet using JDK 1.1 and JFC 1.1, then you might see an error message that looks like this:

```
Swing: checked access to system event queue.
```

You can often avoid this message by telling the applet not to check whether it has access to the system event queue. To do so, put the following code in the constructor for the applet class:

```
getRootPane().putClientProperty(
                  "defeatSystemEventQueueCheck",
                  Boolean.TRUE);
```

Threads in Applets

Because applets inherently use multiple threads and Swing components aren't thread safe, you should take care with threads in Swing applets. It's generally considered safe to create and manipulate Swing components directly in the `init` method. However, the other milestone methods -- `start`, `stop`, and `destroy` -- might cause trouble when the browser invokes them after the applet's already visible. To avoid trouble, you should make these methods thread safe.

For example, when you implement a `stop` or `start` method, be aware that the browser doesn't call them from the event-dispatching thread. Thus, those methods shouldn't affect or query Swing components directly. Instead, they should use techniques such as using the `SwingUtilities.invokeLater` method to affect components.

For more information about using threads, see Threads and Swing◆ and How to Use Threads◆.

Using Images in a Swing Applet

The `Applet` class provides the `getImage` method for loading images into an applet. The `getImage` method creates and returns an `Image` object that represents the loaded image. Because Swing components use `Icon`s rather than `Image`s to refer to pictures, Swing applets tend not to use `getImage`. Instead Swing applets create instances of `ImageIcon`--an icon loaded from an image file. `ImageIcon` comes with a code-saving benefit: it handles image tracking automatically. Refer to How to Use Icons◆ for more information.

The animation of Duke doing cartwheels requires 17 different pictures. The applet uses one `ImageIcon` per picture and loads them in its `init` method. Because images can take a long time to load, the icons are loaded in a separate thread implemented by a `SwingWorker` object◆. Here's the code:

```
public void init() {
    ...
    imgs = new ImageIcon[nimgs];
    final SwingWorker worker = new SwingWorker() {
        public Object construct() {
            URL baseURL = getCodeBase();
            String prefix = dir + "/T";

            //Images are numbered 1 to nimgs,
            //but fill array from 0 to nimgs-1
            for (int i = 0; i < nimgs; i++) {
                imgs[i] = new ImageIcon(getURL(baseURL,
                                               prefix + (i+1)
                                               + ".gif"));
            }
            finishedLoading = true;
            timer.start(); //Start the animation.
            return imgs;
        }
```

```
            ...
        };
        worker.start();
        ...
    }
```

To create an `ImageIcon` and load it with an image, you specify the image file's URL to the `ImageIcon`'s constructor. The `getURL` method is implemented as follows:

```
    protected URL getURL(URL codeBase, String filename) {
        URL url = null;

        try {
            url = new URL(codeBase, filename);
        } catch (java.net.MalformedURLException e) {
            System.out.println("Couldn't create image: "
                             + "badly specified URL");
            return null;
        }

        return url;
    }
```

Providing an OBJECT/EMBED Tag for Java Plug-in

To run, an applet must be included in an HTML page. If your applet's users have Swing-enabled browsers, then you can include the applet in an HTML page with an <APPLET> tag. Here's the <APPLET> tag for the cartwheeling Duke applet:

```
    <applet code="TumbleItem.class"
            codebase="example-swing/"
            archive="tumble.jar"
            width="600" height="95">
        <param name="maxwidth" value="120">
        <param name="nimgs" value="17">
        <param name="offset" value="-57">
        <param name="img" value="images/tumble">

    Your browser is completely ignoring the &lt;APPLET&gt; tag!

    </applet>
```

To find out about the various <APPLET> tag parameters, refer to Test Driving an Applet◆ and Using the APPLET Tag◆.

If your applet's users don't have a Swing-enabled browser, then they'll need to use Java Plug-in to run the applet. Java Plug-in requires that an applet be included in an HTML page with an <OBJECT> tag or <EMBED> tag. You can download a free tool that automatically generates the necessary tags from an <APPLET> tag. To download Java Plug-in and the HTML conversion tool, and for related documentation, go to the Java Plug-in home page .

Because Plug-in can take a while to download and load into the browser, it's considerate to give users advance warning that a page contains an applet. You might have noticed that the tutorial's applets don't run the same page as the text that describes the applet. Instead, we provide a screenshot of the applet running and a link that brings up a separate browser window in which to run the applet. This provides a better experience because they can choose whether or not to visit a page that contains an applet.

The JApplet API

The next table lists the interesting methods that `JApplet` adds to the applet API. They give you access to features provided by the root pane. Other methods you might use are defined by the `Component` and `Applet` classes. See Component Methods for a list of commonly used `Component` methods, and Taking Advantage of the Applet API for help in using `Applet` methods.

Method	Purpose

`void setContentPane(Container)`
`Container getContentPane()`
	Set or get the applet's content pane. The content pane contains the applet's visible GUI components and should be opaque.

`JRootPane createRootPane()`
`void setRootPane(JRootPane)`
`JRootPane getRootPane()`
	Create, set, or get the applet's root pane. The root pane manages the interior of the applet including the content pane, the glass pane, and so on.

`void setJMenuBar(JMenuBar)`
`JMenuBar getJMenuBar()`
	Set or get the applet's menu bar to manage a set of menus for the frame.

`void setGlassPane(Component)`
`Component getGlassPane()`
	Set or get the applet's glass pane. You can use the glass pane to intercept mouse events.

`void setLayeredPane(JLayeredPane)`
`JLayeredPane getLayeredPane()`
	Set or get the applet's layered pane. You can use the frame's layered pane to put components on top of or behind other components.

Applet Examples

This table shows examples of Swing applets and where those examples are described.

Example	Where Described	Notes
`TumbleItem`	This page	An animation applet
`HelloSwingApplet`	Running Swing Applets◆	The simplest of all Swing applets -- it contains only a label.
`AppletDemo`	Running Swing Applets◆	The applet version of the button demo program. Can be run either as an application or as an applet.
`IconDemoApplet`	How to Use Icons◆	An applet for showing photos.
Several examples.	Using Layout Managers◆	You can run several applets from the page listed. Each applet demonstrates a different layout manager.
Several examples.	Some Simple Event-Handling Examples◆	You can run several applets from the page listed. Each applet shows how to handle different types of events.

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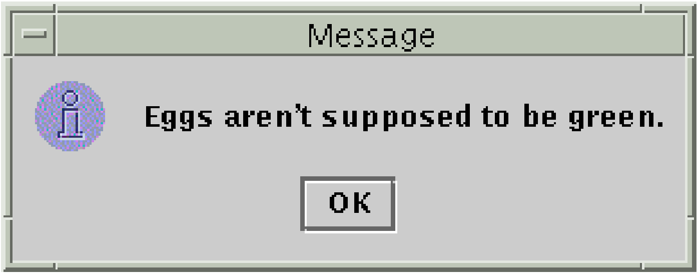
Trail: Creating a GUI with JFC/Swing
Lesson: Using Swing Components

How to Make Dialogs

Several classes support *dialogs* -- windows that are more limited than frames. To create simple, standard dialogs, you use the `JOptionPane`◆ class. The `ProgressMonitor` class can put up a dialog that shows the progress of an operation. Two other classes, `JColorChooser` and `JFileChooser`, also supply standard dialogs. To bring up a print dialog, you can use either the `getPrintJob` method defined in the `Toolkit`◆ class or, if you're using the Java 2 platform, the Printing◆ API. To create custom dialogs, use the `JDialog`◆ class directly.

The code for simple dialogs can be minimal. For example, here's an informational dialog:



Eggs aren't supposed to be green.

Here is the code that creates and shows it:

```
JOptionPane.showMessageDialog(frame, "Eggs aren't supposed to be green.");
```

The rest of this section covers the following topics:

- An Overview of Dialogs
- The DialogDemo Example
- JOptionPane Features
- Creating and Showing Simple Dialogs
- Customizing Button Text
- Getting the User's Input from a Dialog
- Stopping Automatic Dialog Closing
- The Dialog API
- Examples that Use Dialogs

An Overview of Dialogs

Every dialog is dependent on a frame. When that frame is destroyed, so are its dependent dialogs. When the frame is iconified, its dependent dialogs disappear from the screen. When the frame is deiconified, its dependent dialogs return to the screen. The AWT automatically provides this behavior.

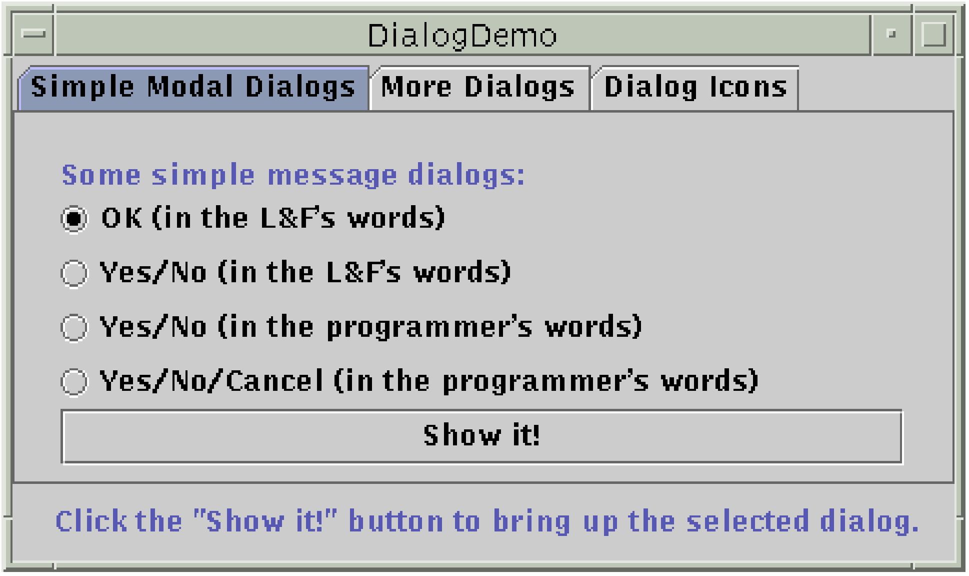
A dialog can be *modal*. When a modal dialog is visible, it blocks user input to all other windows in the program. The dialogs that `JOptionPane` provides are modal. To create a non-modal dialog, you must use the `JDialog` class directly.

The `JDialog` class is a subclass of the AWT `java.awt.Dialog` class. It adds to `Dialog` a root pane and support for a default close operation. These are the same features that `JFrame` has, and using `JDialog` directly is very similar to using `JFrame` directly. If you're going to use `JDialog` directly, then you should understand the material in Using Top-Level Containers and How to Make Frames, especially Responding to Window-Closing Events.

Even when you use `JOptionPane` to implement a dialog, you're still using a `JDialog` behind the scenes. The reason is that `JOptionPane` is simply a container that can automatically create a `JDialog` and add itself to the `JDialog`'s content pane.

The DialogDemo Example

Here's a picture of an application that displays dialogs.



Some simple message dialogs:

● OK (in the L&F's words)

○ Yes/No (in the L&F's words)

○ Yes/No (in the programmer's words)

○ Yes/No/Cancel (in the programmer's words)

Click the "Show it!" button to bring up the selected dialog.

Try this:

1. Compile and run the application. The main source file is `DialogDemo.java`. You will also need one other source file and an image file. See the examples index for links to all the files required by this example.
   See Getting Started with Swing if you need help compiling or running this application.
2. Click the Show it! button.
   A modal dialog will appear. Until you close it, the application will be unresponsive, although it will repaint itself if necessary. You can close the dialog either by clicking a button in the dialog or explicitly, such as by using the dialog's window decorations.
3. Iconify the DialogDemo window while a dialog is showing.
   The dialog will disappear from the screen until you deiconify the DialogDemo window.
4. In the More Dialogs pane, click the bottom radio button and then the Show it! button. A non-modal dialog will appear. Note that the DialogDemo window remains fully

functional while the non-modal dialog is up.

JOptionPane Features

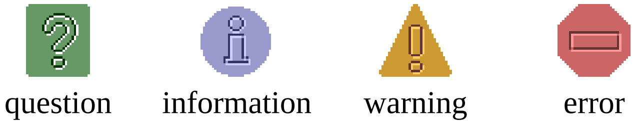
Using `JOptionPane`, you can create and customize several different kinds of dialogs. `JOptionPane` provides support for laying out standard dialogs, providing icons, specifying the dialog's title and text, and customizing the button text. Other features allow you to customize the components the dialog displays and specify where the dialog should appear onscreen. You can even specify that an option pane put itself into an internal frame (`JInternalFrame`) instead of a `JDialog`.

Note: The internal frames that `JOptionPane` creates currently behave differently from modal dialogs. They don't behave modally, and in general seem more like frames than like dialogs. For this reason, we don't currently recommend their use.

When you create a `JOptionPane`, look-and-feel-specific code adds components to the `JOptionPane` and determines the layout of those components.

`JOptionPane`'s icon support lets you easily specify which icon the dialog displays. You can use a custom icon, no icon at all, or any one of four standard `JOptionPane` icons (question, information, warning, and error). Each look and feel has its own versions of the four standard icons. The following figure shows the icons used in the Java Look & Feel.

Icons provided by JOptionPane
(Java Look & Feel shown)



Creating and Showing Simple Dialogs

For most simple modal dialogs, you create and show the dialog using one of `JOptionPane`'s `show`*`Xxx`*`Dialog` methods. If your dialog should be an internal frame, then add `Internal` after `show` -- for example, `showMessageDialog` changes to `showInternalMessageDialog`. If you need to control the dialog's window-closing behavior or if the dialog isn't modal, then you should directly instantiate `JOptionPane` and add it to a `JDialog` instance. Then invoke `setVisible(true)` on the `JDialog` to make it appear.

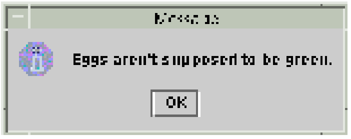
The two most useful `show`*`Xxx`*`Dialog` methods are `showMessageDialog` and `showOptionDialog`. The `showMessageDialog` method displays a simple, one-button dialog. The `showOptionDialog` method displays a customized dialog -- it can display a variety of buttons with customized button text, and can contain a standard text message or a collection of components.

The other two `show`*`Xxx`*`Dialog` methods are used less often. The `showConfirmDialog` method asks the user to confirm something, but has the disadvantage of having standard button text (Yes/No or the localized equivalent, for example), rather than button text customized to the user's situation (Start/Cancel, for example). A fourth method, `showInputDialog`, is designed to display a modal dialog that gets a string from the user, using either a text field or an uneditable combo box. However, input dialogs aren't very useful right now, since the text field doesn't let you perform validation before the dialog goes away, and combo boxes in dialogs don't yet work well.

Here are some examples, taken from `DialogDemo.java`◆, of using `showMessageDialog`, `showOptionDialog`, and the `JOptionPane` constructor. For more example code, see `DialogDemo.java`◆ and the other programs listed in Examples that Use Dialogs.

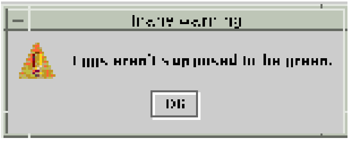
`showMessageDialog`

Displays a modal dialog with one button, which is labeled "OK" (or the localized equivalent). You can easily specify the message, icon, and title that the dialog displays. Here are some examples of using `showMessageDialog`:



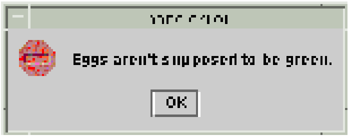
Eggs aren't supposed to be green.

```
//default title and icon
JOptionPane.showMessageDialog(frame,
    "Eggs aren't supposed to be green.");
```



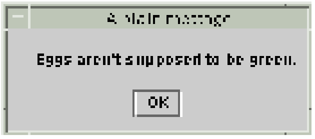
Eggs aren't supposed to be green.

```
//custom title, warning icon
JOptionPane.showMessageDialog(frame,
    "Eggs aren't supposed to be green.",
    "Inane warning",
    JOptionPane.WARNING_MESSAGE);
```



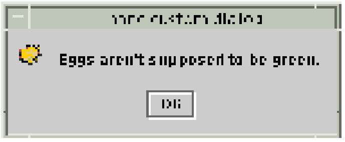
Eggs aren't supposed to be green.

```
//custom title, error icon
JOptionPane.showMessageDialog(frame,
    "Eggs aren't supposed to be green.",
    "Inane error",
    JOptionPane.ERROR_MESSAGE);
```



Eggs aren't supposed to be green.

```
//custom title, no icon
JOptionPane.showMessageDialog(frame,
    "Eggs aren't supposed to be green.",
    "A plain message",
    JOptionPane.PLAIN_MESSAGE);
```

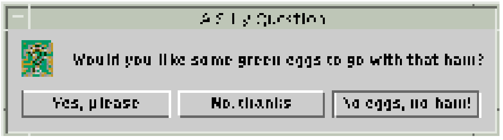


Eggs aren't supposed to be green.

```
//custom title, custom icon
JOptionPane.showMessageDialog(frame,
    "Eggs aren't supposed to be green.",
    "Inane custom dialog",
    JOptionPane.INFORMATION_MESSAGE,
    icon);
```

`showOptionDialog`

Displays a modal dialog with the specified buttons, icons, message, title, and so on. With this method, you can change the text that appears on the buttons of standard dialogs. You can also perform many other kinds of customization.

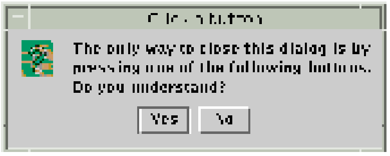


Would you like some green eggs to go with that ham?

```
//Custom button text
Object[] options = {"Yes, please",
                    "No, thanks",
                    "No eggs, no ham!"};
int n = JOptionPane.showOptionDialog(frame,
    "Would you like some green eggs to go "
    + "with that ham?",
    "A Silly Question",
    JOptionPane.YES_NO_CANCEL_OPTION,
    JOptionPane.QUESTION_MESSAGE,
    null,
    options,
    options[2]);
```

`JOptionPane` (constructor)

Creates a `JOptionPane` with the specified buttons, icons, message, title, and so on. You must then add the option pane to a `JDialog`, register a property-change listener on the option pane, and show the dialog. See Stopping Automatic Dialog Closing for details.



The only way to close this dialog is by
pressing one of the following buttons.
Do you understand?

```
final JOptionPane optionPane = new JOptionPane(
    "The only way to close this dialog is by\n"
    + "pressing one of the following buttons.\n"
    + "Do you understand?",
    JOptionPane, QUESTION_MESSAGE,
    JOptionPane.YES_NO_OPTION);
```

The arguments to all of the `show`*`Xxx`*`Dialog` methods and `JOptionPane` constructors are standardized, though the number of arguments for each method and constructor varies. The following list describes each argument. To see the exact list of arguments for a particular method, see The Dialog API.

`Component` *`parentComponent`*

The first argument to each `show`*`Xxx`*`Dialog` method is always the parent component, which must be a frame, a component inside a frame, or null. If you specify a frame, then the dialog will appear over the center of the frame, and depend on that frame. If you specify a component inside a frame, then the dialog will appear over the center of that component, and depend on that component's frame. If you specify null, then the look and feel picks an appropriate position for the dialog -- generally the center of the screen, and the dialog doesn't depend on any visible frame.

The `JOptionPane` constructors do not include this argument. Instead, you specify the parent frame when you create the `JDialog` that contains the `JOptionPane`, and you use the `JDialog` `setLocationRelativeTo` method to set the dialog's position.

`Object` *`message`*

This required argument specifies what the dialog should display in its main area. Generally, you specify a string, which results the dialog displaying a label with the specified text. You can split the message over several lines by putting newline (`\n`) characters inside the message string. For example:

```
"Complete the sentence:\n \"Green eggs and...\""
```

`String` *`title`*

The title of the dialog.

`int` *`optionType`*

Specifies the set of buttons that appear at the bottom of the dialog. Choose from one of the following standard sets: `DEFAULT_OPTION`, `YES_NO_OPTION`, `YES_NO_CANCEL_OPTION`, `OK_CANCEL_OPTION`.

`int` *`messageType`*

This argument determines the icon displayed in the dialog. Choose from one of the following values: `PLAIN_MESSAGE` (no icon), `ERROR_MESSAGE`, `INFORMATION_MESSAGE`, `WARNING_MESSAGE`, `QUESTION_MESSAGE`.

`Icon` *`icon`*

The icon to display in the dialog.

`Object[]` *`options`*

Further specifies the option buttons to appear at the buttom of the dialog. Generally, you specify an array of strings for the buttons. See Customizing Button Text in a Standard Dialog for more information.

`Object` *`initialValue`*

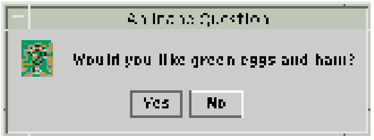
Specifies the default value to be selected.

You can either let the default icon be used or specify the icon using the message type or icon argument. By default, a dialog created with `showMessageDialog` displays the information icon, and a dialog created with `showConfirmDialog` or `showInputDialog` displays the question icon. An option pane created with a `JOptionPane` constructor displays no icon, by default. To specify that the dialog display a standard icon or no icon, specify the message type. To specify a custom icon, use the icon argument. The icon argument takes precedence over the message type; as long as the icon argument has a non-null value, the dialog displays the specified icon.

Customizing Button Text

When you use `JOptionPane` to create a dialog, you can choose either to use the standard button text (which might vary by look and feel) or to specify different text.

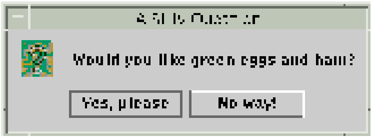
The following code, taken from `DialogDemo.java`, creates two Yes/No dialogs. The first dialog is implemented with `showConfirmDialog`, which uses the look-and-feel wording for the two buttons. The second dialog uses `showOptionDialog` so it can customize the wording. With the exception of wording changes, the dialogs are identical.



An Inane Question

Would you like green eggs and ham?

```
//default icon, custom title
int n = JOptionPane.showConfirmDialog(
    frame,
    "Would you like green eggs and ham?",
    "An Inane Question",
    JOptionPane.YES_NO_OPTION);
```



A Silly Question

Would you like green eggs and ham?

```
Object[] options = {"Yes, please",
                    "No way!"};
int n = JOptionPane.showOptionDialog(frame,
    "Would you like green eggs and ham?",
    "A Silly Question",
    JOptionPane.YES_NO_OPTION,
    JOptionPane.QUESTION_MESSAGE,
    null,     //don't use a custom Icon
    options,  //the titles of buttons
    options[0]); //default button title
```

Getting the User's Input from a Dialog

As the previous code snippets showed, the `showMessageDialog`, `showConfirmDialog`, and `showOptionDialog` methods return an integer indicating the user's choice. The values for this integer are `YES_OPTION`, `NO_OPTION`, `CANCEL_OPTION`, `OK_OPTION`, and `CLOSED_OPTION`. Except for `CLOSED_OPTION`, each option corresponds to the button the user pressed. When `CLOSED_OPTION` is returned, it indicates that the user closed the dialog window explicitly, rather than by choosing a button inside the option pane.

Even if you change the strings that the standard dialog buttons display, the return value is still one of the pre-defined integers. For example, a `YES_NO_OPTION` dialog always returns one of the following values: `YES_OPTION`, `NO_OPTION`, or `CLOSED_OPTION`.

If you're designing a custom dialog, on the other hand, then you need to design your dialog's API so that you can query the dialog about what the user chose. For example, the dialog implemented in `CustomDialog.java`◆ has a `getValidatedText` method that returns the text the user entered.

Stopping Automatic Dialog Closing

By default, when the user clicks a `JOptionPane`-created button, the dialog closes. But what if you want to check the user's answer before closing the dialog? In this case, you must implement your own property change listener so that when the user clicks a button, the dialog doesn't automatically close.

`DialogDemo` contains two dialogs that implement a property change listener. One of these dialogs is a custom modal dialog, implemented in `CustomDialog`◆, that uses `JOptionPane` both to get the standard icon and to get layout assistance. The other dialog, whose code is below, uses a standard Yes/No `JOptionPane`, Though this dialog is rather useless as written, its code is simple enough that you can use it as a template for more complex dialogs.

Besides setting the property change listener, the following code also calls the `JDialog`'s `setDefaultCloseOperation` method and implements a window listener that handles the window close attempt properly. If you don't care to be notified when the user closes the window explicitly, then ignore the bold code.

```
final JOptionPane optionPane = new JOptionPane(
                "The only way to close this dialog is by\n"
                + "pressing one of the following buttons.\n"
                + "Do you understand?",
                JOptionPane.QUESTION_MESSAGE,
                JOptionPane.YES_NO_OPTION);

final JDialog dialog = new JDialog(frame,
                             "Click a button",
                             true);
dialog.setContentPane(optionPane);
dialog.setDefaultCloseOperation(
    JDialog.DO_NOTHING_ON_CLOSE);
dialog.addWindowListener(new WindowAdapter() {
    public void windowClosing(WindowEvent we) {
        setLabel("Thwarted user attempt to close window.");
    }
});
optionPane.addPropertyChangeListener(
    new PropertyChangeListener() {
        public void propertyChange(PropertyChangeEvent e) {
            String prop = e.getPropertyName();

            if (dialog.isVisible()
             && (e.getSource() == optionPane)
             && (prop.equals(JOptionPane.VALUE_PROPERTY) ||
                 prop.equals(JOptionPane.INPUT_VALUE_PROPERTY)))
            {
                //If you were going to check something
                //before closing the window, you'd do
                //it here.
                dialog.setVisible(false);
            }
        }
    });
dialog.pack();
dialog.setVisible(true);

int value = ((Integer)optionPane.getValue()).intValue();
if (value == JOptionPane.YES_OPTION) {
    setLabel("Good.");
} else if (value == JOptionPane.NO_OPTION) {
    setLabel("Try using the window decorations "
             + "to close the non-auto-closing dialog. "
             + "You can't!");
}
```

The Dialog API

The following tables list the commonly used `JOptionPane` and `JDialog` constructors and methods. Other methods you're likely to call are defined by the `Dialog`◆, `Window`◆ and `Component`◆ classes and include `pack`, `setSize`, and `setVisible`.

The API is listed as follows:

- Showing Standard Modal Dialogs (using `JOptionPane` Class Methods
- Methods for Using `JOptionPane`s Directly
- Frequently Used `JDialog` Constructors and Methods

Showing Standard Modal Dialogs (Using `JOptionPane` Class Methods)

Method	Purpose

`int showMessageDialog(Component, Object)`
`int showMessageDialog(Component, Object, String, int)`
`int showMessageDialog(Component, Object, String, int, Icon)`
	Show a one-button, modal dialog that gives the user some information. The arguments specify (in order) the parent component, message, title, message type, and icon for the dialog. See Creating and Showing Simple Dialogs for a discussion of the arguments and their effects.

`int showOptionDialog(Component, Object, String, int, int, Icon, Object[], Object)`	Show a customized modal dialog. The arguments specify (in order) the parent component, message, title, option type, message type, icon, options, and initial value for the dialog. See Creating and Showing Simple Dialogs for a discussion of the arguments and their effects.

`int showConfirmDialog(Component, Object)`
`int showConfirmDialog(Component, Object, String, int)`
`int showConfirmDialog(Component, Object, String, int, int)`
`int showConfirmDialog(Component, Object, String, int, int, Icon)`
	Show a modal dialog that asks the user a question. The arguments specify (in order) the parent component, message, title, option type, message type, and icon for the dialog. See Creating and Showing Simple Dialogs for a discussion of the arguments and their effects.

String showInputDialog(Object) String showInputDialog(Component, Object) String showInputDialog(Component, Object, String, int) String showInputDialog(Component, Object, String, int, Icon, Object[], Object)	Show a modal dialog that prompts the user for input. The single-argument version specifies just the message, with the parent component assumed to be null. The arguments for the other versions specify (in order) the parent component, message, title, message type, icon, options, and initial value for the dialog. See Creating and Showing Simple Dialogs for a discussion of the arguments and their effects.
int showInternalMessageDialog(...) int showInternalOptionDialog(...) int showInternalConfirmDialog(...) String showInternalInputDialog(...)	Implement a standard dialog as an internal frame. See the `JOptionPane` API documentation for the exact list of arguments.

Methods for Using `JOptionPane`s Directly

Method or Constructor	**Purpose**

JOptionPane()
JOptionPane(Object)
JOptionPane(Object, int)
JOptionPane(Object, int, int)
JOptionPane(Object, int, int, Icon)
JOptionPane(Object, int, int, Icon, Object[])
JOptionPane(Object, int, int, Icon, Object[], Object)
	Creates a `JOptionPane` instance. See Creating and Showing Simple Dialogs for a discussion of the arguments and their effects.

Frame getFrameForComponent(Component) JDesktopPane getDesktopPaneForComponent(Component)	Handy `JOptionPane` class methods that find the frame or desktop pane, respectively, that the specified component is in.

Frequently Used `JDialog` Constructors and Methods

Method/Constructor	**Purpose**

JDialog()
JDialog(Frame)
JDialog(Frame, boolean)
JDialog(Frame, String)
JDialog(Frame, String, boolean)
	Creates a `JDialog` instance. The `Frame` argument, if any, is the frame (usually a `JFrame` object) that the dialog depends on. Make the boolean argument `true` to specify a modal dialog, `false` or absent to specify a non-modal dialog. You can also specify the title of the dialog, using a string argument.

Container getContentPane() setContentPane(Container)	Get and set the content pane, which is usually the container of all the dialog's components. See Using Top-Level Containers for more information.

`int getDefaultCloseOperation()`
`setDefaultCloseOperation(int)`
	Get and set what happens when the user tries to close the dialog. Possible values: `DISPOSE_ON_CLOSE`, `DO_NOTHING_ON_CLOSE`, `HIDE_ON_CLOSE` (the default). See Responding to Window-Closing Events for more information.

`void setLocationRelativeTo(Component)`	Centers the dialog over the specified component.

Examples that Use Dialogs

This table lists examples that use `JOptionPane` or `JDialog`. To find other examples that use dialogs, see the example lists for progress bars, color choosers, and file choosers.

Example	Where Described	Notes
`DialogDemo`, `CustomDialog`	This section	Creates many kinds of dialogs, using `JOptionPane` and `JDialog`.
`Framework`	--	Brings up a confirmation dialog when the user selects the Quit menu item.
`ListDialog`	How to Use BoxLayout	Implements a modal dialog containing a scrolling list and two buttons. Doesn't use `JOptionPane`, except for the utility method `getFrameForComponent`.
`TableDemo`	How to Use Tables	Brings up a warning dialog when the user types a non-number entry into a cell that must contain a number.

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Lesson: Using Swing Components

How to Use Panels

The `JPanel`◆ class provides general-purpose containers for lightweight components. By default, panels don't paint anything except for their background; however, you can easily add borders to them and otherwise customize their painting. For information about using panels to perform custom painting, see Overview of Custom Painting◆.

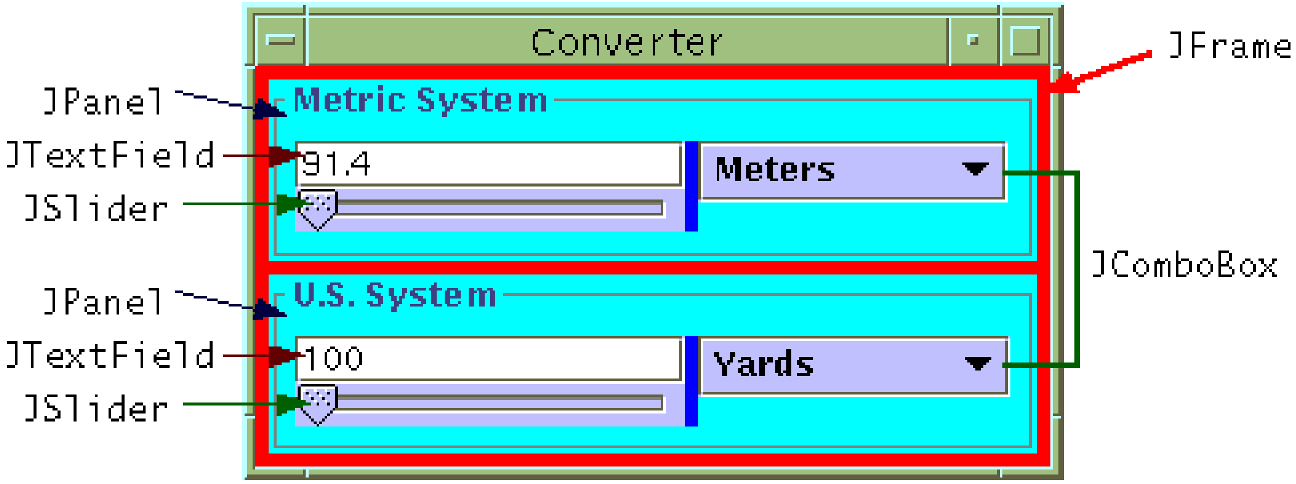
By default, panels are opaque. This makes them work well as content panes, and can help painting efficiency, as described in Painting◆. You can make a panel transparent by invoking `setOpaque(false)`. A transparent panel draws no background, so that any components underneath show through.

An Example

The Converter application described in The Anatomy of a Swing-Based Program◆ uses panels in several ways:

- One `JPanel` instance serves as a content pane for the application's frame. This content pane uses a two-row `GridLayout`◆ to lay out its contents, and an empty border to put 5 pixels of space around them. See Using Top-Level Containers for information about content panes.
- Two instances of a `JPanel` subclass, named `ConversionPanel`, are used to both contain components and coordinate communication between components. The panels also have titled borders, which describe their contents and paint a line around them. The panels use left-to-right `BoxLayout`◆ objects to lay out their contents.
- Two instances of an unnamed `JPanel` subclass are used to group components and restrict their size. The panels use top-to-bottom `BoxLayout`◆ objects to lay out their contents.

The following picture is the same as a picture in The Anatomy of a Swing-Based Program ◆. It shows a colorized version of Converter, in which each panel has a background color.



As the figure shows, panels are useful for grouping components, simplifying component layout, and putting borders around groups of components. The rest of this section gives hints on grouping and laying out components. For information about using borders, see How to Use Borders◆.

Setting the Layout Manager

Like other containers, a panel uses a layout manager to position and size its components. By default, a panel's layout manager is an instance of `FlowLayout`◆, which places the panel's contents in a row. You can easily make a panel use any other layout manager by invoking the `setLayout` method or specifying a layout manager when creating the panel. Here is an example of the first approach:

```
JPanel aPanel = new JPanel();
aPanel.setLayout(new BorderLayout());
```

Here is an example of setting the layout manager at instantiation:

```
JPanel aPanel = new JPanel(new BorderLayout());
```

For more information about choosing and using layout managers, see Laying Out Components Within a Container◆.

Adding Components

When you add components to a panel, you use the `add` method. Exactly which arguments you specify to the `add` method depend on which layout manager the panel uses. When the layout manager is `FlowLayout`, `BoxLayout`, `GridLayout`, or `GridBagLayout`, you'll typically use the one-argument `add` method, like this:

```
aFlowPanel.add(aComponent);
aFlowPanel.add(anotherComponent);
```

When the layout manager is `BorderLayout`, you need to provide a second argument specifying the added component's position within the panel. For example:

```
aBorderPanel.add(aComponent, BorderLayout.CENTER);
aBorderPanel.add(anotherComponent, BorderLayout.SOUTH);
```

For information on the arguments to use with `BorderLayout`, see How to Use Borders ◆.

The Panel API

The API in the `JPanel` class itself is minimal. The methods you are most likely to invoke on a `JPanel` object are those it inherits from its superclasses -- `JComponent`◆, `Container`◆, and `Component`◆. The following tables list the API you're most likely to use, with the exception of methods related to borders and layout hints. For more information about the API all `JComponent`s can use, see The JComponent Class.

- Creating a `JPanel`
- Managing a Container's Components
- Setting/Getting the Layout Manager

Creating a `JPanel`

Constructor	**Purpose**

`JPanel()`
`JPanel(LayoutManager)`
	Create a panel. The `LayoutManager` parameter provides a layout manager for the new panel. By default, a panel uses a `FlowLayout` to lay out its components.

Managing a Container's Components

Method	**Purpose**

`void add(Component)`
`void add(Component, int)`
`void add(Component, Object)`
`void add(Component, Object, int)`
`void add(String, Component)`
	Add the specified component to the panel. When present, the `int` parameter is the index of the component within the container. By default, the first component added is at index 0, the second is at index 1, and so on. The `Object` parameter is layout manager dependent and typically provides information to the layout manager regarding positioning and other layout constraints for the added component. The `String` parameter is similar to the `Object` parameter.

`int getComponentCount()`	Get the number of components in this panel.

`Component getComponent(int)`
`Component getComponentAt(int, int)`
`Component getComponentAt(Point)`
`Component[] getComponents()`
	Get the specified component or components. You can get a component based on its index or x, y position.

`void remove(Component)`
`void remove(int)`
`void removeAll()`
	Remove the specified component(s).

Setting/Getting the Layout Manager

Method	**Purpose**

`void setLayout(LayoutManager)`
`LayoutManager getLayout()`
	Set or get the layout manager for this panel. The layout manager is responsible for positioning the panel's components within the panel's bounds according to some philosophy.

Examples that Use Panels

Many examples contained in this lesson use `JPanel` objects. The following table lists a few.

Example	**Where Described**	**Notes**
`Converter` and other files	This section and The Anatomy of a Swing-Based Program◆	Uses five panels, four of which use `BoxLayout` and one of which uses `GridLayout`. The panels use borders and, as necessary, size and alignment hints to affect layout.

`ListDemo`	How to Use Lists	Uses a panel, with its default `FlowLayout` manager, to center three components in a row.
`ToolBarDemo`	How to Use Toolbar	Uses a panel as a content pane. The panel contains three components, laid out by `BorderLayout`.
`BorderDemo`	How to Use Borders	Contains many panels that have various kinds of borders. Several panels use `BoxLayout`.
`BoxLayoutDemo`	How to Use BoxLayout	Illustrates the use of a panel with Swing's `BoxLayout` manager.

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Trail: Creating a GUI with JFC/Swing
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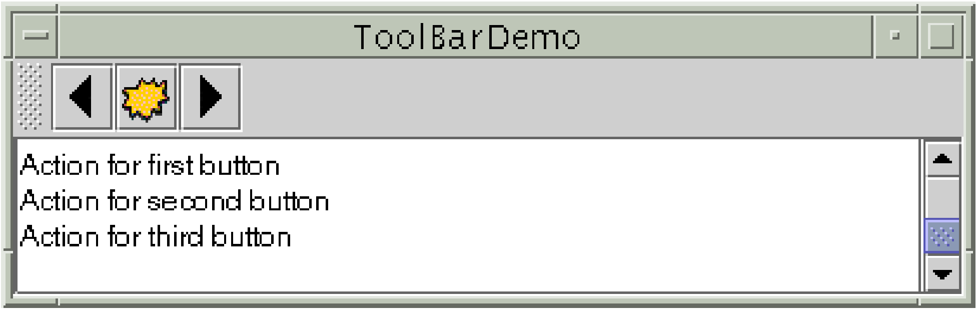
How to Use Scroll Panes

A `JScrollPane` provides a scrollable view of a component. When screen real estate is limited, use a scroll pane to display a component that is large or one whose size can change dynamically.

The code to create a scroll pane can be minimal. For example, here's a picture of a demo program that puts a text area in a scroll pane because the text area's size grows dynamically as text is appended to it:



Action for first button
Action for second button
Action for third button

Here's the code that creates the text area, makes it the scroll pane's client, and adds the scroll pane to the frame:

```
textArea = new JTextArea(5, 30);
JScrollPane scrollPane = new JScrollPane(textArea);
...
contentPane.setPreferredSize(new Dimension(400, 100));
...
contentPane.add(scrollPane, BorderLayout.CENTER);
```

The program provides the text area as an argument to `JScrollPane`'s constructor. This establishes the text area as the scroll pane's client. The scroll pane handles everything else: creating the scroll bars when necessary, redrawing the client when the user moves the scroll knobs, and so on.

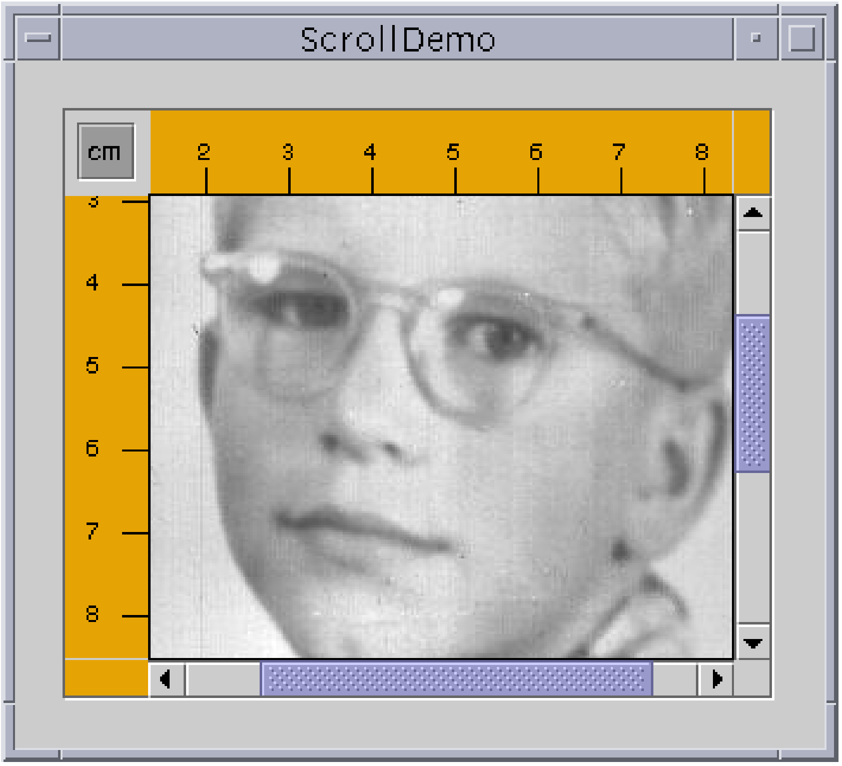
Without the bold line of code, the scroll pane would compute its preferred size so that the text area, at its preferred size, would fit entirely within the scroll pane. Consequently, the scroll pane would have no scroll bars. The bold line sets the preferred size of the scroll pane's container such that the scroll pane is forced into a shorter-than-preferred area. Thus when the program first appears onscreen, the scroll pane has a vertical scroll bar. Refer to Sizing a Scroll Pane for information about using other techniques for making a scroll pane the size you want.

The rest of this section discusses the following topics:

- How a Scroll Pane Works
- Setting the Scroll Bar Policy
- Providing Custom Decorations
- Implementing a Scrolling-Savvy Client
- Sizing a Scroll Pane
- Dynamically Changing the Client's Size
- The Scroll Pane API
- Examples that Use Scroll Panes

How a Scroll Pane Works

Here is a snapshot of an application that uses a customized scroll pane to view a large photograph:



The scroll pane in this application looks very different from the one in the previous demo program. Rather than displaying text, this scroll pane contains a large image. The scroll pane also has two scroll bars, a row header, a column header, and four corners, three of which have been customized.

Try this:

1. Compile and run the application. The main source file is `ScrollDemo.java`◆.
   You also need a few other source files and an image file. See the examples index for links to all the files required by this example.
   See Getting Started with Swing if you need help compiling or running this application.
2. Move the knobs on the scroll bars. Watch the image scroll and the horizontal and

vertical rulers scroll along.

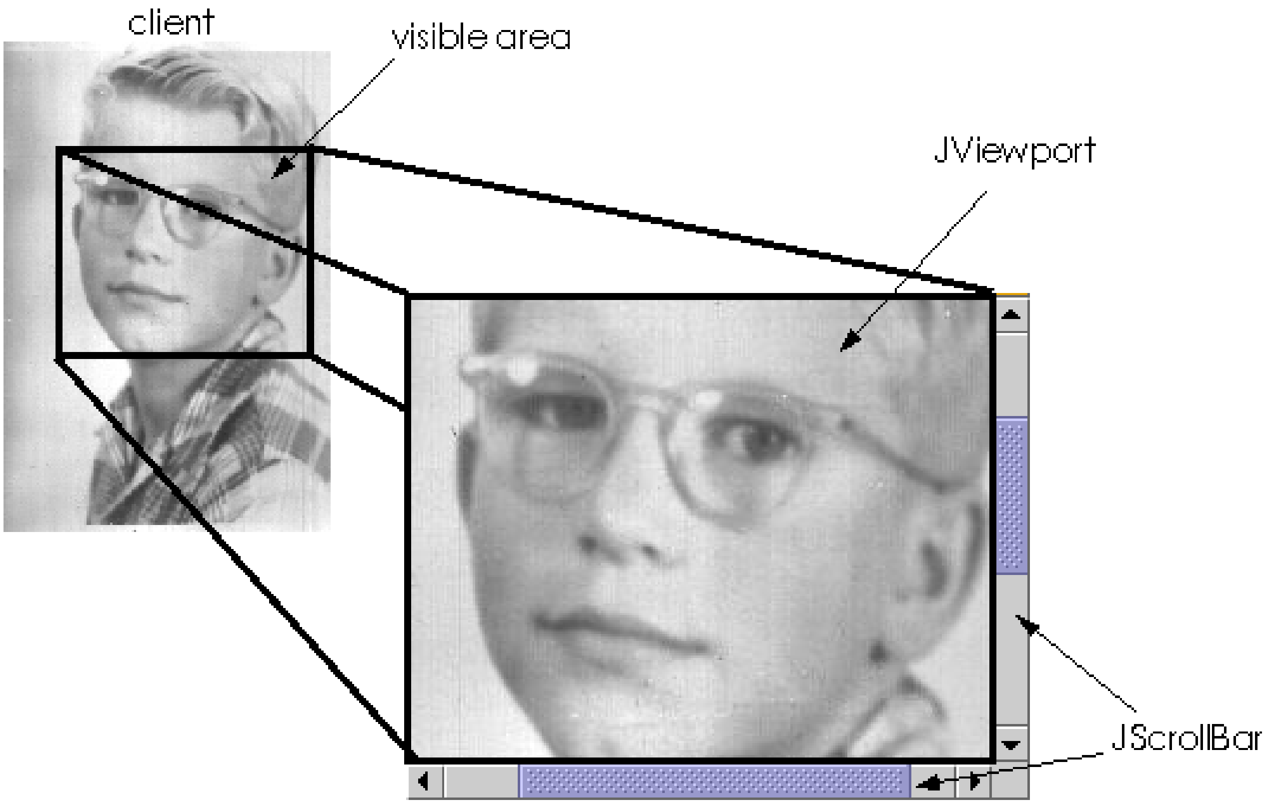
3. Click the **cm** toggle in the upper left corner of the scroll pane. The units on the row and column headers change to inches (or back to centimeters).
4. Click the arrow buttons on the scroll bars. Also, try clicking on the track above or below the knob on the vertical scroll bar, or to the left or right of the horizontal one.
5. Resize the window. Notice that the scroll bars disappear when the scroll pane is large enough to display the entire image and reappear again when the scroll pane is too small to show the entire client.

This program establishes the scroll pane's client when creating the scroll pane:

```
// where the member variables are declared
private ScrollablePicture picture;
...
        // where the GUI is created
        picture = new ScrollablePicture( ... );
        JScrollPane pictureScrollPane = new JScrollPane(picture);
```

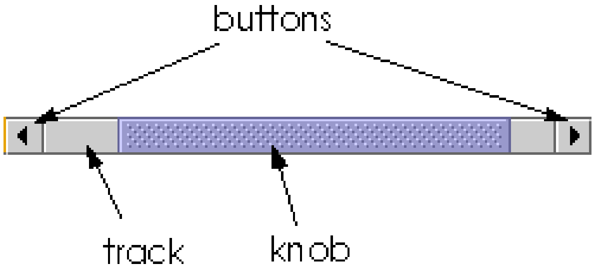
You can change a scroll pane's client dynamically by calling the `setViewportView` method. Note that `JScrollPane` has no corresponding `getViewportView` method, so you should cache the client object in a variable if you need to refer to it later.

When the user manipulates the scroll bars in a scroll pane, the area of the client that is visible changes accordingly. This picture shows the relationship between the scroll pane and its client and indicates the classes that the scroll pane commissions to help:



A scroll pane uses a `JViewport`◆ instance to manage the visible area of the client. The viewport is responsible for computing the bounds of the current visible area, based on the positions of the scroll bars, and displaying it.

A scroll pane uses two separate instances of `JScrollBar`◆ for the scroll bars. The scroll bars provide the interface for the user to manipulate the visible area. The following figure shows the three areas of a scroll bar: the knob, the buttons, and the track.



When the user moves the knob on the vertical scroll bar up and down, the visible area of the client moves up and down. Similarly, when the user moves the knob on the horizontal scroll bar to the right and left, the visible area of the client moves back and forth accordingly. The position of the knob relative to its track is proportionally equal to the position of the visible area relative to the client. In the Java Look & Feel and some others, the size of the knob gives a visual clue as to how much of the client is visible.

By clicking a button, the user can scroll by a *unit increment*. By clicking within the track, the user can scroll by a *block increment*. Information about unit and block increments is in Implementing a Scrolling-Savvy Client.

Typical programs don't directly instantiate or call methods on a viewport or scroll bar. Instead, programs achieve their scrolling behavior using the `JScrollPane` API and the API discussed in Implementing a Scrolling-Savvy Client. Some scrolling-savvy components such as `JList`, `JTable`, and `JTree` also provide additional API to help you affect their scrolling behavior.

Setting the Scroll Bar Policy

On startup, the scroll pane in the `ScrollDemo` application has two scroll bars. If you make the window as large as your screen, both scroll bars disappear because they are no longer needed. If you then shrink the height of the window without changing its width, the vertical scroll bar reappears. Further experimentation will show that in this application both scroll bars disappear and reappear as needed. This behavior is controlled by the scroll pane's *scroll bar policy*, Actually, it's two policies: you specify the policy for each scroll bar separately.

`ScrollDemo` doesn't explicitly set the scroll pane's sroll bar policies--it uses the default. But you can set the policies when you create the scroll pane or change them dynamically.

Of the constructors provided by `JScrollPane`, these two let you set the scroll bar policies when you create the scroll pane:

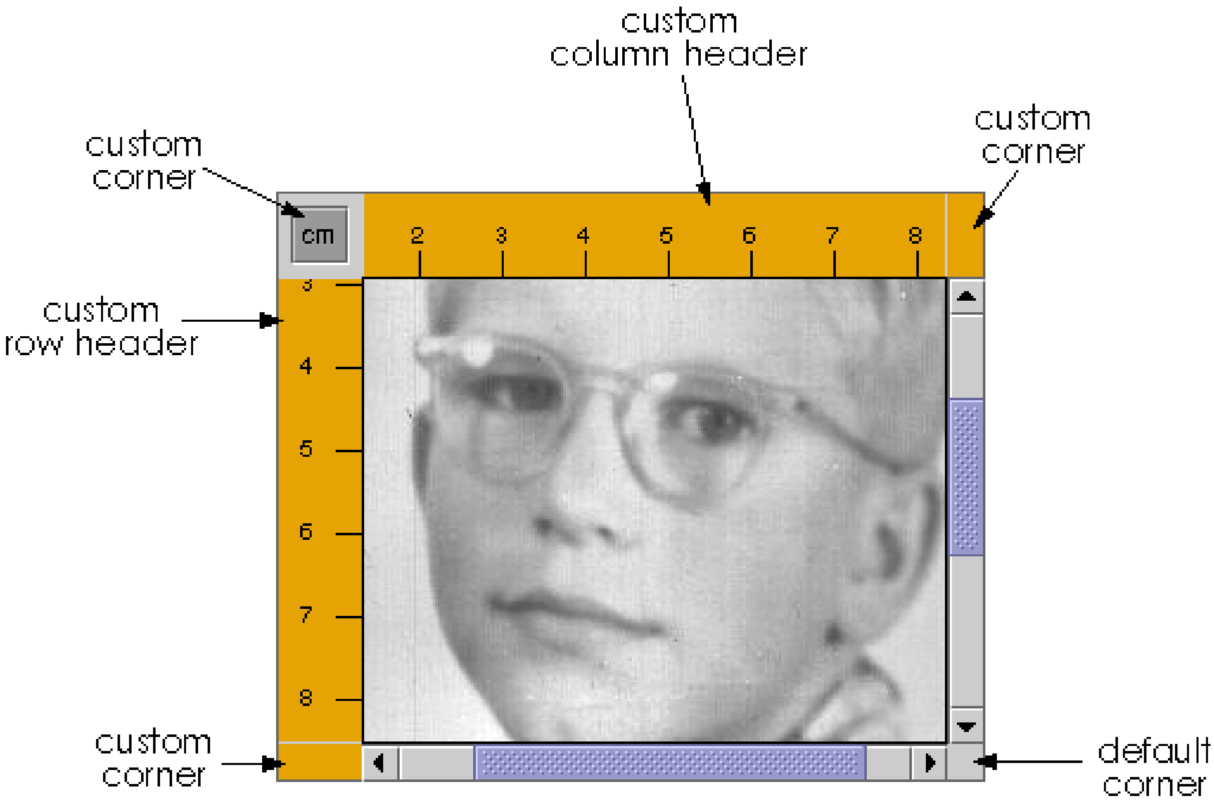
```
JScrollPane(Component, int, int)
JScrollPane(int, int)
```

The first `int` specifies the policy for the vertical scroll bar, the second specifies the policy for the horizontal scroll bar. You can also set the policies dynamically with the `setHorizontalScrollBarPolicy` and `setVerticalScrollBarPolicy` methods. With both the constructors and the methods, use one of the following constants defined in the `ScrollPaneConstants` interface (which is implemented by `JScrollPane`):

Policy	Description
`VERTICAL_SCROLLBAR_AS_NEEDED` `HORIZONTAL_SCROLLBAR_AS_NEEDED`	The default. The scroll bar appears when the viewport is smaller than the client and disappears when the viewport is larger than the client.
`VERTICAL_SCROLLBAR_ALWAYS` `HORIZONTAL_SCROLLBAR_ALWAYS`	Always display the scroll bar. The knob disappears if the viewport is large enough to show the whole client.
`VERTICAL_SCROLLBAR_NEVER` `HORIZONTAL_SCROLLBAR_NEVER`	Never display the scroll bar. Use this option if you don't want the user to directly control what part of the client is shown. Perhaps you have an application that requires all scrolling to occur programmatically.

Providing Custom Decorations

The area drawn by a scroll pane consists of up to nine parts: the center, four sides, and four corners. The center is the only component that is always present in all scroll panes. Besides scroll bars, the sides can contain column and row headers. A corner component is visible only if both sides that intersect at that corner contain visible components.



As shown in the figure, the scroll pane in `ScrollDemo` has custom row and column headers. Additionally, because all four sides are populated, all four corners are present. The program customizes three of the corners--two just fill their area with the same color as the `Rule`s, and the other contains a toggle button. The fourth corner, the lower right corner, is the default provided by the scroll pane. Notice that because the row and column headers are always present in this example, that the toggle button is also always present.

If a corner contains a control that the user needs access to all the time, make sure the sides that intersect at the corner are always present. For example, if this application placed the toggle in the lower right corner where the scroll bars intersect, then the toggle would disappear if the user resized the window and even one of the scroll bars disappeared.

The scroll pane's row and column headers are provided by a custom `JComponent` subclass, `Rule`, that draws a ruler in centimeters or inches. Here's the code that creates and sets the scroll pane's row and column headers:

```
//...where the member variables are defined:
private Rule columnView;
private Rule rowView;
...
    //...where the GUI is initialized:
    ImageIcon david = new ImageIcon("images/youngdad.jpeg");
    ...
    // Create the row and column headers
    columnView = new Rule(Rule.HORIZONTAL, true);
    columnView.setPreferredWidth(david.getIconWidth());
```

```
rowView = new Rule(Rule.VERTICAL, true);
rowView.setPreferredHeight(david.getIconHeight());
...
pictureScrollPane.setColumnHeaderView(columnView);
pictureScrollPane.setRowHeaderView(rowView);
...
```

You can use any component for a scroll pane's row and column headers. The scroll pane puts the row and column headers in `JViewPort`s of their own. Thus, when scrolling horizontally, the column header follows along, and when scrolling vertically, the row header follows along.

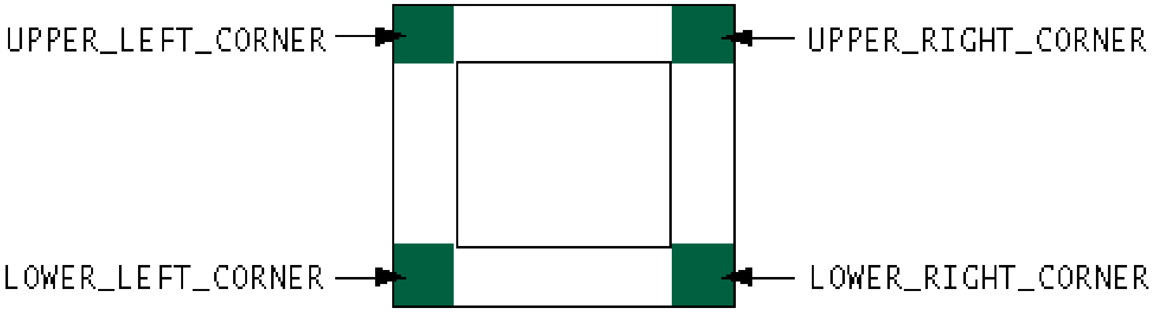
As a `JComponent` subclass, our custom `Rule` class puts its rendering code in its `paintComponent` method. Careful scrutiny of the code reveals that special effort is taken to draw only within the current clipping bounds. Your custom row and column headers should do the same to ensure speedy scrolling.

You can also use any component for the corners of a scroll pane. `ScrollDemo` illustrates this by putting a toggle button in the upper left corner, and custom `Corner` objects in the upper right and lower left corners. Here's the code that creates the `Corner` objects and calls `setCorner` to place them:

```
// Create the corners.
JPanel buttonCorner = new JPanel();
isMetric = new JToggleButton("cm", true);
isMetric.setFont(new Font("SansSerif", Font.PLAIN, 11));
isMetric.setMargin(new Insets(2,2,2,2));
isMetric.addItemListener(new UnitsListener());
buttonCorner.add(isMetric); //Use the default FlowLayout
...
// Set the corners.
pictureScrollPane.setCorner(JScrollPane.UPPER_LEFT_CORNER,
                            buttonCorner);
pictureScrollPane.setCorner(JScrollPane.LOWER_LEFT_CORNER,
                            new Corner());
pictureScrollPane.setCorner(JScrollPane.UPPER_RIGHT_CORNER,
                            new Corner());
```

Remember that the size of each corner is determined by the size of the sides intersecting there. For some components you must take care that the specific instance of the component fits in its corner. For example, the program sets the font and margins on the toggle button so that it fits within the space established by the headers. It's not an issue with the `Corner` class because that class colors its entire bounds, whatever they happen to be, with a solid color.

As you can see from the code, constants indicate the corner positions. This figure shows the constant for each position:

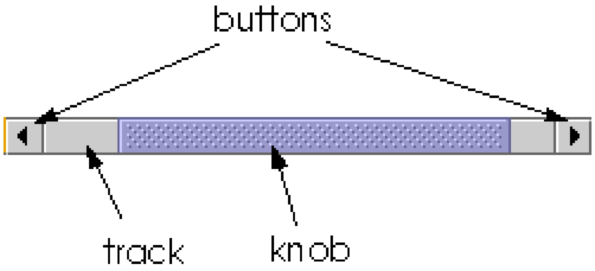


The constants are defined in the `ScrollPaneConstants` interface, which `JScrollPane` implements.

Implementing a Scrolling-Savvy Client

To customize the way that a client component interacts with its scroll pane, you can make the component implement the `Scrollable` interface. By implementing `Scrollable`, a client can specify both the size of the viewport used to view it and the amount to scroll for clicks on the different controls on a scroll bar.

Here again are the three control areas of a scroll bar: the knob, the buttons, and the track.



You might have noticed when manipulating the scroll bars in `ScrollDemo` that clicking the buttons scrolls the image to a tick boundary. You might also have noticed that clicking in the track scrolls the picture by a "screenful". More generally, the button scrolls the visible area by a *unit increment* and the track scrolls the visible area by a *block increment*. The behavior you see in the example is not the scroll pane's default behavior, but is specified by the client in its implementation of the `Scrollable` interface.

The client for the `ScrollDemo` program is `ScrollablePicture`. `ScrollablePicture` is a subclass of `JLabel` that provides implementations of all five `Scrollable` methods:

- `getScrollableBlockIncrement`
- `getScrollableUnitIncrement`
- `getPreferredScrollableViewportSize`
- `getScrollableTracksViewportHeight`
- `getScrollableTracksViewportWidth`

`ScrollablePicture` implements the `Scrollable` interface primarily to affect the unit and block increments. However, it must provide implementations for all five methods. So it provides reasonable defaults for the other three methods that you might want to copy for your scrolling-savvy classes.

The scroll pane calls the client's `getScrollableUnitIncrement` method whenever the user clicks one of the buttons on the scroll bar. This method returns the number of pixels to scroll. An obvious implementation of this method returns the number of pixels between tick marks on the header rulers. But `ScrollablePicture` does something different: It returns the value required to position the image on a tick mark boundary. Here's the implementation:

```
public int getScrollableUnitIncrement(Rectangle visibleRect,
                                      int orientation,
                                      int direction) {
    //get the current position
    int currentPosition = 0;
    if (orientation == SwingConstants.HORIZONTAL)
        currentPosition = visibleRect.x;
    else
        currentPosition = visibleRect.y;

    //return the number of pixels between currentPosition
    //and the nearest tick mark in the indicated direction
    if (direction < 0) {
        int newPosition = currentPosition -
                         (currentPosition / maxUnitIncrement) *
                          maxUnitIncrement;
        return (newPosition == 0) ? maxUnitIncrement : newPosition;
    } else {
        return ((currentPosition / maxUnitIncrement) + 1) *
                 maxUnitIncrement - currentPosition;
    }
}
```

If the image is already on a tick mark boundary, this method returns the number of pixels between ticks. Otherwise, it returns the number of pixels from the current location to the nearest tick.

Likewise, the scroll pane calls the client's `getScrollableBlockIncrement` method each time the user clicks on the track. Here's `ScrollablePicture`'s implementation of this method:

```
public int getScrollableBlockIncrement(Rectangle visibleRect,
                                       int orientation,
                                       int direction) {
    if (orientation == SwingConstants.HORIZONTAL)
        return visibleRect.width - maxUnitIncrement;
    else
        return visibleRect.height - maxUnitIncrement;
}
```

This method returns the height of the visible rectangle minus a tick mark. This behavior is typical. A block increment should be slightly smaller than the viewport to leave a little of the previous visible area for context. For example, a text area might leave one or two lines of text for context and a table might leave a row or column (depending on the scroll direction).

These Swing components implement the `Scrollable` interface:

- lists
- tables
- text components
- trees

Some of these classes include other methods related to scrolling.

Sizing a Scroll Pane

Unless you explicitly set a scroll pane's preferred size, the scroll pane computes it based on the preferred size of its nine components (the viewport, and, if present, the two scroll bars, the row and column headers, and the four corners). The largest factor, and the one most programmers care about, is the size of the viewport used to display the client.

If the client is not scrolling-savvy, then the scroll pane sizes itself so that the client displays at its preferred size. For typical unsavvy clients, this makes the scroll pane redundant. That is, the scroll pane has no scroll bars because the client's preferred size is big enough to display the entire client. In this case, if the client doesn't change size dynamically, you should probably limit the size of the scroll pane by setting its preferred size or the preferred size of its container.

If the client is scrolling-savvy, then the scroll pane uses the value returned by the client's `getPreferredScrollableViewportSize` method to compute the size of its viewport. Implementations of this method generally report a preferred size for scrolling that's smaller than the component's standard preferred size. For example, by default, the value returned by `JList`'s implementation of `getPreferredScrollableViewportSize` is just big enough to display eight rows.

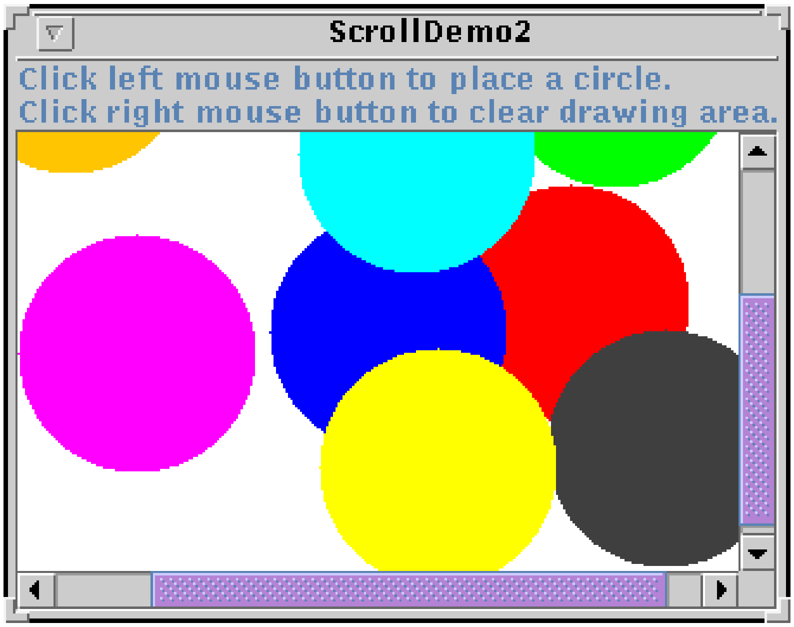
Scrolling-savvy classes, like lists, tables, text components, and trees, often provide one or more methods that let programmers affect the size returned from `getPreferredScrollableViewportSize`. For example, you can set the number of visible rows in a list or a tree by calling the `setVisibleRowCount`. The list or tree takes care of figuring out the size needed to display that number of rows.

Refer to the Methods in Other Classes Related to Scrolling for information about scrolling-related methods provided by classes other than `JScrollPane`. And remember -- if you don't like the value that `getPreferredScrollableViewportSize` returns, you can always set the preferred size of the scroll pane or its container.

Dynamically Changing the Client's Size

Changing the size of a scroll pane's client is a two-step process. First, set the client's preferred size. Then, call `revalidate` on the client to let the scroll pane know that it should update itself and its scroll bars. Let's look at an example.

Here's a picture of an application that changes the client's size whenever the user places a circle whose bounds fall outside of the client's current bounds. The program also changes the client's size when the user clears the drawing area:



Click left mouse button to place a circle.
Click right mouse button to clear drawing area.

You can find the full source code for this example in ScrollDemo2.java, which is based on an example provided by tutorial reader John Vella.

Here's the code that changes the drawing area's size when necessary:

```
    if (changed) {
        //Update client's preferred size because the area taken up
        //by the graphics has gotten larger or smaller (if cleared)
        drawingArea.setPreferredSize(/* the new size */);

        //This lets the scroll pane know to update itself
        //and its scroll bars.
        drawingArea.revalidate();
    }
```

Note that when the client changes size, the scroll bars adjust. The scroll pane doesn't resize, nor does the viewport.

Refer to SplitPaneDemo for another example in which the client object changes size.

The Scroll Pane API

The following tables list the commonly used `JScrollPane` constructors and methods. Other methods you are most likely to invoke on a `JScrollPane` object are those such as `setPreferredSize` that its superclasses provide. See The JComponent API for tables of commonly used inherited methods.

The API for using scroll panes falls into these categories:

- Setting Up the Scroll Pane
- Decorating the Scroll Pane
- Implementing the Scrollable Interface
- Methods in Other Classes Related to Scrolling

Setting Up the Scroll Pane

Method	Purpose

`JScrollPane()`
`JScrollPane(Component)`
`JScrollPane(int, int)`
`JScrollPane(Component, int, int)`
	Create a scroll pane. The `Component` parameter, when present, sets the scroll pane's client. The two `int` parameters, when present, set the vertical and horizontal scroll bar policies (respectively).

`void setViewportView(Component)`	Set the scroll pane's client.

`void setVerticalScrollBarPolicy(int)`
`int getVerticalScrollBarPolicy()`
	Set or get the vertical scroll policy. `ScrollPaneConstants` defines three values for specifying this policy: `VERTICAL_SCROLLBAR_AS_NEEDED (the default)`, `VERTICAL_SCROLLBAR_ALWAYS, and VERTICAL_SCROLLBAR_NEVER.`

`void setHorizontalScrollBarPolicy(int)`
`int getHorizontalScrollBarPolicy()`
	Set or get the horizontal scroll policy. `ScrollPaneConstants` defines three values for specifying this policy: `HORIZONTAL_SCROLLBAR_AS_NEEDED (the default)`, `HORIZONTAL_SCROLLBAR_ALWAYS, and HORIZONTAL_SCROLLBAR_NEVER.`

`void setViewportBorder(Border)`
`Border getViewportBorder()`
	Set or get the border around the viewport.

Decorating the Scroll Pane

Method	Purpose

`void setColumnHeaderView(Component)`
`void setRowHeaderView(Component)`
	Set the column or row header for the scroll pane.

`void setCorner(Component, int)`
`Component getCorner(int)`
	Set or get the corner specified. The `int` parameter specifies which corner and must be one of the following constants defined in `ScrollPaneConstants`: `UPPER_LEFT_CORNER`, `UPPER_RIGHT_CORNER`, `LOWER_LEFT_CORNER`, and `LOWER_RIGHT_CORNER`.

Implementing the Scrollable Interface

Method	Purpose

`int getScrollableUnitIncrement(Rectangle, int, int)`
`int getScrollableBlockIncrement(Rectangle, int, int)`
	Get the unit or block increment in pixels. The `Rectangle` parameter is the bounds of the currently visible rectangle. The first `int` parameter is either `SwingConstants.HORIZONTAL` or `SwingConstants.VERTICAL` depending on what scroll bar the user clicked on. The second `int` parameter indicates which direction to scroll. A value less than 0 indicates up or left. A value greater than 0 indicates down or right.

`Dimension getPreferredScrollableViewportSize()`	Get the preferred size of the viewport. This allows the client to influence the size of the viewport in which it is displayed. If the viewport size is unimportant, implement this method to return `getPreferredSize`.

`boolean getScrollableTracksViewportWidth()`
`boolean getScrollableTracksViewportHeight()`
	Get whether the scroll pane should force the client to be the same width or height as the viewport. A return value of `true` from either of these methods effectively disallows horizontal or vertical scrolling (respectively).

Methods in Other Classes Related to Scrolling

Method	Purpose
`void scrollRectToVisible(Rectangle)` *(in `JComponent`)*	If the component is in a container that supports scrolling, such as a scroll pane, then calling this method scrolls the scroll pane such that the specified rectangle is visible.

`void setAutoscrolls(boolean)`
`boolean getAutoScrolls()`
(in `JComponent`)
	Set or get whether the component automatically scrolls when the user drags the component with the mouse. Even if autoscrolling is turned on, autoscrolling works only when the component is in a container that supports scrolling.

`void setVisibleRowCount(int)`
`int getVisibleRowCount()`
(in `JList`)
	Set or get how many rows of the list are visible. The `getPreferredScrollableViewportSize` method uses the visible row count to compute its return value.

void ensureIndexIsVisible(int) *(in JList)*	Scroll so that the row at the specified index is visible. This method calls `scrollRectToVisible` and works only if the list is in a container that supports scrolling.
void setVisibleRowCount(int) int getVisibleRowCount() *(in JTree)*	Set or get how many rows of the tree are visible. The `getPreferredScrollableViewportSize` method uses the visible row count to compute its return value.
void scrollPathToVisible(TreePath) void scrollRowToVisible(int) *(in JTree)*	Scroll so that the specified tree path or row at the specified index is visible. These methods call `scrollRectToVisilbe`. and work only if the tree is in a container that supports scrolling.
void setScrollsOnExpand(boolean) boolean getScrollsOnExpand() *(in JTree)*	Set or get whether scrolling occurs automatically when the user expands a node. True by default. This feature works only when the tree is in a container that supports scrolling.
void setPreferredScrollableViewportSize(Dimension) *(in JTable)*	Set the value to be returned by `getPreferredScrollableViewportSize`.

Examples that Use Scroll Panes

This table shows the examples that use `JScrollPane` and where those examples are described.

Example	Where Described	Notes
`ToolBarDemo`	This section, How to Use Tool Bars	Shows a simple, yet typical, use of a scroll pane.
`ScrollDemo`	This section	Uses many of scroll pane's bells and whistles.
`ScrollDemo2`	This section	Shows how change the client's size.
`SplitPaneDemo`	How to Use Split Panes, How to Use Lists	Puts a list and a label in a scroll pane. Also, shows how to handle the case when a scroll pane's client changes size.
`TableDemo`	How to Use Tables	Puts a table in a scroll pane.
`TextSamplerDemo`	An Example of Using Each Text Component	Puts a text area, an editor pane, and a text pane each in a scroll pane.
`TreeDemo`	How to Use Trees	Puts a tree in a scroll pane.

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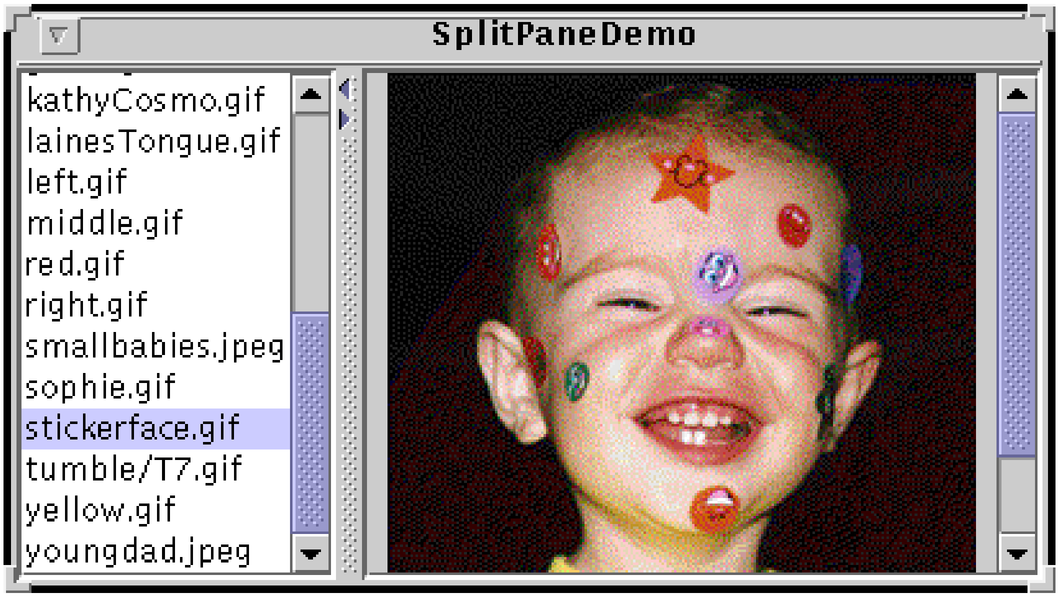
How to Use Split Panes

A `JSplitPane` displays two components, either side by side or one on top of the other. By dragging the divider that appears between the components, the user can specify how much of the split pane's total area goes to each component. You can divide screen space among three or more components by putting split panes inside of split panes, as described in Nesting Split Panes.

Instead of adding the components of interest directly to a split pane, you often put each component into a scroll pane. You then put the scroll panes into the split pane. This allows the user to view any part of a component of interest, without requiring the component to take up a lot of screen space or adapt to displaying itself in varying amounts of screen space.

Here's a picture of an application that uses a split pane to display a list and an image side by side:



Try this:

1. Compile and run the application. The main source file is `SplitPaneDemo.java`. This example requires some additional files.

See the examples index for links to all the files required by this example.
See Getting Started with Swing if you need help compiling or running this application.
This program gets the names of the images for the list from a properties resource bundle. For this demo you just need to know that the resource bundle contains a space-separated list of file names and the program parses the list into a `Vector`. The properties resource bundle is backed by `imagenames.properties`, which you need to put in the same directory as the application's class files. You can learn more about resource bundles in Isolating Locale-Specific Data◆.

2. Drag the dimpled line that divides the list and the image to the left or right. Try to drag the divider all the way to the window's edge.
3. Click the tiny arrows on the divider to hide/expand the left or right component.

Below is the code from `SplitPaneDemo` that creates and sets up the split pane.

```
//Create a split pane with the two scroll panes in it.
splitPane = new JSplitPane(JSplitPane.HORIZONTAL_SPLIT,
                           listScrollPane, pictureScrollPane);
splitPane.setOneTouchExpandable(true);
splitPane.setDividerLocation(150);

//Provide minimum sizes for the two components in the split pane
Dimension minimumSize = new Dimension(100, 50);
listScrollPane.setMinimumSize(minimumSize);
pictureScrollPane.setMinimumSize(minimumSize);
```

The constructor used by this example takes three arguments. The first indicates the split direction. The other arguments are the two components to put in the split pane. Refer to Setting the Components in a Split Pane for information about `JSplitPane` methods that set the components dynamically.

The split pane in this example is split horizontally--the two components appear side by side--as specified by the `JSplitPane.HORIZONTAL_SPLIT` argument to the constructor. Split pane provides one other option, specified with `JSplitPane.VERTICAL_SPLIT`, that places one component above the other. You can change the split direction after the split pane has been created with the `setOrientation` method.

Two small arrows appear at the top of the divider in the example's split pane. These arrows let the user collapse (and then expand) either of the components with a single click. The current look and feel determines whether these controls appear by default. In the Java Look & Feel, they are turned off by default. The example turned them on with a call to the `setOneTouchExpandable`.

The range of a split pane's divider is determined in part by the minimum sizes of the components within the split pane. See Positioning the Divider and Restricting its Range for details.

The rest of this section covers these topics:

- Setting the Components in a Split Pane
- Positioning the Divider and Restricting its Range
- Nesting Split Panes
- The Split Pane API
- Examples that Use Split Panes

Setting the Components in a Split Pane

A program can set a split pane's two components dynamically with these four methods:

- `setLeftComponent`
- `setRightComponent`
- `setTopComponent`
- `setBottomComponent`

You can use any of these methods at any time regardless of the split pane's current split direction. Calls to `setLeftComponent` and `setTopComponent` are equivalent and set the specified component in the top or left position, depending on the split pane's current split orientation. Similarly, calls to `setRightComponent` and `setBottomComponent` are equivalent. These methods replace whatever component is already in that position with the new one.

Like other containers, `JSplitPane` supports the `add` method. Split pane puts the first component added in the left or top position. The danger of using `add` is that you can inadvertantly call it too many times, in which case, the split pane's layout manager will throw a rather esoteric-looking exception. If you are using the `add` method and a split pane is already populated, you first need to remove the existing components with `remove`.

If you put only one component in a split pane, then the divider will be stuck at the right side or the bottom of the split pane, depending on its split direction.

Positioning the Divider and Restricting Its Range

Use the `setDividerLocation` method to position the divider programmatically. You can specify the new position by pixel or by percentage. To get the current divider location specified in pixels call `getDividerLocation`.

```
//Set divider at pixel 150
splitPane.setDividerLocation(150);
//25% of the space goes to left/top
splitPane.setDividerLocation(0.25);
```

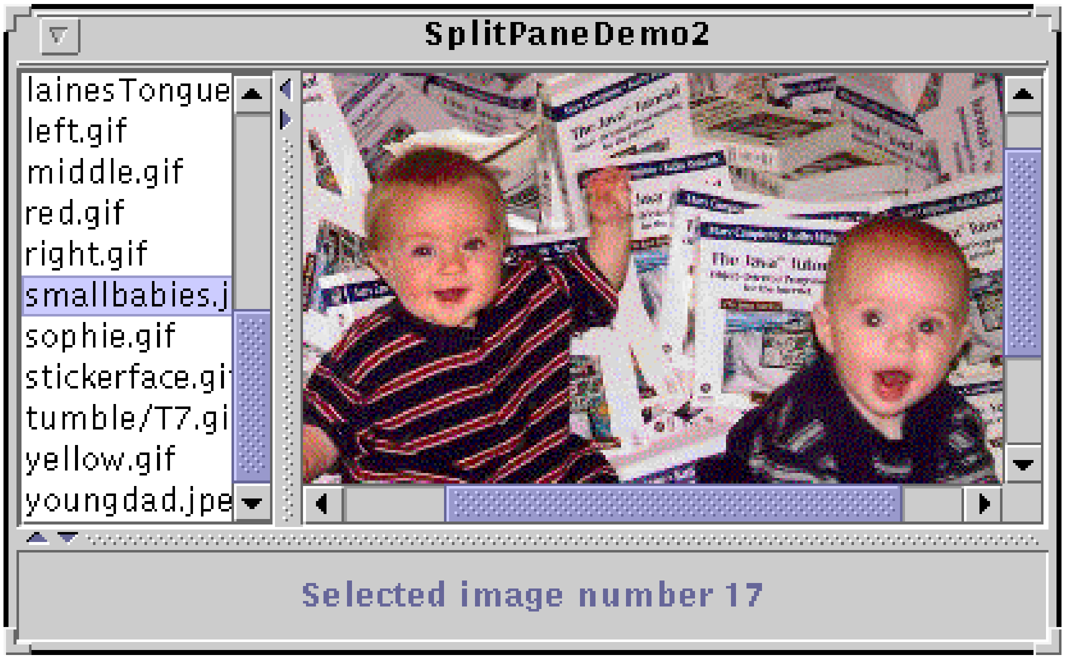
Another handy method, `resetToPreferredSizes`, sets the divider location such that the two components are at their preferred sizes. This is the initial arrangement of a split pane, unless specified otherwise.

The user can set the divider location by dragging it. A split pane does not allow the user to make either of its components smaller than the component's minimum size by dragging the divider. So, you can affect the divider's range by setting the minimum sizes of the two components in the split pane. For example, to ensure that a minimum amount of each component in a split is visible at all times, set the minimum size of each component. To allow the user to drag the divider all the way to the edge of the split pane, use 0 for the minimum size.

If you don't set the minimum size of the two components in a split pane, then you might end up with a split pane whose divider won't move. By default, a split pane sizes its components at their preferred size, which for many components is equal to the minimum size. This means that both components are already displayed at their minimum sizes and the divider is stuck. Most programs that put standard components in a split pane need to set the minimum sizes of the components in the split pane to a smaller size.

Nesting Split Panes

Here's a picture of a program that achieves a three-way split by nesting one split pane inside of another:



If the top portion of the split pane looks familiar to you, it's because the program puts the split pane created by `SplitPaneDemo` inside a second split pane. A simple `JLabel` is the other component in the second split pane. This is not the most practical use of a nested split pane, but it gets the point across. Here's the code, which you can find in `SplitPaneDemo2.java`:

```
//Create an instance of SplitPaneDemo
SplitPaneDemo splitPaneDemo = new SplitPaneDemo();
JSplitPane top = splitPaneDemo.getSplitPane();

...
//Create a regular old label
label = new JLabel("Click on an image name in the list.",
                   JLabel.CENTER);

//Create a split pane and put "top" (a split pane)
//and JLabel instance in it.
JSplitPane splitPane = new JSplitPane(JSplitPane.VERTICAL_SPLIT,
                                      top, label);
```

Refer to Solving Common Component Problems for information about fixing a border problem that can appear when nesting split panes.

The Split Pane API

The following tables list the commonly used `JSplitPane` constructors and methods. Other methods you are most likely to invoke on a `JSplitPane` object are those such as `setPreferredSize` that its superclasses provide. See The JComponent API for tables of commonly used inherited methods.

The API for using lists falls into these categories:

- Setting up the Split Pane
- Managing the Split Pane's Contents
- Positioning the Divider

Setting Up the Split Pane

Method	**Purpose**

`JSplitPane()`
`JSplitPane(int)`
`JSplitPane(int, boolean)`
`JSplitPane(int, Component, Component)`
`JSplitPane(int, boolean, Component, Component)`
	Create a split pane. When present, the `int` parameter indicates the split pane's orientation, either `HORIZONTAL_SPLIT` (the default) or `VERTICAL_SPLIT`. The `boolean` parameter, when present, sets whether the components continually repaint as the user drags the split pane. If left unspecified, this option (called *continuous layout*) is turned off. The `Component` parameters set the initial left and right, or top and bottom components, respectively.

`void setOrientation(int)`
`int getOrientation()`
	Set or get the split pane's orientation. Use either `HORIZONTAL_SPLIT` or `VERTICAL_SPLIT` defined in `JSplitPane`. If left unspecified, the split pane will be horizontally split.

`void setDividerSize(int)`
`int getDividerSize()`
	Set or get the size of the divider in pixels.

`void setContinuousLayout(boolean)`
`boolean getContinuousLayout()`
	Set or get whether the split pane's components are continually layed out and painted while the user is dragging the divider. By default, continuous layout is turned off.

`void setOneTouchExpandable(boolean)`
`boolean getOneTouchExpandable()`
	Set or get whether the split pane displays a control on the divider to expand/collapse the divider. The default depends on the look and feel. In the Java Look & Feel, it's off by default.

Managing the Split Pane's Contents

Method	**Purpose**

`void setTopComponent(Component)`
`void setBottomComponent(Component)`
`void setLeftComponent(Component)`
`void setRightComponent(Component)`
`Component getTopComponent()`
`Component getBottomComponent()`
`Component getLeftComponent()`
`Component getRightComponent()`
	Set or get the indicated component. Each method works regardless of the split pane's orientation. Top and left are equivalent, and bottom and right are equivalent.

`void remove(Component)`
`void removeAll()`
	Remove the indicated component(s) from the split pane.

`void add(Component)`	Add the component to the split pane. You can add only two components to a split pane. The first component added is the top/left component. The second component added is the bottom/right component. Attempt to add more components result in an exception.

Positioning the Divider

Method	**Purpose**

`void setDividerLocation(double)`
`void setDividerLocation(int)`
`int getDividerLocation()`
	Set or get the current divider location. When setting the divider location, you can specify the new location as a percentage (`double`) or a pixel location (`int`).

`void resetToPreferredSizes()`	Move the divider such that both components are at their preferred sizes. This is how a split pane divides itself at startup, unless specified otherwise.

`void setLastDividerLocation(int)`
`int getLastDividerLocation()`
	Set or get the previous position of the divider.

`int getMaximumDividerLocation()`
`int getMinimumDividerLocation()`
	Get the minimum and maximum locations for the divider. These are set implicitly by setting the minimum sizes of the split pane's two components.

Examples that Use Split Panes

This table shows the examples that use `JSplitPane` and where those examples are described.

Example	Where Described	Notes
`SplitPaneDemo`	This page and How to Use Lists.	Shows a split pane with a horizontal split.
`SplitPaneDemo2`	This page	Puts a split pane within a split pane to create a three-way split.
`TreeDemo`	How to Use Trees	Uses a split pane with a vertical split. Does not use the one-touch expandable feature.

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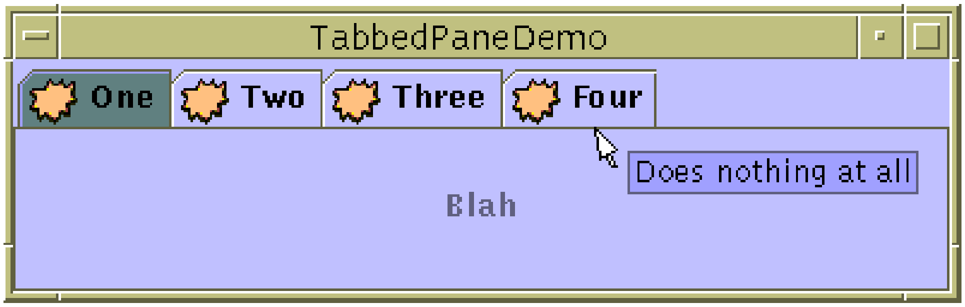
How to Use Tabbed Panes

With the `JTabbedPane` class, you can have several components (usually panels) share the same space. The user chooses which component to view by selecting the tab corresponding to the desired component. If you want similar functionality without the tab interface, you might want to use a card layout instead of a tabbed pane.

To create a tabbed pane, you simply instantiate `JTabbedPane`, create the components you wish it to display, and then add the components to the tabbed pane using the `addTab` method.

Here is a picture of an application that has a tabbed pane with four tabs:



Try this:

1. Compile and run the application. The source file is `TabbedPaneDemo.java`. You also need one image file: `middle.gif`.
   See Getting Started with Swing if you need help compiling or running this application.
2. Put the cursor over a tab.
   After a short time, you'll see the tool tip associated with the tab. As a convenience, you can specify tool tip text when you add a component to the tabbed pane.
3. Select a tab.
   The tabbed pane displays the component corresponding to the tab.

As the `TabbedPaneDemo` example shows, a tab can have a tool tip, and it can display both text and an image. The example shows the tabs in their default position, at the top of the tabbed pane. You can change the tab position to be at the left, right, or bottom of the tabbed pane.

Below is the code from TabbedPaneDemo.java that creates the tabbed pane in the previous example. Note that no event-handling code is necessary. The JTabbedPane object takes care of mouse events for you.

```
ImageIcon icon = new ImageIcon("images/middle.gif");
JTabbedPane tabbedPane = new JTabbedPane();

Component panel1 = makeTextPanel("Blah");
tabbedPane.addTab("One", icon, panel1, "Does nothing");
tabbedPane.setSelectedIndex(0);

Component panel2 = makeTextPanel("Blah blah");
tabbedPane.addTab("Two", icon, panel2, "Does twice as much nothing");

Component panel3 = makeTextPanel("Blah blah blah");
tabbedPane.addTab("Three", icon, panel3, "Still does nothing");

Component panel4 = makeTextPanel("Blah blah blah blah");
tabbedPane.addTab("Four", icon, panel4, "Does nothing at all");
```

The Tabbed Pane API

The following tables list the commonly used JTabbedPane constructors and methods. The API for using tabbed panes falls into these categories:

- Creating and Setting Up a Tabbed Pane
- Inserting, Removing, Finding, and Selecting Tabs
- Changing Tab Appearance

Creating and Setting Up a Tabbed Pane

Method	**Purpose**

JTabbedPane()
JTabbedPane(int)
	Create a tabbed pane. The optional argument specifies where the tabs should appear. By default, the tabs appear at the top of the tabbed pane. You can specify these positions (defined in the SwingConstants interface, which JTabbedPane implements): TOP, BOTTOM, LEFT, RIGHT.

`addTab(String, Icon, Component, String)`
`addTab(String, Icon, Component)`
`addTab(String, Component)`
	Add a new tab to the tabbed pane. The first argument specifies the text on the tab. The optional icon argument specifies the tab's icon. The component argument specifies the component that the tabbed pane should show when the tab is selected. The fourth argument, if present, specifies the tool tip text for the tab.

Inserting, Removing, Finding, and Selecting Tabs

Method	**Purpose**
`insertTab(String, Icon, Component, String, int)`	Insert a tab at the specified index, where the first tab is at index 0. The arguments are the same as for `addTab`.

`remove(Component)`
`removeTabAt(int)`
	Remove the tab corresponding to the specified component or index.

`removeAll()`	Remove all tabs.

`int indexOfComponent(Component)`
`int indexOfTab(String)`
`int indexOfTab(Icon)`
	Return the index of the tab that has the specified component, title, or icon.

`void setSelectedIndex(int)`
`void setSelectedComponent(Component)`
	Select the tab that has the specified component or index. Selecting a tab has the effect of displaying its associated component.

`int getSelectedIndex()`
`Component getSelectedComponent()`
	Return the index or component for the selected tab.

Changing Tab Appearance

Method	**Purpose**

`void setComponentAt(int, Component)`
`Component getComponentAt(int)`
	Set or get which component is associated with the tab at the specified index. The first tab is at index 0.

`void setTitleAt(int, String)`
`String getTitleAt(int)`
	Set or get the title of the tab at the specified index.

`void setIconAt(int, Icon)`
`Icon getIconAt(int)`
`void setDisabledIconAt(int, Icon)`
`Icon getDisabledIconAt(int)`
	Set or get the icon displayed by the tab at the specified index.

`void setBackgroundAt(int, Color)`
`Color getBackgroundAt(int)`
`void setForegroundAt(int, Color)`
`Color getForegroundAt(int)`
	Set or get the background or foreground color used by the tab at the specified index. By default, a tab uses the tabbed pane's background and foreground colors. For example, if the tabbed pane's foreground is black, then each tab's title is black except for any tabs for which you specify another color using `setForegroundAt`.

`void setEnabledAt(int, boolean)`
`boolean isEnabledAt(int)`
	Set or get the enabled state of the tab at the specified index.

Examples that Use Tabbed Panes

This table lists examples that use `JTabbedPane` and where those examples are described.

Example	Where Described	Notes
`TabbedPaneDemo`	This page	Demonstrates a few tabbed pane features, such as tool tips and icons in tabs. The frame's size is set using `setSize`.
`AlignmentDemo`	How to Use BoxLayout	Uses a `JTabbedPane` as the only child of a frame's content pane. The tabs' components have different preferred sizes, and the frame uses `pack` rather than `setSize` to set its size.
`BorderDemo`	How to Use Borders	Uses its tabbed pane in a manner similar to AlignmentDemo's usage.
`DialogDemo`	How to Use Dialogs	Has a tabbed pane in the center of a frame's content pane, with a label below it. Uses `pack`, not `setSize`, to set the frame's size.

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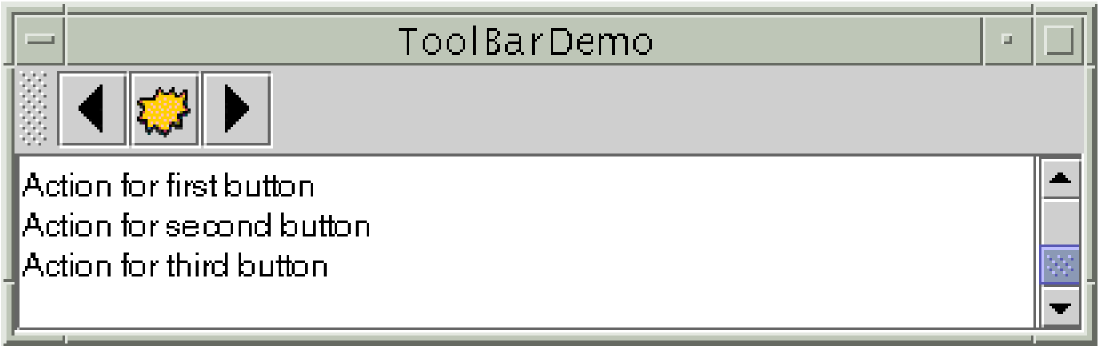
How to Use Tool Bars

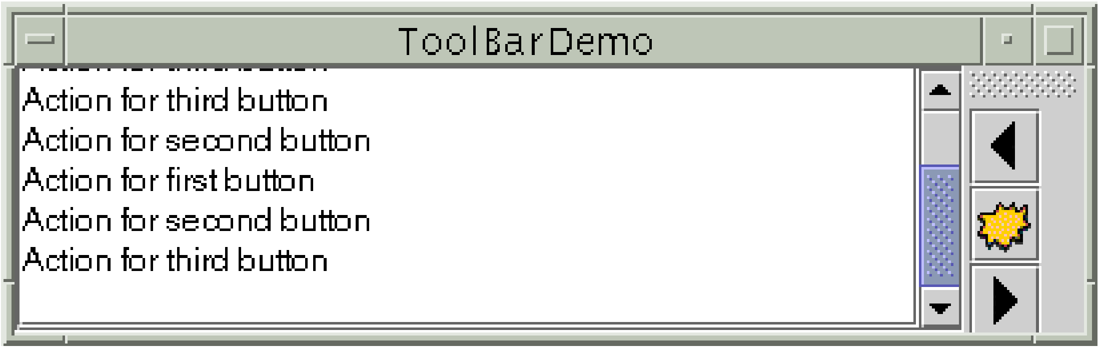
A `JToolBar` is a container that groups several components -- usually buttons with icons -- into a row or column. Often, tool bars provide easy access to functionality that is also in menus. How to Use Actions describes how to provide the same functionality in menu items and tool bar buttons.

The following pictures show an application that contains a tool bar above a text area.



```
Action for first button
Action for second button
Action for third button
```

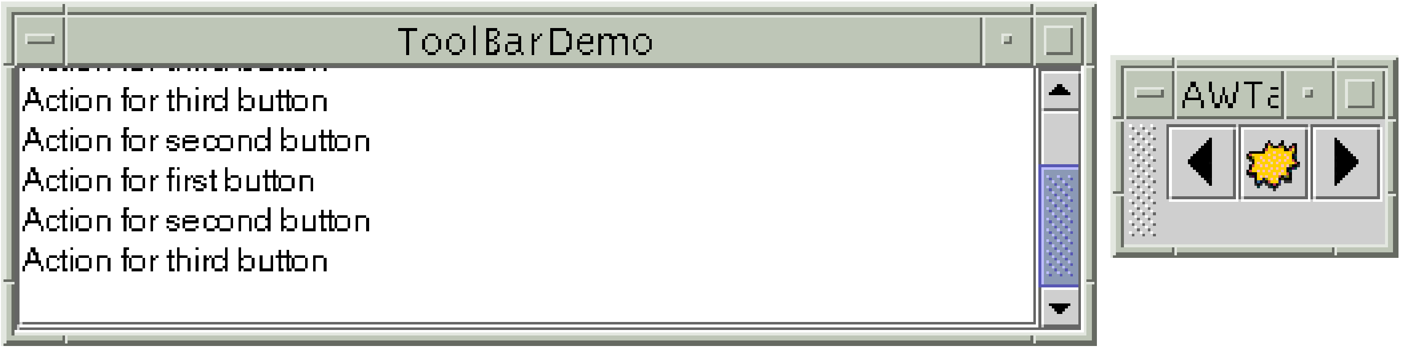
By default, the user can drag the tool bar to a different edge of its container or out into a window of its own. The next figure shows how the application looks after the user has dragged the tool bar to the right edge of its container.



```
Action for third button
Action for second button
Action for first button
Action for second button
Action for third button
```

For the drag-out behavior to work correctly, the tool bar must be in a container that uses `BorderLayout`. The component that the tool bar affects is generally in the center of the container. The tool bar must be the only other component in the container; it must not be in the center.

The next figure shows how the application looks after the user has dragged the tool bar outside its window.



```
Action for third button
Action for second button
Action for first button
Action for second button
Action for third button
```

The following code implements the tool bar. You can find the entire program in ToolBarDemo.java. It relies on three images.

Note: If any buttons in your tool bar duplicate functionality of other components, such as menu items, then you should probably create and add the tool-bar buttons as described in How to Use Actions.

```
public ToolBarDemo() {
    ...
    JToolBar toolBar = new JToolBar();
    addButtons(toolBar);
    ...
    JPanel contentPane = new JPanel();
    contentPane.setLayout(new BorderLayout());
    ...
    contentPane.add(toolBar, BorderLayout.NORTH);
    contentPane.add(scrollPane, BorderLayout.CENTER);
    ...
}

protected void addButtons(JToolBar toolBar) {
    JButton button = null;

    //first button
    button = new JButton(new ImageIcon("images/left.gif"));
    ...
    toolBar.add(button);

    //second button
```

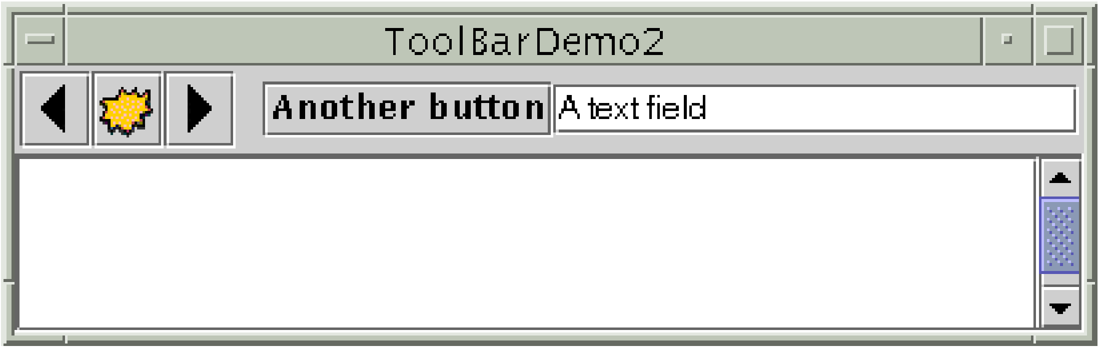
```
            button = new JButton(new ImageIcon("images/middle.gif"));
            ...
            toolBar.add(button);

            //third button
            button = new JButton(new ImageIcon("images/right.gif"));
            ...
            toolBar.add(button);
        }
```

By adding a few lines of code to the preceding example, we can demonstrate some more tool bar features:

- Using the `setFloatable(false)` to make a tool bar immovable.
- Adding a separator to a tool bar.
- Adding a non-button component to a tool bar.

Here is a picture of the new UI,



You can find the entire program in `ToolBarDemo2.java`. It relies on three images.

Because the tool bar can no longer be dragged, it no longer has bumps at its left edge. Here's the code that turns off dragging:

```
toolBar.setFloatable(false);
```

The biggest visible difference is that the tool bar contains two new components, which are preceded by a blank space -- a *separator*. Here is the code that adds the separator:

```
toolBar.addSeparator();
```

Here is the code that adds the new components:

```
//fourth button
button = new JButton("Another button");
...
toolBar.add(button);

//fifth component is NOT a button!
JTextField textField = new JTextField("A text field");
...
toolBar.add(textField);
```

You can easily make the components in a tool bar be aligned along their tops or bottoms, instead of centered, by invoking the `setAlignmentY` method. For example, to align the tops of all the components in a tool bar, invoke `setAlignmentY(TOP_ALIGNMENT)` on each component. Similarly, you can use the `setAlignmentX` method to specify the alignment of components when the tool bar is vertical. This flexibility of layout is possible because tool bars use `BoxLayout` to position their components. For more information, see How to Use BoxLayout.

The Tool Bar API

The following table lists the commonly used `JToolBar` constructors and methods. Other methods you might call are listed in the API tables in The JComponent Class.

Method	Purpose
`JToolBar()`	Create a tool bar.

`JButton add(Action)`
`Component add(Component)`
`void addSeparator()`
	Add a component (usually a button) to the tool bar. If the argument to `add` is an `Action` object, then the tool bar automatically creates a `JButton` and adds it.

`void addSeparator()`	Add a separator to the end of the tool bar.

`void setFloatable(boolean)`
`boolean isFloatable()`
	The floatable property is true by default, to indicate that the user can drag the tool bar out into a separate window. To turn off tool bar dragging, use `toolbar.setFloatable(false)`.

Examples that Use Tool Bars

This table lists examples that use `JToolBar` and where those examples are described.

Example	Where Described	Notes
`ToolBarDemo`	This page.	A basic tool bar with icon-only buttons.
`ToolBarDemo2`	This page	Demonstrates a non-floatable tool bar containing a separator and non-button components.
`ActionDemo`	How to Use Actions	Implements a tool bar using `Action` objects.

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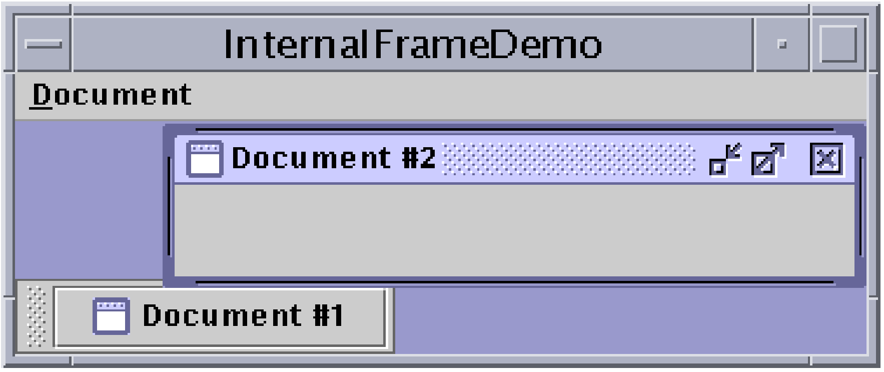
How to Use Internal Frames

With the `JInternalFrame` class, you can display a `JFrame`-like window within another window. Usually, you add internal frames to a desktop pane. The desktop pane, in turn, might be used as the content pane of a `JFrame`. The desktop pane is an instance of `JDesktopPane`, which is a subclass of `JLayeredPane` that has added API for managing multiple overlapping internal frames.

You should consider carefully whether to base your program's GUI around frames or internal frames. Switching from internal frames to frames or vice versa isn't necessarily a simple task. By experimenting with both frames and internal frames, you can get an idea of the tradeoffs involved in choosing one over the other.

Here is a picture of an application that has two internal frames (one of which is iconified) inside a regular frame:



As the figure shows, the window decorations on an internal frame reflect the Java Look & Feel. However, the window that contains the internal frame has the decorations for the native look and feel (in this case, Motif).

Try this:

1. Compile and run the application. The source files are `InternalFrameDemo.java` and `MyInternalFrame.java`.
   See Getting Started with Swing if you need help compiling or running this application.
2. Create new internal frames using the Create item in the Document menu.
   Each internal frame comes up 30 pixels lower and to the right of the place where the previous internal frame first appeared. This functionality is implemented in the `MyInternalFrame` class, which is the custom subclass of `JInternalFrame`.

The following code, taken from InternalFrameDemo.java, creates the desktop and internal frames in the previous example.

```
...//In the constructor of InternalFrameDemo, a JFrame subclass:
    desktop = new JDesktopPane();
    createFrame(); //Create first window
    setContentPane(desktop);
    ...
    //Make dragging faster:
    //desktop.putClientProperty("JDesktopPane.dragMode", //pre-1.3 code
                                "outline");
    desktop.setDragMode(JDesktopPane.OUTLINE_DRAG_MODE); //1.3 code
...
protected void createFrame() {
    MyInternalFrame frame = new MyInternalFrame();
    frame.setVisible(true); //necessary as of kestrel
    desktop.add(frame);
    try {
        frame.setSelected(true);
    } catch (java.beans.PropertyVetoException e) {}
}

...//In the constructor of MyInternalFrame, a JInternalFrame subclass:
static int openFrameCount = 0;
static final int xOffset = 30, yOffset = 30;

public MyInternalFrame() {
    super("Document #" + (++openFrameCount),
          true, //resizable
          true, //closable
          true, //maximizable
          true);//iconifiable
    //...Create the GUI and put it in the window...
    //...Then set the window size or call pack...
    ...
    //Set the window's location.
    setLocation(xOffset*openFrameCount, yOffset*openFrameCount);
}
```

Internal Frames vs. Regular Frames

The code for using internal frames is similar in many ways to the code for using regular Swing frames. Because internal frames have root panes, setting up the GUI for a `JInternalFrame` is very similar to setting up the GUI for a `JFrame`. `JInternalFrame` also provides other API, such as `pack`, that makes it similar to `JFrame`.

> **Note:** Just as for a regular frame, you must invoke `setVisible(true)` or `show()` on an internal frame to display it. In early versions of the Java 2 platform (such as v1.2.2), this code has no effect because the internal frame is visible by default. However, starting in the Kestrel release, the internal frame does not appear until you explicitly make it visible.

Internal frames aren't windows or top-level containers, however, which makes them different from frames. For example, you must add an internal frame to a container (usually a `JDesktopPane`); an internal frame can't be the root of a containment hierarchy. Also, internal frames don't generate window events. Instead, the user actions that would cause a frame to fire window events cause an internal frame to fire internal frame events.

Because internal frames are implemented with platform-independent code, they add some features that frames can't give you. One such feature is that internal frames give you more control over their state and capabilities than frames do. You can programatically iconify or maximize an internal frame. You can also specify what icon goes in the internal frame's title bar. You can even specify whether the internal frame has the window decorations to support resizing, iconifying, closing, and maximizing.

Another feature is that internal frames are designed to work within desktop panes. The `JInternalFrame` API contains methods such as `moveToFront` that work only if the internal frame's container is a layered pane such as a `JDesktopPane`.

Rules of Using Internal Frames

If you've built any programs using `JFrame` and the other Swing components, then you already know a lot about how to use internal frames. The following list summarizes the rules for using internal frames. For additional information, see How to Make Frames and The JComponent Class.

You must set the size of the internal frame.
If you don't set the size of the internal frame, it will have zero size and thus never be visible. You can set the size using one of the following methods: `setSize`, `pack`, or `setBounds`.

As a rule, you should set the location of the internal frame.
If you don't set the location of the internal frame, it will come up at 0,0 (the upper left of its container). You can use the `setLocation` or `setBounds` method to specify the upper left point of the internal frame, relative to its container.

To add components to an internal frame, you add them to the internal frame's content pane.
This is exactly like the `JFrame` situation. See Adding Components to the Content Pane for details.

Dialogs that are internal frames should be implemented using `JOptionPane` or `JInternalFrame`, not `JDialog`.
To create a simple dialog, you can use the `JOptionPane` `showInternal`*`Xxx`*`Dialog` methods, as described in How to Make Dialogs.

You must add an internal frame to a container.
If you don't add the internal frame to a container (usually a `JDesktopPane`), the internal frame won't appear.

You need to call `show` or `setVisible` on internal frames.
Beginning with the Kestrel release, internal frames are invisible by default. You must invoke `setVisible(true)` or `show()` to make them visible.

Internal frames fire internal frame events, not window events.

Handling internal frame events is almost identical to handling window events. See How to Write an Internal Frame Listener for more information.

Performance Tip: Because dragging internal frames can be slow, Swing 1.1.1 and the Java 2 Platform, v 1.2.2, add a way to make it zippy: outline dragging. With outline dragging, only the outline of the internal frame is painted at the current mouse position while the window's being dragged. The internal frame's innards are not repainted at a new position until dragging stops. The default, slower behavior is to reposition and repaint the entire internal frame continuously while it's being moved.

In releases before v 1.3, you can specify outline dragging by setting a client property of the desktop pane, like this:

```
desktop.putClientProperty("JDesktopPane.dragMode",
                          "outline");
```

The preceding code has no effect in JFC implementations before Swing 1.1.1 Beta 1.

In v 1.3, use the new `JDesktopPane` method `setDragMode` to specify outline dragging. For example:

```
desktop.setDragMode(JDesktopPane.OUTLINE_DRAG_MODE);
```

The Internal Frame API

The following tables list the commonly used `JInternalFrame` constructors and methods, as well as a few methods that `JDesktopPane` provides. Besides the API listed in this section, `JInternalFrame` inherits useful API from its superclasses, `JComponent`, `Component`, and `Container`. See The JComponent Class for lists of methods from those classes.

Like `JInternalFrame`, `JDesktopPane` descends from `JComponent`, and thus provides the methods described in The JComponent Class. Because `JDesktopPane` extends `JLayeredPane`, it also supports the methods described in The Layered Pane API.

The API for using internal frames falls into these categories:

- Creating the internal frame
- Adding components to the internal frame
- Specifying the internal frame's visibility, size, and location
- Performing window operations on the internal frame
- Controlling window decorations and capabilities
- Using the JDesktopPane API

Creating the Internal Frame

Constructor or Method	Purpose

`JInternalFrame()`
`JInternalFrame(String)`
`JInternalFrame(String, boolean)`
`JInternalFrame(String, boolean, boolean)`
`JInternalFrame(String, boolean, boolean, boolean)`
`JInternalFrame(String, boolean, boolean, boolean, boolean)`
	Create a `JInternalFrame` instance. The first argument specifies the title (if any) to be displayed by the internal frame. The rest of the arguments specify whether the internal frame should contain decorations allowing the user to resize, close, maximize, and iconify the internal frame (specified in that order). The default value for each boolean argument is `false`, which means that the operation is not allowed.

`JOptionPane` class methods: ● `showInternalConfirmDialog` ● `showInternalInputDialog` ● `showInternalMessageDialog` ● `showInternalOptionDialog`	Create a `JInternalFrame` that simulates a dialog. See How to Make Dialogs for details.

Adding Components to the Internal Frame

Method	Purpose

`void setContentPane(Container)`
`Container getContentPane()`
	Set or get the internal frame's content pane, which generally contains all of the internal frame's GUI, with the exception of the menu bar and window decorations.

`void setJMenuBar(JMenuBar)`
`JMenuBar getJMenuBar()`
	Set or get the internal frame's menu bar. Note that some early Swing releases do not include this method.

Specifying the Internal Frame's Visibility, Size, and Location

Method	Purpose
`void setVisible(boolean)`	Make the internal frame visible (if `true`) or invisible (if `false`). You should invoke `setVisible(true)` on each `JInternalFrame` before adding it to its container. (Inherited from `Component`).
`void pack()`	Size the internal frame so that its components are at their preferred sizes.

`void setLocation(Point)`
`void setLocation(int, int)`
	Set the position of the internal frame. (Inherited from `Component`).

`void setBounds(Rectangle)`
`void setBounds(int, int, int, int)`
	Explicitly set the size and location of the internal frame. (Inherited from `Component`).

`void setSize(Dimension)`
`void setSize(int, int)`
	Explicitly set the size of the internal frame. (Inherited from `Component`).

Performing Window Operations on the Internal Frame

Method	**Purpose**

`void setDefaultCloseOperation(int)`
`int getDefaultCloseOperation()`
	Set or get what the internal frame does when the user attempts to "close" the internal frame. The default value is `HIDE_ON_CLOSE`. Other possible values are `DO_NOTHING_ON_CLOSE` and `DISPOSE_ON_CLOSE`. See Responding to Window-Closing Events for details.

`void addInternalFrameListener(InternalFrameListener)`
`void removeInternalFrameListener(InternalFrameListener)`
	Add or remove an internal frame listener (`JInternalFrame`'s equivalent of a window listener). See How to Write an Internal Frame Listener for more information.

`void moveToFront()`
`void moveToBack()`
	If the internal frame's parent is a layered pane such as a desktop pane, moves the internal frame to the front or back (respectively) of its layer.

`void setClosed(boolean)`
`boolean isClosed()`
	Set or get whether the internal frame is currently closed.

`void setIcon(boolean)`
`boolean isIcon()`
	Iconify or deiconify the internal frame, or determine whether it's currently iconified.

`void setMaximum(boolean)`
`boolean isMaximum()`
	Maximize or restore the internal frame, or determine whether it's maximized.

`void setSelected(boolean)`
`boolean isSelected()`
	Set or get whether the internal frame is the currently "selected" (activated) internal frame.

Controlling Window Decorations and Capabilities

Method	**Purpose**

`void setFrameIcon(Icon)`
`Icon getFrameIcon()`
	Set or get the icon displayed in the title bar of the internal frame (usually in the top-left corner).

`void setClosable(boolean)`
`boolean isClosable()`
	Set or get whether the user can close the internal frame.

`void setIconifiable(boolean)`
`boolean isIconifiable()`
	Set or get whether the internal frame can be iconified.

`void setMaximizable(boolean)`
`boolean isMaximizable()`
	Set or get whether the user can maximize this internal frame.

`void setResizable(boolean)`
`boolean isResizable()`
	Set or get whether the internal frame can be resized.

`void setTitle(String)`
`String getTitle()`
	Set or get the window title.

Using the `JDesktopPane` API

Constructor or Method	Purpose
`JDesktopPane()`	Creates a new instance of `JDesktopPane`.
`JInternalFrame[] getAllFrames()`	Returns all `JInternalFrame` objects that the desktop contains.
`JInternalFrame[] getAllFramesInLayer(int)`	Returns all `JInternalFrame` objects that the desktop contains that are in the specified layer. See How to Use Layered Panes for information about layers.

Examples that Use Internal Frames

The following examples use internal frames. Because internal frames are similar to regular frames, you should also look at Examples that Use Frames.

Example	Where Described	Notes
`MyInternalFrame`	This page.	Implements an internal frame that appears at an offset to the previously created internal frame.
`InternalFrameDemo`	This page.	Lets you create internal frames (instances of `MyInternalFrame`) that go into the application's `JDesktopPane`.
`InternalFrameEventDemo`	How to Write an Internal Frame Listener	Demonstrates listening for internal frame events. Also demonstrates positioning internal frames within a desktop pane.

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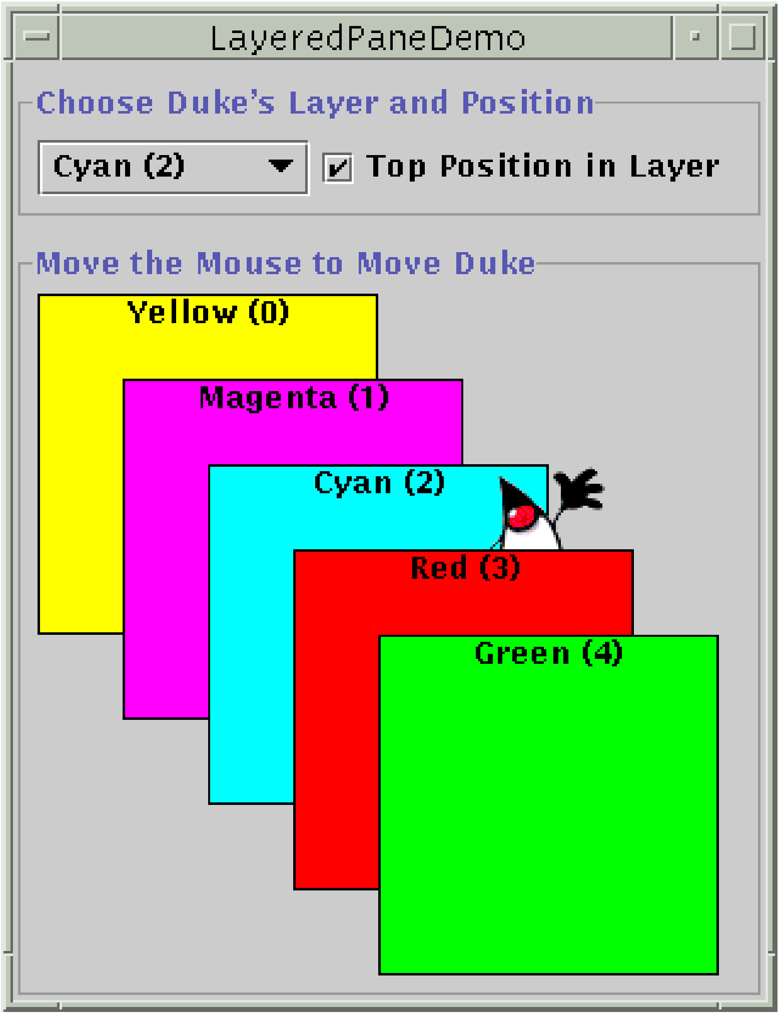
How to Use Layered Panes

A layered pane is a Swing container that provides a third dimension for positioning components: *depth*, also known as *Z order*. When adding a component to a layered pane, you specify its depth as an integer. The higher the number, the higher the depth. If components overlap, components at a higher depth are drawn on top of components at a lower depth. The relationship between components at the same depth is determined by their positions within the depth.

Every Swing container that has a root pane -- such as `JFrame`, `JApplet`, `JDialog`, or `JInternalFrame` -- automatically has a layered pane. Most programs don't explicitly use the root pane's layered pane, so we don't discuss it in this section. You can find information about it in The Root Pane, which provides an overview, and The Layered Pane, which has further details. This section concentrates on telling you how to create your own layered pane and use it anywhere you might use a regular Swing container.

Swing provides two layered pane classes. The first, `JLayeredPane`, is the class that root panes use and is the class used by the example in this section. The second, `JDesktopPane`, is a `JLayeredPane` subclass that's specialized for the task of holding internal frames. For examples of using `JDesktopPane`, see How to Use Internal Frames.

Here's a picture of an application that creates a layered pane and places overlapping, colored labels at different depths:



Try this:

1. Compile and run the application. The source file is `LayeredPaneDemo.java`. You will also need the `dukeWaveRed.gif` image file.
   See Getting Started with Swing if you need help compiling or running this application.
2. Move the mouse around in the lower part of the window. The image of Duke drags behind the green and red labels, but in front of the other three labels.
3. Use the combo box at the top of the window to change Duke's depth. Use the check box to set whether Duke is in the top position -- position 0 -- within the current depth.

Here's the code from the example program that creates the layered pane:

```
layeredPane = new JLayeredPane();
layeredPane.setPreferredSize(new Dimension(300, 310));
layeredPane.setBorder(BorderFactory.createTitledBorder(
                                    "Move the Mouse to Move Duke"));
layeredPane.addMouseMotionListener(new MouseMotionAdapter() {
    ...
});
```

The code uses `JLayeredPane`'s only constructor -- the no-argument constructor -- to create the layered pane. The rest of the code uses methods inherited from superclasses to give the layered pane a preferred size and a border, and add a mouse-motion listener to it. The mouse-motion listener just moves the Duke image around in response to mouse movement.

Ultimately, the example adds the layered pane to the frame's content pane:

```
    Container contentPane = getContentPane();
    ...
    contentPane.add(layeredPane);
```

As we'll show you a bit later, you add components to a layered pane using an `add` method. When adding a component to a layered pane, you specify the component's depth, and optionally, its position within its depth. The layered pane in the demo program contains six labels -- the five colored labels and a sixth one that displays the Duke image. As the program demonstrates, both the depth of a component and its position with that depth can change dynamically.

The rest of this section covers these topics:

- Adding Components and Setting Component Depth
- Setting a Component's Position Within Its Depth
- Laying Out Components in a Layered Pane
- The Layered Pane API
- Examples that Use Layered Panes

Adding Components and Setting Component Depth

Here's the code from the sample program that adds the colored labels to the layered pane:

```
    for (int i = 0; i < ...number of labels...; i++) {
        JLabel label = createColoredLabel(...);
        layeredPane.add(label, new Integer(i));
        ...
    }
```

You can find the implementation of the `createColoredLabel` method in the source code for the program. It just creates an opaque `JLabel` initialized with a background color, a border, some text, and a size.

The example program uses a two-argument version of the `add` method. The first argument is the component to add, the second is an Integer object, specifying the depth. This program uses the for loop's iteration variable to specify depths. The actual values don't matter much. What matters is the relative value of the depths and that you are consistent within your program in how you use each depth.

Note: If you use the root pane's layered pane, be sure to use its depth conventions. Refer to The Layered Pane for details. That section shows you how to modify LayeredPaneDemo to use the root pane's layered pane. With the modifications, you can see how the dragging Duke image relates to the combo box in the control panel.

As you can see from the example program, if components overlap, components at a higher depth are on top of components at a lower depth. To change a component's depth dynamically, use the setLayer method. In the example, the user can change Duke's layer by making a selection from the combo box. Here's the actionPerformed method of the action listener registered on the combo box:

```
public void actionPerformed(ActionEvent e) {
    int position = onTop.isSelected() ? 0 : 1;
    layeredPane.setLayer(dukeLabel, layerList.getSelectedIndex(),
                         position);
}
```

The setLayer method used here takes three arguments: the component whose depth is to be set, the new depth, and the position within the depth. JLayeredPane has a two-argument version of setLayer that takes only the component and the new depth. That method puts the component at the bottom position in its depth.

A note of caution: When adding a component to a layered pane you specify the layer with an Integer. When using setLayer to change a component's layer, you use an int. You might think that if you use an int instead of an Integer with the add method, the compiler would complain or your program would throw an illegal argument exception. But the compiler says nothing, which results in a common layered pane problem. You can use the API tables at the end of this section to check the types of the arguments and return values for methods that deal with layers.

Setting a Component's Position Within Its Depth

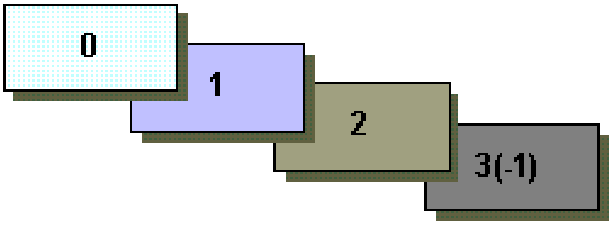
The following code creates the label that displays Duke's image, and then adds the label to the layered pane.

```
final ImageIcon icon = new ImageIcon("images/dukeWaveRed.gif");
...
```

```
dukeLabel = new JLabel(icon);
dukeLabel.setBounds(15, 225,
                    icon.getIconWidth(),
                    icon.getIconHeight());
layeredPane.add(dukeLabel, new Integer(2), 0);
```

This code uses the three-argument version of the `add` method. The third argument specifies the Duke label's position within its depth, which determines the component's relationship with other components at the same depth.

Positions are specified with an `int` between -1 and (*n* - 1), where *n* is the number of components at the depth. Unlike layer numbers, the smaller the position number, the higher the component within its depth. Using -1 is the same as using *n* - 1; it indicates the bottom-most position. Using 0 specifies that the component should be in the top-most position within its depth. As the following figure shows, with the exception of -1, a lower position number indicates a higher position within a depth.



A component's position within its layer can change dynamically. In the example, you can use the check box to determine whether Duke label is in the top position at its depth. Here's the `actionPerformed` method for the action listener registered on the check box:

```
public void actionPerformed(ActionEvent e) {
    if (onTop.isSelected())
        layeredPane.moveToFront(dukeLabel);
    else
        layeredPane.moveToBack(dukeLabel);
}
```

When the user selects the check box, the `moveToFront` method moves Duke to the front (position 0). And when the user deselects check box, Duke gets moved to the back with the `moveToBack` method. You can also use the `setPosition` method or the three-argument version of `setLayer` to change a component's position.

Laying Out Components in a Layered Pane

By default a layered pane has no layout manager. This means that you typically have to write the code that positions and sizes the components you put in a layered pane.

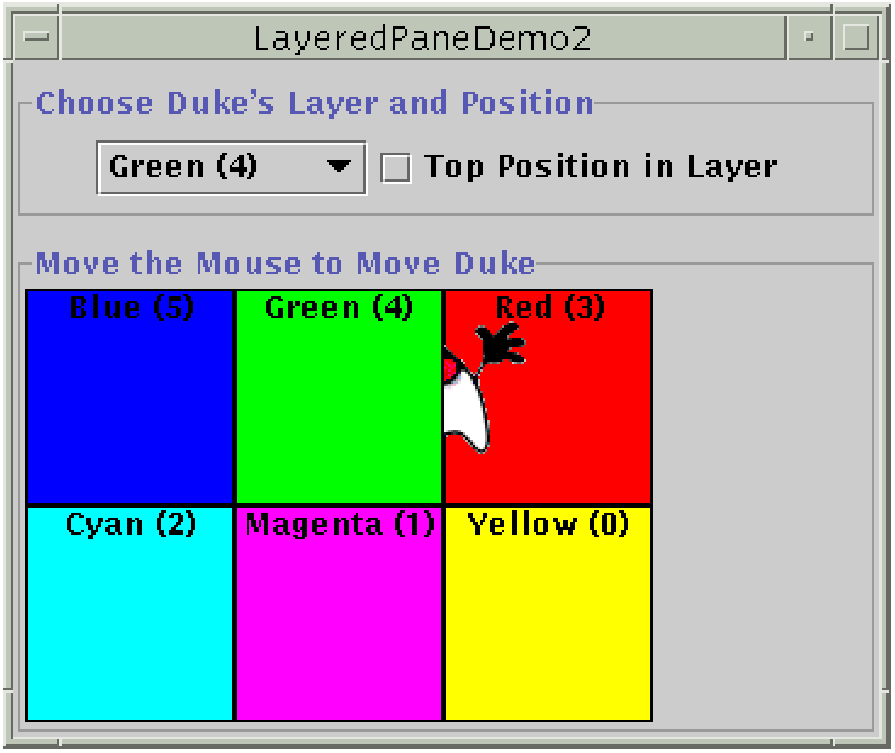
The example uses the `setBounds` method to set the size and position of each of the labels:

```
    dukeLabel.setBounds(15, 225,
                        icon.getIconWidth(),
                        icon.getIconHeight());
    ...
    label.setBounds(origin.x, origin.y, 140, 140);
```

When the user moves the mouse around, the program calls `setPosition` to change Duke's position:

```
    dukeLabel.setLocation(e.getX()-XFUDGE, e.getY()-YFUDGE);
```

Although a layered pane has no layout manager by default, you can still assign a layout manager to the layered pane. All of the layout managers provided by the Java platform arrange the components as if they were all on one layer. Here's a version of the previous demo that sets the layered pane's layout manager to an instance of `GridLayout`, using that layout manager to lay out six colored labels.



Green (4) ▾ □ Top Position in Layer

You can find the code for this program in [`LayeredPaneDemo2.java`]◆. This program also needs the [`dukeWaveRed.gif`] image file.

Many programs use intermediate containers (such as panels) and their layout managers to lay out components on the same layer, but use absolute positioning to lay out components on different layers. For more information about absolute positioning, see [Doing Without a Layout Manager (Absolute Positioning)]◆.

The Layered Pane API

The following tables list the commonly used `JLayeredPane` constructors and methods. Other methods you are most likely to invoke on a `JLayeredPane` object are those it inherits from its superclasses, such as `setBorder`, `setPreferredSize`, and so on. See The JComponent API for tables of commonly used inherited methods.

The API for using layered pane falls into these categories:

- Creating or Getting a Layered Pane
- Layering Components
- Setting Component's Intra-Layer Positions

Creating or Getting a Layered Pane

Method	**Purpose**
`JLayeredPane()`	Create a layered pane.
`JLayeredPane getLayeredPane()` *(in `JApplet`, `JDialog`, `JFrame`, and `JInternalFrame`)*	Get the automatic layered pane in an applet, dialog, frame, or internal frame.

Layering Components

Method	**Purpose**

`void add(Component)`
`void add(Component, Integer)`
`void add(Component, Integer, int)`
	Add the specified component to the layered pane. The second argument, when present, indicates the layer. The third argument, when present, indicates the component's position within its layer. If you use the one-argument version of this method, the component is added to layer 0. If you use the one- or two-argument version of this method, the component is placed underneath all other components currently in the same layer.

`void setLayer(Component, int)`
`void setLayer(Component, int, int)`
	Change the component's layer. The second argument indicates the layer. The third argument, when present, indicates the component's position within its layer.

`int getLayer(Component)`
`int getLayer(JComponent)`
	Get the layer for the specified component.

`int getComponentCountInLayer(int)`	Get the number of components in the specified layer. The value returned by this method can be useful for computing position values.
`Component[] getComponentsInLayer(int)`	Get an array of all the components in the specified layer.

`int highestLayer()`
`int lowestLayer()`
	Compute the highest or lowest layer currently in use.

Setting Components' Intra-Layer Positions

Method	**Purpose**

`void setPosition(Component, int)`
`int getPosition(Component)`
	Set or get the position for the specified component within its layer.

`void moveToFront(Component)`
`void moveToBack(Component)`
	Move the specified component to the front or back of its layer.

Examples that Use Layered Panes

This table shows the examples that use `JLayeredPane` and where those examples are described.

Example	**Where Described**	**Notes**
`LayeredPaneDemo`	This section	Illustrates layers and intra-layer positions of a `JLayeredPane`.
`LayeredPaneDemo2`	This section	Uses a layout manager to help lay out the components in a layered pane.
No source provided	The Layered Pane	The description describes how to change `LayeredPaneDemo` to use the root pane's layered pane.
`InternalFrameDemo`	How to Use Internal Frames	Uses a `JDesktopFrame` to manage internal frames.
`MovingLabels`	Moving an Image Across the Screen◆	Animates a rocketship using layers in a layered pane.

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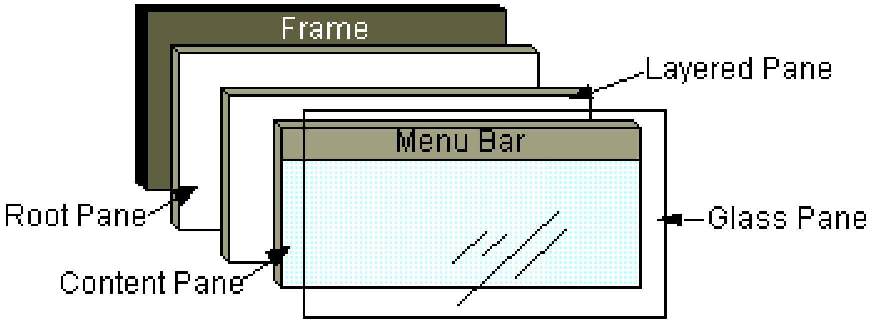
How to Use Root Panes

In general, you don't directly create a `JRootPane` object. Instead, you get a `JRootPane` (whether you want it or not!) when you instantiate `JInternalFrame` or one of the top-level Swing containers, such as `JApplet`, `JDialog`, and `JFrame`.

Using Top-Level Containers tells you the basics of using root panes -- getting the content pane, setting its layout manager, and adding Swing components to it. This section tells you more about root panes, including the components that make up a root pane and how you can use them. Another place to get information about root panes is The Swing Connection, especially the article Understanding Containers.



As the preceding figure shows, a root pane has four parts:

The glass pane
Hidden, by default. If you make the glass pane visible, then it's like a sheet of glass over all the other parts of the root pane. It's completely transparent unless you implement the glass pane's `paint` method so that it does something, and it intercepts input events for the root pane. In the next section, you'll see an example of using a glass pane.

The layered pane
Serves to position its contents, which consist of the content pane and the optional menu bar. Can also hold other components in a specified Z order. For information, see The Layered Pane.

The content pane
The container of the root pane's visible components, excluding the menu bar. For information on using the content pane, see Using Top-Level Containers.

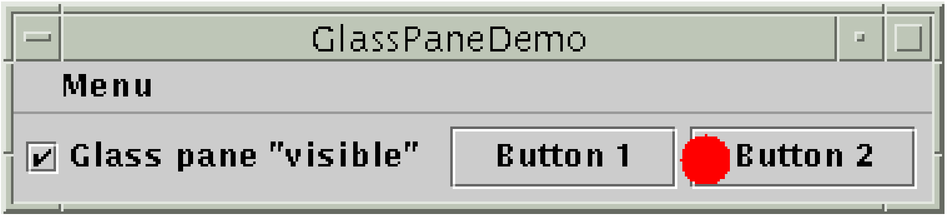
The optional menu bar
The home for the root pane's container's menus. If the container has a menu bar, you

generally use the container's `setJMenuBar` method to put the menu bar in the appropriate place. For more information on using menus and menu bars, see How to Use Menus.

The Glass Pane

The glass pane is useful when you want to be able to catch events or paint over an area that already contains one or more components. For example, you can deactivate mouse events for a multi-component region by having the glass pane intercept the events. Or you can display an image over multiple components using the glass pane.

Here's a picture of an application that demonstrates glass pane features. It contains a check box that lets you set whether the glass pane is "visible" -- whether it can get events and paint itself onscreen. When the glass pane is visible, it blocks all input events from reaching the components in the content pane. It also paints a red dot in the place where it last detected a mouse-pressed event.



Try this:

1. Compile and run the application. The source file is `GlassPaneDemo.java`.
   See Getting Started with Swing if you need help compiling or running this application.
2. Click Button 1.
   The button's appearance changes to show that it's been clicked.
3. Click the check box so that the glass pane becomes "visible," and then click Button 1 again.
   The button does *not* detect the mouse-pressed event because the glass pane intercepts it. When the glass pane detects the event, it beeps and paints a red circle where you clicked.
4. Click the check box again so that the glass pane is hidden.
   When the root pane detects an event over the check box, it forwards it to the check box. Otherwise, the check box would not respond to clicks.

The following code from `GlassPaneDemo.java` shows and hides the glass pane. This program happens to create its own glass pane, setting it using the `JFrame` `setGlassPane` method. However, if a glass pane doesn't do any painting, the program might simply attach listeners to the default glass pane, as returned by `getGlassPane`.

```
...//where GlassPaneDemo's UI is initialized:
JCheckBox changeButton =
        new JCheckBox("Glass pane \"visible\"");
changeButton.setSelected(false);
changeButton.addItemListener(new ItemListener() {
    public void itemStateChanged(ItemEvent e) {
        myGlassPane.setVisible(e.getStateChange()
                               == ItemEvent.SELECTED);
    }
});
```

The next code snippet implements the mouse-event handling for the glass pane. If a mouse event occurs over the check box or menu bar, then the glass pane redispatches the event so that the check box or menu component receives it. So that the check box and menu behave properly, they also receive all drag events that started with a press in the button or menu bar.

```
...//In the implementation of the glass pane's mouse listener:
public void mouseMoved(MouseEvent e) {
    redispatchMouseEvent(e, false);
}

.../* The mouseDragged, mouseClicked, mouseEntered,
    * mouseExited, and mousePressed methods have the same
    * implementation as mouseMoved*/...

public void mouseReleased(MouseEvent e) {
    redispatchMouseEvent(e, true);
    inDrag = false;
}

private void redispatchMouseEvent(MouseEvent e, boolean repaint) {
    boolean inButton = false;
    boolean inMenuBar = false;
    Point glassPanePoint = e.getPoint();
    Component component = null;
    Container container = contentPane;
    Point containerPoint = SwingUtilities.convertPoint(
                                    glassPane,
                                    glassPanePoint,
                                    contentPane);
    int eventID = e.getID();

    if (containerPoint.y < 0) {
        inMenuBar = true;
        //...set container and containerPoint accordingly...
        testForDrag(eventID);
    }

    component = SwingUtilities.getDeepestComponentAt(
                                    container,
                                    containerPoint.x,
                                    containerPoint.y);

    if (component.equals(liveButton)) {
        inButton = true;
        testForDrag(eventID);
    }

    if (inMenuBar || inButton || inDrag) {
        ...//Redispatch the event to component...
    }

    if (repaint) {
        toolkit.beep();
        glassPane.setPoint(glassPanePoint);
        glassPane.repaint();
    }
}

private void testForDrag(int eventID) {
    if (eventID == MouseEvent.MOUSE_PRESSED) {
        inDrag = true;
    }
}
```

Here is the code that implements the painting for the glass pane:

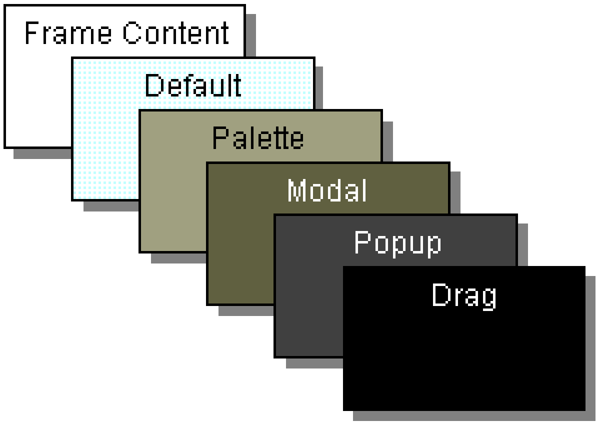
```
...//where GlassPaneDemo's UI is initialized:
myGlassPane = new MyGlassPane(...);
frame.setGlassPane(myGlassPane);
...
/**
 * We have to provide our own glass pane so that it can paint.
 */
class MyGlassPane extends JComponent {
    Point point = null;

    public void paint(Graphics g) {
        if (point != null) {
            g.setColor(Color.red);
```

```
                g.fillOval(point.x - 10, point.y - 10, 20, 20);
            }
        }
        ...
    }
```

The Layered Pane

A root pane places its menu bar and content pane in an instance of `JLayeredPane`--a container with depth--such that overlapping components can appear one on top of the other. This is useful for displaying popup menus above other components, for example. Your programs can also put components in the root pane's layered pane. If you do, then you should be aware that certain depths are defined to be used for specific functions, and you should use the depths as intended. Otherwise, your components might not play well with the others. Here's a diagram that shows the functional layers and their relationship:



The table below describes the intended use for each layer and the named constant defined in the `JLayeredPane` class that corresponds to it:

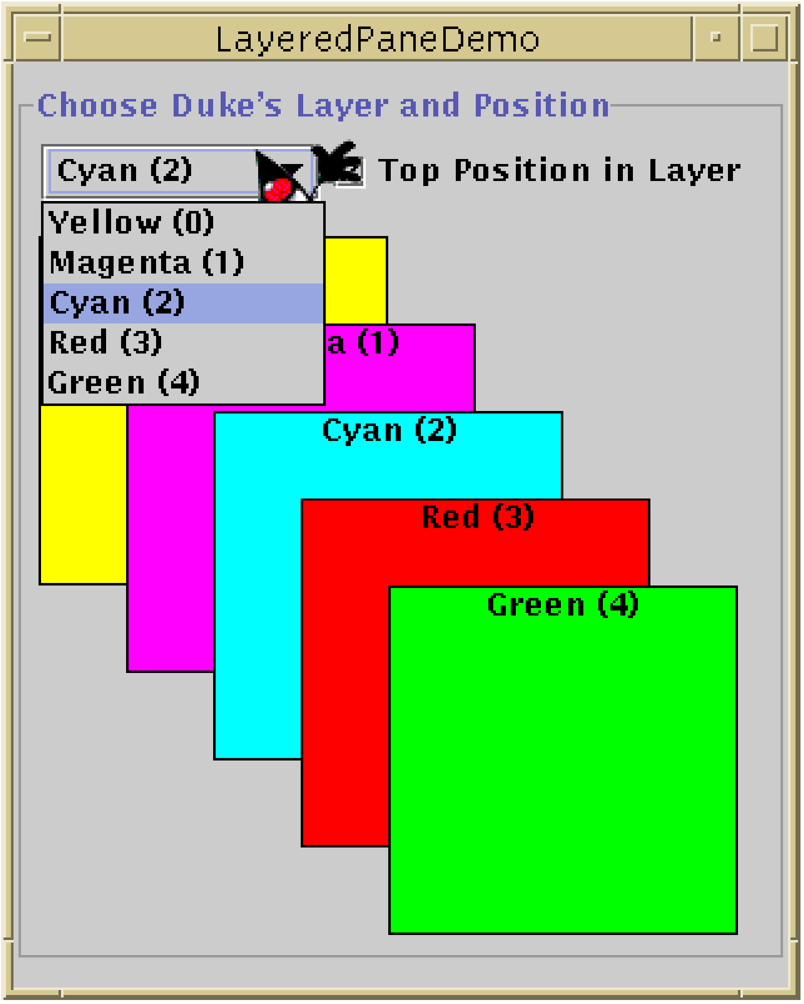
Layer Name	Value	Description
`FRAME_CONTENT_LAYER`	`new Integer(-30000)`	This layer is used to position the frame's content pane and menu bar. Most programs won't use this. The root pane adds the menu bar and content pane to its layered pane at this depth.
`DEFAULT_LAYER`	`new Integer(0)`	Most components go in this layer. If you don't specify a component's depth, the layered pane puts it at this depth.

PALETTE_LAYER	new Integer(100)	This layer is useful for floating toolbars and palettes.
MODAL_LAYER	new Integer(200)	Modal internal-frame dialogs would belong in this layer.
POPUP_LAYER	new Integer(300)	Popups go in this layer because they need to appear above just about everything.
DRAG_LAYER	new Integer(400)	Move a component to this layer when dragging. Return the component to its regular layer when dropped.

This tutorial does not provide an example of using the root pane's layered pane. However, by modifying a few lines of code in the example described in How to Use Layered Panes, you can make the program use the root pane's layered pane instead of creating one. The left column in this table shows the code as it appears in LayeredPaneDemo.java. The right column shows how to change it:

From...	**To...**
layeredPane = new JLayeredPane();	layeredPane = **getLayeredPane**();
final int YFUDGE = 57;	final int YFUDGE = **27**;
Point origin = new Point(10, 20);	Point origin = new Point(10, **70**);
contentPane.add(layeredPane);	//contentPane.add(layeredPane);
frame.pack();	frame.**setSize(new Dimension(350, 400))**;

Because the program now uses the root pane's layered pane, the Duke label can be dragged all around inside the window and over the components in the control panel. What do you suppose happens when you bring up the combo box? Will Duke be under the combo box's menu or over it?



Notice that the layered pane's mouse listener is not notified of events when the mouse is over the combo box or the checkbox.

The Root Pane API

The tables that follow list the API for using root panes, glass panes, and content panes. For more information on using content panes, go to Using Top-Level Containers. Here are the tables in this section:

- Using a Root Pane
- Setting or Getting the Glass Pane
- Setting or Getting the Content Pane

The API for using other parts of the root pane is described elsewhere:

- The Layered Pane API
- The Menu API

Using a Root Pane

Method	**Purpose**
`JRootPane getRootPane()` *(in `JApplet`, `JDialog`, `JFrame`, `JInternalFrame`, and `JWindow`)*	Get the root pane of the applet, dialog, frame, internal frame, or window.
`JRootPane SwingUtilities.getRootPane(Component)`	If the component contains a root pane, returns that root pane. Otherwise, returns the root pane (if any) that contains the component.
`JRootPane getRootPane()` *(in `JComponent`)*	Invokes the `SwingUtilities` `getRootPane` method on the `JComponent`.

`void setDefaultButton(JButton)`
`JButton getDefaultButton()`
	Set or get which button (if any) is the default button in the root pane. A look-and-feel-specific action, such as pressing Enter, causes the button's action to be performed.

Setting or Getting the Glass Pane

Method	**Purpose**

`setGlassPane(Component)`
`Component getGlassPane()`
(in `JApplet`, `JDialog`, `JFrame`, `JInternalFrame`, `JRootPane`, and `JWindow`)
	Sets or gets the glass pane.

Setting or Getting the Content Pane

Method	**Purpose**

`setContentPane(Container)`
`Container getContentPane()`
(in `JApplet`, `JDialog`, `JFrame`, `JInternalFrame`, `JRootPane`, and `JWindow`)
	Set or get the content pane.

Examples that Use Root Panes

Every Swing program has a root pane, but few reference it directly. The examples in the following list illustrate how to use features of `JRootPane` or the glass pane. Also see these lists:

- Examples that Use Layered Panes
- Examples that Use Menus

- Examples that Use Frames (for examples of using content panes)

Example	Where Described	Notes
`GlassPaneDemo`	This section	Uses a glass pane. Redispatches events.
`ListDialog`	How to Use BoxLayout◆	Sets the default button for a top-level container, using the root pane's `setDefaultButton` method.
`AppletDemo`	How to Make Applets	Sets a property on the root pane, to try to avoid a security check that can cause disturbing messages in the console in JDK 1.1.

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How to Use Combo Boxes

A `JComboBox`◆ comes in two very different forms: uneditable and editable.

By default, a combo box is uneditable. A uneditable combo box looks like a button until the user interacts with it. When the user presses or clicks it, the combo box displays a menu of items to choose from. Use an uneditable combo box to display one-of-many choices when space is limited, when the number of choices is large, or when the menu items are computed at run-time. Other components that display one-of-many choices are lists and groups of radio buttons.

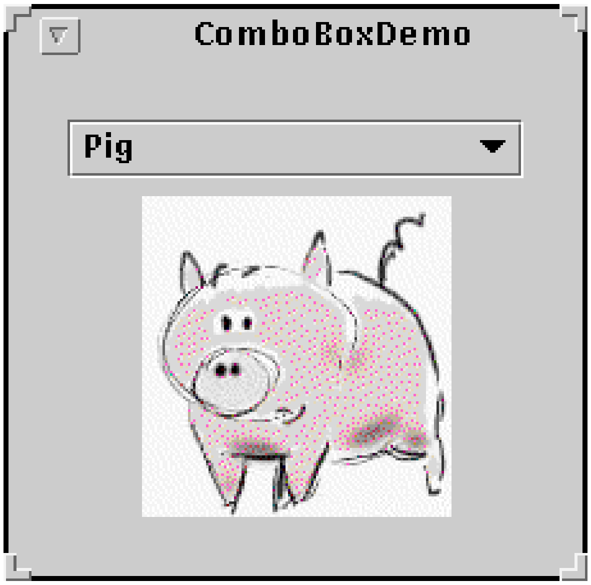
An editable `JComboBox` looks like a text field with a small button abutting it. The user can type a value in the text field or click the button to choose a value from a menu. An editable combo box saves data-entry time by providing shortcuts to commonly entered values.

Because editable and uneditable combo boxes are so different, this section treats them separately. This section covers these topics:

- Using an Uneditable Combo Box
- Handling Events on a Combo Box
- Using an Editable Combo Box
- Providing a Custom Renderer
- The Combo Box API
- Examples that Use Combo Boxes

Using an Uneditable Combo Box

The application shown here uses an uneditable combo box for choosing a pet picture:



Try this:

1. Compile and run the program: `ComboBoxDemo.java`. You will also need five image files.
   See Getting Started with Swing if you need help compiling or running this application.
2. Choose a pet name from the combo box to view its picture.
3. How to Use Radio Buttons provides a version of this program, `RadioButtonDemo`, that uses a group of radio buttons instead of a combo box. Compile and run that program. Compare the source code, operation, and UI of the two programs.

The following code, taken from `ComboBoxDemo.java`, creates an uneditable combo box and sets it up:

```
String[] petStrings = { "Bird", "Cat", "Dog", "Rabbit", "Pig" };

// Create the combo box, select item at index 4.
// Indices start at 0, so 4 specifies the pig.
JComboBox petList = new JComboBox(petStrings);
petList.setSelectedIndex(4);
...
```

The code initializes the combo box with an array of strings. You can also put icons in a combo box. To put other types of objects in a combo box, or to customize how the items in a combo box look, you need to write a custom renderer. An editable combo box would also need a custom editor. Refer to Providing a Custom Renderer for information and an example.

Although not shown above, the program registers an action listener on the combo box. To see the code and learn about other types of listeners supported by combo box, refer to Handling Events on a Combo Box.

No matter which constructor you use, a combo box uses a combo box model to contain and manage the items in its menu. When you initialize a combo box with an array or a vector, the combo box creates a default model object for you. As with other Swing components, you can customize a combo box in part by implementing a custom model -- an object that implements the `ComboBoxModel` interface.

Note: Be careful when implementing a custom model for a combo box. The `JComboBox` methods that change the items in the combo box's menu, such as `insertItemAt`, work only if the data model implements the `MutableComboBoxModel` interface (a subinterface of `ComboBoxModel`). Refer to the API tables to see which methods are affected.

Handling Events on a Combo Box

Here's the code from `ComboBoxDemo` that registers and implements an action listener on the combo box:

```
petList.addActionListener(new ActionListener() {
    public void actionPerformed(ActionEvent e) {
        JComboBox cb = (JComboBox)e.getSource();
        String petName = (String)cb.getSelectedItem();
        picture.setIcon(new ImageIcon("images/" +
                                      petName + ".gif"));
    }
});
```

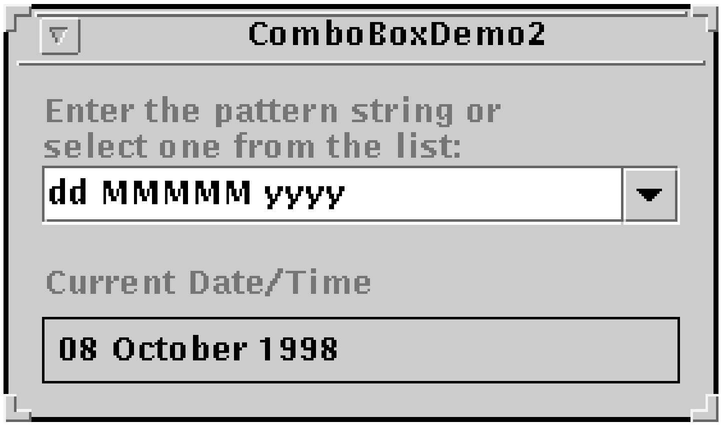
This action listener gets the newly selected item from the combo box, uses it to compute the name of an image file, and updates a label to display the image. The combo box fires an action event when the user selects an item from the combo box's menu. See How to Write an Action Listener, for general information about implementing action listeners.

Combo boxes also generate item events, which are fired when any of the items' selection state changes. Only one item at a time can be selected in a combo box, so when the user makes a new selection the previously selected item becomes unselected. Thus two item events are fired each time the user selects a different item from the menu. If the user chooses the same item, no item events are fired. Use `addItemListener` to register an item listener on a combo box. How to Write an Item Listener◆ gives general information about implementing item listeners.

Although `JComboBox` inherits methods to register listeners for low-level events -- focus, key, and mouse events, for example -- we recommend that you don't listen for low-level events on a combo box. Here's why: A combo box is a *compound component* -- it is comprised of two or more other components. The combo box itself fires high-level events such as action events. Its subcomponents fire low-level events such as mouse, key, and focus events. The low-level events and the subcomponent that fires them are look-and-feel-dependent. To avoid writing look-and-feel-dependent code, you should listen only for high-level events on a compound component such as a combo box. For information about events, including a discussion about high- and low-level events, refer to Writing Event Listeners◆.

Using an Editable Combo Box

Here's a picture of a demo application, provided by our coworker Dale Green, that uses an editable combo box to enter a pattern with which to format dates.



Enter the pattern string or
select one from the list:

dd MMMMM yyyy

Current Date/Time

08 October 1998

Try this:

1. Compile and run the example: `ComboBoxDemo2.java`◆.
   See Getting Started with Swing if you need help compiling or running this application.
2. Enter a new pattern by choosing one from the combo box's menu. The program reformats the current date and time.
3. Enter a new pattern by typing one in and pressing Return. Again the program reformats the current date and time.

The following code, taken from `ComboBoxDemo2.java`◆, creates and sets up the combo box:

```
String[] patternExamples = {
         "dd MMMMM yyyy",
         "dd.MM.yy",
         "MM/dd/yy",
         "yyyy.MM.dd G 'at' hh:mm:ss z",
         "EEE, MMM d, ''yy",
         "h:mm a",
         "H:mm:ss:SSS",
         "K:mm a,z",
         "yyyy.MMMMM.dd GGG hh:mm aaa"
};
. . .
JComboBox patternList = new JComboBox(patternExamples);
patternList.setEditable(true);
patternList.addActionListener(...);
. . .
```

This code is very similar to the previous example, but warrants a few words of explanation. The bold line of code explicitly turns on editing to allow the user to type values in. This is necessary because, by default, a combo box is not editable. This particular example allows editing on the combo box because its menu does not provide all possible date formatting patterns, just shortcuts to frequently used patterns.

An editable combo box fires an action event when the user chooses an item from the menu and when the user types Return. Note that the menu remains unchanged when the user enters a value into the combo box. If you want, you can easily write an action listener that adds a new item to the combo box's menu each time the user types in a unique value.

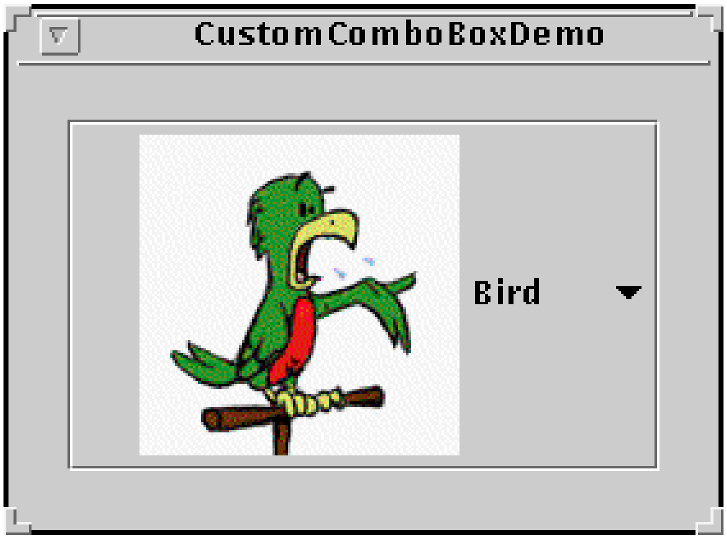
See Internationalization to learn more about formatting dates and other types of data.

Providing a Custom Renderer

A combo box uses a *renderer* to display each item in its menu. If the combo box is uneditable, it also uses the renderer to display the currently selected item. An editable combo box, on the other hand, uses an *editor* to display the selected item. A renderer for a combo box must implement the `ListCellRenderer` interface. A combo box's editor must implement `ComboBoxEditor`. This section shows how to provide a custom renderer for an uneditable combo box.

The default renderer knows how to render strings and icons. If you put other objects in a combo box, the default renderer calls the `toString` method to provide a string to display. You can customize the way a combo box renders itself and its items by implementing your own `ListCellRenderer`.

Here's a picture of an application that uses a combo box with a custom renderer:



You can find the full source code for this example in `CustomComboBoxDemo.java`. This example needs the five pet image files.

The following statements from the example create an instance of `ComboBoxRenderer` (a custom class) and set up the instance as the combo box's renderer:

```
JComboBox petList = new JComboBox(images);
ComboBoxRenderer renderer = new ComboBoxRenderer();
renderer.setPreferredSize(new Dimension(200, 130));
petList.setRenderer(renderer);
petList.setMaximumRowCount(3);
```

To see how the default renderer renders icons, just comment out the call to `setRenderer`, and compile and run the program again.

The code also sets the combo box's maximum row count. This attribute controls the number of items visible when the menu is displayed. If the number of items in the combo box is larger than its maximum row count, the menu has a scroll bar. The icons are pretty big for a menu, so the code limits the number of rows to 3. Here's the complete implementation of `ComboBoxRenderer`, a renderer that puts an icon and text side-by-side:

```
class ComboBoxRenderer extends JLabel
                       implements ListCellRenderer {
    public ComboBoxRenderer() {
        setOpaque(true);
```

```
            setHorizontalAlignment(CENTER);
            setVerticalAlignment(CENTER);
        }
        public Component getListCellRendererComponent(
            JList list,
            Object value,
            int index,
            boolean isSelected,
            boolean cellHasFocus)
        {
            if (isSelected) {
                setBackground(list.getSelectionBackground());
                setForeground(list.getSelectionForeground());
            } else {
                setBackground(list.getBackground());
                setForeground(list.getForeground());
            }

            ImageIcon icon = (ImageIcon)value;
            setText(icon.getDescription());
            setIcon(icon);
            return this;
        }
    }
```

As a `ListCellRenderer`, `ComboBoxRenderer` implements a method called `getListCellRendererComponent`, which returns a component whose `paintComponent` method is used to display the combo box and each of its items. The easiest way to display an image and an icon is to use a label. So `ComboBoxRenderer` is a subclass of label and returns itself. The implementation of `getListCellRendererComponent` configures the renderer to display the currently selected icon and its description.

These arguments are passed to `getListCellRendererComponent`:

- `JList list` -- a list object used behind the scenes to display the items. The example uses this object's colors to set up foreground and background colors.
- `Object value` -- the object to render. An `Icon` in this example.
- `int index` -- the index of the object to render.
- `boolean isSelected` -- indicates whether the object to render is selected. Used by the example to determine which colors to use.
- `boolean cellHasFocus` -- indicates whether the object to render has the focus.

Note that combo boxes and lists use the same type of renderer -- `ListCellRenderer`. You can save yourself some time by sharing renderers between combo boxes and lists, if it makes sense for your program.

The Combo Box API

The following tables list the commonly used `JComboBox` constructors and methods. Other methods you are most likely to invoke on a `JComboBox` object are those it inherits from its superclasses, such as `setPreferredSize`. See The JComponent API for tables of commonly used inherited methods.

The API for using combo boxes falls into two categories:

- Setting or Getting the Items in the Combo Boxes's Menu
- Customizing the Combo Box's Operation

Setting or Getting the Items in the Combo Boxes's Menu

Method	**Purpose**

`JComboBox()`
`JComboBox(ComboBoxModel)`
`JComboBox(Object[])`
`JComboBox(Vector)`
	Create a combo box with the specified items in its menu. A combo box created with the default constructor has no items in the menu initially. Each of the other constructors initializes the menu from its argument: a model object, an array of objects, or a `Vector` of objects.

`void addItem(Object)`
`void insertItemAt(Object, int)`
	Add or insert the specified object into the combo box's menu. The insert method places the specified object *at* the specified index, thus inserting it before the object currently at that index. These methods require that the combo box's data model be an instance of `MutableComboBoxModel`.

`Object getItemAt(int)`
`Object getSelectedItem()`
	Get an item from the combo box's menu.

`void removeAllItems()`
`void removeItemAt(int)`
`void removeItem(Object)`
	Remove one or more items from the combo box's menu. These methods require that the combo box's data model be an instance of `MutableComboBoxModel`.

`int getItemCount()`	Get the number of items in the combo box's menu.

`void setModel(ComboBoxModel)`
`ComboBoxModel getModel()`
	Set or get the data model that provides the items in the combo box's menu.

Customizing the Combo Box's Operation

Method	Purpose
`void addActionListener(ActionListener)`	Add an action listener to the combo box. The listener's `actionPerformed` method is called when the user selects an item from the combo box's menu or, in an editable combo box, when the user presses Return.
`void addItemListener(ItemListener)`	Add an item listener to the combo box. The listener's `itemStateChanged` method is called when the selection state of any of the combo box's items change.

`void setEditable(boolean)`
`boolean isEditable()`
	Set or get whether the user can type in the combo box.

`void setRenderer(ListCellRenderer)`
`ListCellRenderer getRenderer()`
	Set or get the object responsible for painting the selected item in the combo box. The renderer is used only when the combo box is uneditable. If the combo box is editable, the editor is used to paint the selected item instead.

`void setEditor(ComboBoxEditor)`
`ComboBoxEditor getEditor()`
	Set or get the object responsible for painting and editing the selected item in the combo box. The editor is used only when the combo box is editable. If the combo box is uneditable, the renderer is used to paint the selected item instead.

Examples that Use Combo Boxes

This table shows the examples that use `JComboBox` and where those examples are described.

Example	Where Described	Notes
`ComboBoxDemo`	This section	Uses an uneditable combo box.
`ComboBoxDemo2`	This section	Uses an editable combo box.
`CustomComboBoxDemo`	This section	Provides a custom renderer for a combo box.
`TableRenderDemo`	How to Use Tables (Further Customizing Table Display and Event Handling)	Shows how to use a combo box as a table cell editor.

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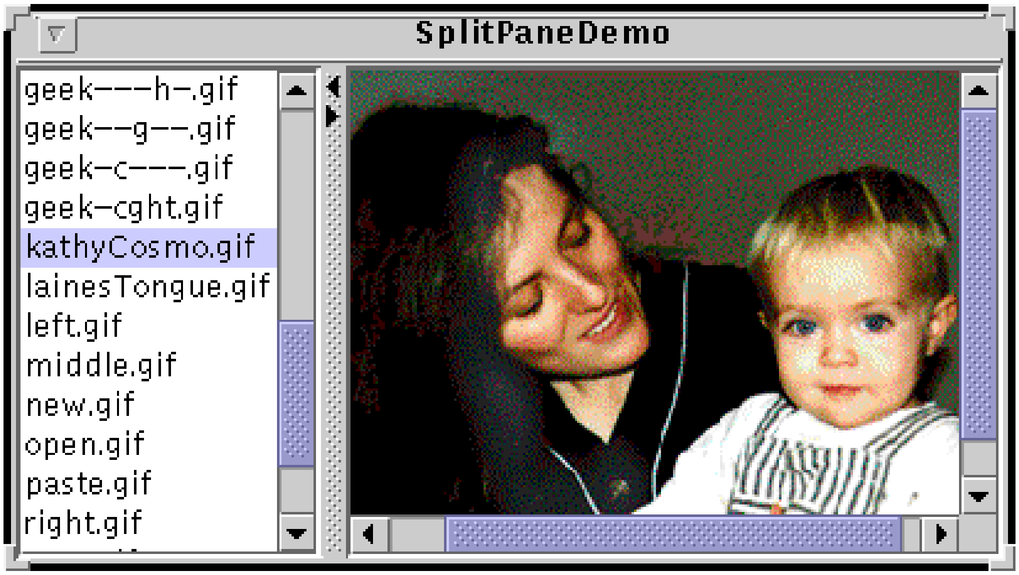
How to Use Lists

A `JList` presents the user with a group of items, displayed in a column, to choose from. Lists can have many items, so they are often put in scroll panes. Because of this, `JList` is a scrolling-savvy class.

In addition to lists, the following Swing components present multiple selectable items to the user: combo boxes, menus, tables, and groups of check boxes or radio buttons, Only tables, lists, and groups of check boxes allow multiple items to be selected at the same time.

The following figure shows an application that uses a `JList` to display a list of image names. When the user clicks on an image name, the application displays the image.



Try this:

1. Compile and run the application. The main source file is `SplitPaneDemo.java`. `imagenames.properties` provides the image names to put in the `JList`. You can check the examples index to find our image files or you can modify the properties file to use images you already have. Put the image files in a directory named `images`.
2. Choose an image from the list. Use the scroll bar to see more names.
3. Refer to How to Use Split Panes to find out about this demo's use of a split

pane.

This section uses the preceding example as a basis for discussing the following topics:

- Working With a List's Model
- Selecting Items in a List
- Adding Items to and Removing Items from a List
- Writing a Custom Cell Renderer
- The List API
- Examples that Use Lists

Working With a List's Model

Here is the code from `SplitPaneDemo.java` that creates and sets up the list:

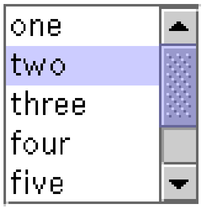
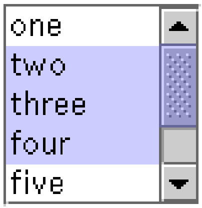
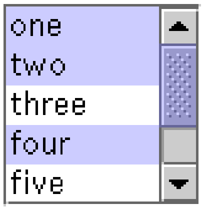
```
//...where member variables are declared:
static Vector imageList;
//...initialize the vector from a properties file...//
...
//...where the GUI is created:
// Create the list of images and put it in a scroll pane
JList list = new JList(imageList);
list.setSelectionMode(ListSelectionModel.SINGLE_SELECTION);
...
JScrollPane listScrollPane = new JScrollPane(list);
```

The code passes a `Vector` to the list's constructor. The vector is filled with strings that were read in from a properties file. Each string contains the name of an image file.

Other `JList` constructors let you initialize a list from an array of objects or from an object that adheres to the `ListModel` interface. If you initialize a list with an array or vector, the constructor implicitly creates a default list model. The default list model is immutable -- you cannot add, remove, or replace items in the list. To create a list whose items can be changed individually, set the list's model to an instance of a mutable list model class, such as an instance of `DefaultListModel`. You can set a list's model when you create the list or by calling the `setModel` method. See Adding Items to and Removing Items from a List for an example.

Selecting Items in a List

A list uses an instance of `ListSelectionModel` to manage its selection. By default, a list selection model allows any combination of items to be selected at a time. You can specify a different selection mode by calling the `setSelectionMode` method on the list. For example, `SplitPaneDemo` sets the selection mode to `SINGLE_SELECTION` (a constant defined by `ListSelectionModel`) so that only one item in the list can be selected. The following table describes the three list selection modes:

Mode	Description	Example
`SINGLE_SELECTION`	Only one item can be selected at a time. When the user selects an item, any previously selected item is deselected first.	 one two three four five
`SINGLE_INTERVAL_SELECTION`	Multiple, contiguous items can be selected. When the user begins a new selection range, any previously selected items are deselected first.	 one two three four five
`MULTIPLE_INTERVAL_SELECTION`	The default. Any combination of items can be selected. The user must explicitly deselect items.	 one two three four five

No matter which selection mode your list uses, the list fires list selection events whenever the selection changes. You can process these events by adding a list selection listener to the list with the `addListSelectionListener` method. A list selection listener must implement one method:

valueChanged. Here's the valueChanged method for the listener in SplitPaneDemo:

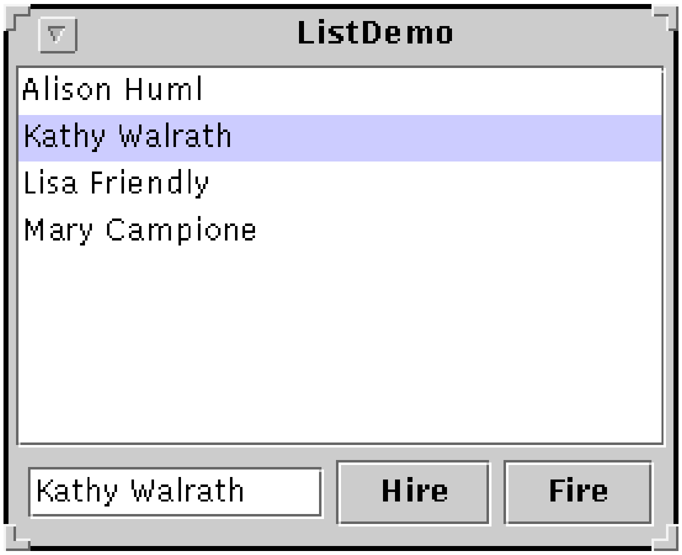
```
public void valueChanged(ListSelectionEvent e) {
    if (e.getValueIsAdjusting())
        return;

    JList theList = (JList)e.getSource();
    if (theList.isSelectionEmpty()) {
        picture.setIcon(null);
    } else {
        int index = theList.getSelectedIndex();
        ImageIcon newImage = new ImageIcon("images/" +
                        (String)imageList.elementAt(index));
        picture.setIcon(newImage);
        picture.setPreferredSize(new Dimension(
                        newImage.getIconWidth(),
                        newImage.getIconHeight() ));
        picture.revalidate();
    }
}
```

Many list selection events can be generated from a single user action such as a mouse click. The getValueIsAdjusting method returns true if the user is still manipulating the selection. This particular program is interested only in the final result of the user's action, so the valueChanged method updates the image only if getValueIsAdjusting returns false.

Because the list is in single selection mode, this code can use getSelectedIndex to get the index of the just-selected item. JList provides other methods for setting or getting the selection when the selection mode allows more than one item to be selected. If you want, you can listen for events on the list's list selection model rather than on the list itself. Examples of Handling List Selection Events provides an example that shows how to listen for list selection events on the list selection model and lets you change the selection mode of a list dynamically

Adding Items to and Removing Items from a List

Here's an application that lets a user modify a list of employees by hiring and firing them:



Try this:

1. Compile and run the application. The source file is `ListDemo.java`.
2. Select a name from the list and click the **Fire** button.
3. Type in a new name and click the **Hire** button.

Here's the code from `ListDemo` that creates a mutable list model object, puts the initial items in it, and uses the list model to create a list:

```
listModel = new DefaultListModel();
listModel.addElement("Alison Huml");
listModel.addElement("Kathy Walrath");
listModel.addElement("Lisa Friendly");
listModel.addElement("Mary Campione");

list = new JList(listModel);
```

This particular program uses an instance of `DefaultListModel`, a class provided by Swing. In spite of the name, a list does not have a `DefaultListModel` unless your program explicitly makes it so. If this class doesn't suit your needs, you can write a custom list model, which must adhere to the `ListModel` interface. Here's the `actionPerformed` method for the action listener registered on the **Fire** button:

```
public void actionPerformed(ActionEvent e) {
    int index = list.getSelectedIndex();
    listModel.remove(index);

    int size = listModel.getSize();
    //Nobody's left, disable firing
    if (size == 0) {
        fireButton.setEnabled(false);

    //Adjust the selection
    } else {
        //removed item in last position
        if (index == listModel.getSize())
            index--;
        //otherwise select same index
        list.setSelectedIndex(index);
    }
}
```

The bold line of code removes the selected item in the list. The remaining lines in the method disable the fire button if the list is now empty, and make another selection.

Here's the `actionPerformed` method for the action listener shared by the **Hire** button and the text field:

```
public void actionPerformed(ActionEvent e) {
    //User didn't type in a name...
    if (employeeName.getText().equals("")) {
        Toolkit.getDefaultToolkit().beep();
        return;
    }

    int index = list.getSelectedIndex();
    int size = listModel.getSize();

    //If no selection or if item in last position is selected,
    //add the new hire to end of list, and select new hire
    if (index == -1 || (index+1 == size)) {
        listModel.addElement(employeeName.getText());
        list.setSelectedIndex(size);

    //Otherwise insert the new hire after the current selection,
    //and select new hire
    } else {
        listModel.insertElementAt(employeeName.getText(), index+1);
        list.setSelectedIndex(index+1);
    }
}
```

This code uses the list model's `addElement` method to add the new name to the end of the list if the last item in the list is selected or if there's no selection. Otherwise, the code calls `insertElementAt` to insert the new name after the current selection.

Whenever items are added to, removed from, or modified in a list, the list model fires list data events. Refer to How to Write a List Data Listener for information about listening for these events. That section contains an example that is similar to `ListDemo`, but adds buttons that move items up or down in the list.

Writing a Custom Cell Renderer

A list uses an object called a cell renderer to display each of its items. The default cell renderer knows how to display strings and icons. If you want to put any other `Object` in a list or if you want to change the way the default renderer display icons or strings, you can implement a custom cell renderer. Take these steps to provide a custom cell renderer for a list:

- Write a class that implements the `ListCellRenderer` interface.
- Create an instance of your class and call the list's `setCellRenderer` using the instance as an argument.

We don't provide an example of a list with a custom cell renderer, but we do have an example of a combo box with a custom renderer -- and combo boxes use the same type of renderer as lists. See the example described in Providing a Custom Renderer.

The List API

The following tables list the commonly used `JList` constructors and methods. Other methods you are most likely to invoke on a `JList` object are those such as `setPreferredSize` that its superclasses provide. See The JComponent API for tables of commonly used inherited methods.

Much of the operation of a list is managed by other objects. The items in the list are managed by a list model object, the selection is managed by a list selection model object, and most programs put a list in a scroll pane to handle scrolling. For the most part, you don't need to worry about the models because `JList` creates them as necessary and you interact with them implicitly with `JList`'s convenience methods.

That said, the API for using lists falls into these categories:

- Setting the Items in the List
- Managing the List's Selection
- Working with a Scroll Pane

Setting the Items in the List

Method	**Purpose**

`JList(ListModel)`
`JList(Object[])`
`JList(Vector)`
	Create a list with the initial list items specified. The second and third constructors implicitly create an immutable `ListModel`.

`void setModel(ListModel)`
`ListModel getModel()`
	Set or get the model that contains the contents of the list.

`void setListData(Object[])`
`void setListData(Vector)`
	Set the items in the list. These methods implicitly create an immutable `ListModel`.

Managing the List's Selection

Method	**Purpose**
`void addListSelectionListener(ListSelectionListener)`	Register to receive notification of selection changes.

`void setSelectedIndex(int)`
`void setSelectedIndices(int[])`
`void setSelectedValue(Object, boolean)`
`void setSelectedInterval(int, int)`
	Set the current selection as indicated. Use `setSelectionMode` to set what ranges of selections are acceptable. The boolean argument specifies whether the list should attempt to scroll itself so that the selected item is visible.

`int getSelectedIndex()`
`int getMinSelectionIndex()`
`int getMaxSelectionIndex()`
`int[] getSelectedIndices()`
`Object getSelectedValue()`
`Object[] getSelectedValues()`
	Get information about the current selection as indicated.

`void setSelectionMode(int)`
`int getSelectionMode()`
	Set or get the selection mode. Acceptable values are: `SINGLE_SELECTION`, `SINGLE_INTERVAL_SELECTION`, or `MULTIPLE_INTERVAL_SELECTION` (the default), which are defined in `ListSelectionModel`.

`void clearSelection()`
`boolean isSelectionEmpty()`
	Set or get whether any items are selected.

`boolean isSelectedIndex(int)`	Determine whether the specified index is selected.

Working with a Scroll Pane

Method	**Purpose**
`void ensureIndexIsVisible(int)`	Scroll so that the specified index is visible within the viewport that this list is in.

`int getFirstVisibleIndex()`
`int getLastVisibleIndex()`
	Get the index of the first or last visible item.

`void setVisibleRowCount(int)`
`int getVisibleRowCount()`
	Set or get how many rows of the list are visible.

Examples that Use Lists

This table shows the examples that use `JList` and where those examples are described.

Example	Where Described	Notes
`SplitPaneDemo`	This section and How to Use Split Panes	Contains a single selection, immutable list.
`ListDemo`	This section	Demonstrates how to add and remove items from a list at runtime.
`ListDialog`	How to Use BoxLayout	Implements a modal dialog with a single selection list.
`ListDataEventDemo`	How to Write a List Data Listener	Demonstrates listening for list data events on a list model.
`ListSelectionDemo`	How to Write a List Selection Listener	Contains a list and a table that share the same selection model. You can dynamically choose the selection mode.
`SharedModelDemo`	Nowhere	Modifies `ListSelectionDemo` so that the list and table share the same data model.
`CustomComboBoxDemo`	Providing a Custom Renderer	Shows how to provide a custom renderer for a combo box. Because lists and combo boxes use the same type of renderer, you can use what you learn there an apply it to lists. In fact, a list and a combo box can share a renderer.

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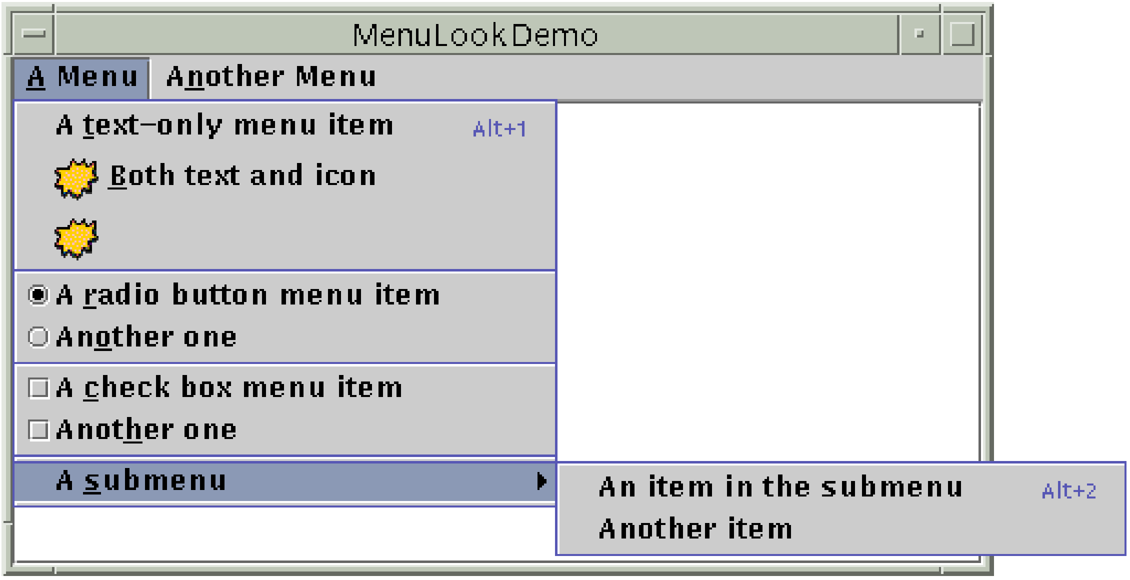
How to Use Menus

A menu provides a space-saving way to let the user choose one of several options. Other components with which the user can make a one-of-many choice include combo boxes, lists, radio buttons, and tool bars. If any of your menu items performs an action that is duplicated by another menu item or by a tool-bar button, then in addition to this section you should read How to Use Actions.

Menus are unique in that, by convention, they aren't placed with the other components in the UI. Instead, a menu usually appears either in a *menu bar* or as a *popup menu*. A menu bar contains one or more menus and has a customary, platform-dependent location -- usually along the top of a window. A popup menu is a menu that is invisible until the user makes a platform-specific mouse action, such as pressing the right mouse button, over a popup-enabled component. The popup menu then appears under the cursor.

The following figure shows the Swing components that implement each part of the menu system.

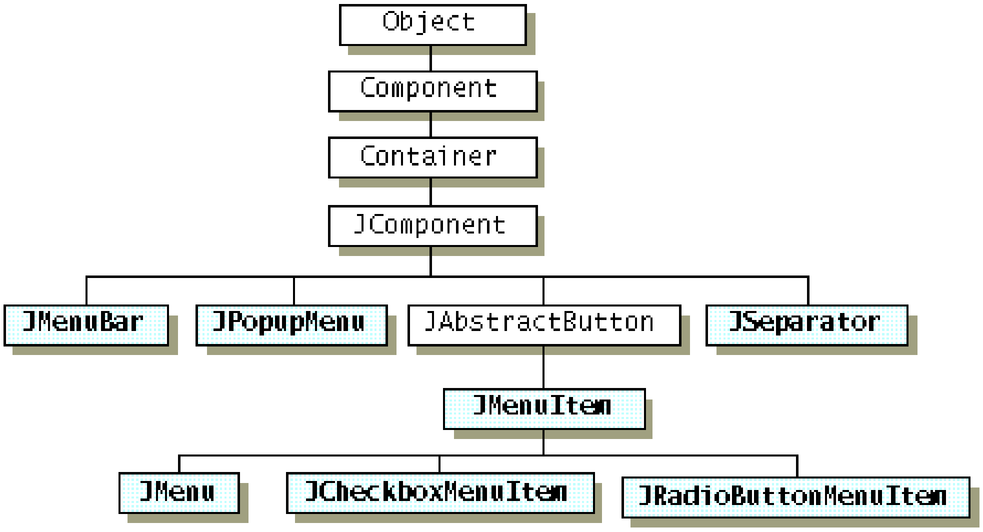


The rest of this section teaches you about the menu components and tells you how to use various menu features:

- The menu component hierarchy
- Creating menus
- Handling events from menu items
- Enabling keyboard operation
- Bringing up a popup menu
- Customizing menu layout
- The Menu API
- Examples that use menus

The Menu Component Hierarchy

Here is a picture of the inheritance hierarchy for the menu-related classes:



As the figure shows, menu items (including menus) are simply buttons. You might be wondering how a menu, if it's only a button, shows its menu items. The answer is that when a menu is activated, it automatically brings up a popup menu that displays the menu items.

Creating Menus

The following code creates the menus shown near the beginning of this menu section. The bold lines of code create and connect the menu objects; the other code sets up or customizes the menu objects. You can find the entire program in `MenuLookDemo.java`. To run the program, you need to have the following image file: `images/middle.gif`.

Note: Because this code has no event handling, the menus do nothing useful except look like they should. If you run the example, you'll notice that despite the lack of custom event handling, menus and submenus appear when they should, and the check boxes and radio buttons respond appropriately when the user chooses them.

```
//in the constructor for a JFrame subclass:
JMenuBar menuBar;
JMenu menu, submenu;
JMenuItem menuItem;
JCheckBoxMenuItem cbMenuItem;
JRadioButtonMenuItem rbMenuItem;
...
//Create the menu bar.
menuBar = new JMenuBar();
setJMenuBar(menuBar);

//Build the first menu.
menu = new JMenu("A Menu");
menu.setMnemonic(KeyEvent.VK_A);
```

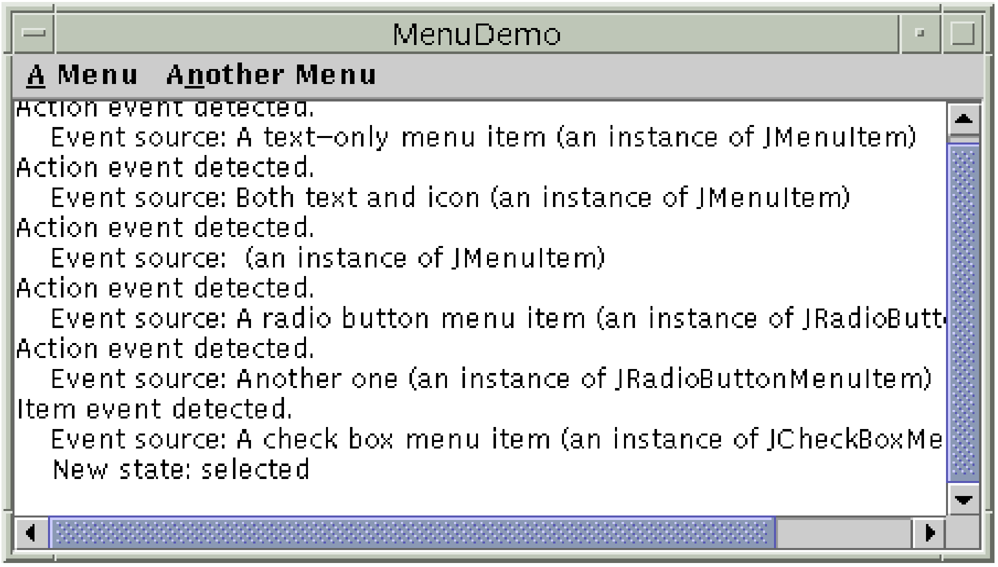
```
        menu.getAccessibleContext().setAccessibleDescription(
                "The only menu in this program that has menu items");
        menuBar.add(menu);

        //a group of JMenuItems
        menuItem = new JMenuItem("A text-only menu item",
                                 KeyEvent.VK_T);
        menuItem.setAccelerator(KeyStroke.getKeyStroke(
                KeyEvent.VK_1, ActionEvent.ALT_MASK));
        menuItem.getAccessibleContext().setAccessibleDescription(
                "This doesn't really do anything");
        menu.add(menuItem);

        menuItem = new JMenuItem("Both text and icon",
                                 new ImageIcon("images/middle.gif"));
        menuItem.setMnemonic(KeyEvent.VK_B);
        menu.add(menuItem);

        menuItem = new JMenuItem(new ImageIcon("images/middle.gif"));
        menuItem.setMnemonic(KeyEvent.VK_D);
        menu.add(menuItem);

        //a group of radio button menu items
        menu.addSeparator();
        ButtonGroup group = new ButtonGroup();
        rbMenuItem = new JRadioButtonMenuItem("A radio button menu item");
        rbMenuItem.setSelected(true);
        rbMenuItem.setMnemonic(KeyEvent.VK_R);
        group.add(rbMenuItem);
        menu.add(rbMenuItem);

        rbMenuItem = new JRadioButtonMenuItem("Another one");
        rbMenuItem.setMnemonic(KeyEvent.VK_O);
        group.add(rbMenuItem);
        menu.add(rbMenuItem);

        //a group of check box menu items
        menu.addSeparator();
        cbMenuItem = new JCheckBoxMenuItem("A check box menu item");
        cbMenuItem.setMnemonic(KeyEvent.VK_C);
        menu.add(cbMenuItem);

        cbMenuItem = new JCheckBoxMenuItem("Another one");
        cbMenuItem.setMnemonic(KeyEvent.VK_H);
        menu.add(cbMenuItem);

        //a submenu
        menu.addSeparator();
        submenu = new JMenu("A submenu");
        submenu.setMnemonic(KeyEvent.VK_S);

        menuItem = new JMenuItem("An item in the submenu");
        menuItem.setAccelerator(KeyStroke.getKeyStroke(
                KeyEvent.VK_2, ActionEvent.ALT_MASK));
        submenu.add(menuItem);

        menuItem = new JMenuItem("Another item");
        submenu.add(menuItem);
        menu.add(submenu);

        //Build second menu in the menu bar.
        menu = new JMenu("Another Menu");
        menu.setMnemonic(KeyEvent.VK_N);
        menu.getAccessibleContext().setAccessibleDescription(
                "This menu does nothing");
        menuBar.add(menu);
```

As the code shows, to set the menu bar for a `JFrame`, you use the `setJMenuBar` method. To add a `JMenu` to a `JMenuBar`, you use the `add(JMenu)` method. To add menu items and submenus to a `JMenu`, you use the `add(JMenuItem)` method. Other methods in the preceding code include `setAccelerator` and `setMnemonic`, which are discussed in Enabling Keyboard Operation. The `setAccessibleDescription` method is discussed in How to Support Assistive Technologies◆.

Handling Events from Menu Items

To detect when the user selects a `JMenuItem`, you can listen for action events (just as you would for a `JButton`). To detect when the user selects a `JRadioButtonMenuItem`, you can listen for either action events or item events, as described in How to Use Radio Buttons. For `JCheckBoxMenuItem`s, you generally listen for item events, as described in How to Use Check Boxes.

The following picture shows a program that adds event detection to the preceding example. The program's code is in `MenuDemo.java`◆. Like `MenuLookDemo`, `MenuDemo` uses the `images/middle.gif` image file.



```
Action event detected.
   Event source: A text-only menu item (an instance of JMenuItem)
Action event detected.
   Event source: Both text and icon (an instance of JMenuItem)
Action event detected.
   Event source:  (an instance of JMenuItem)
Action event detected.
   Event source: A radio button menu item (an instance of JRadioButt
Action event detected.
   Event source: Another one (an instance of JRadioButtonMenuItem)
Item event detected.
   Event source: A check box menu item (an instance of JCheckBoxMe
   New state: selected
```

Here is the code that implements the event handling:

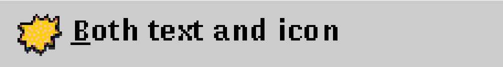
```
public class MenuDemo ... implements ActionListener,
                                     ItemListener {
    ...
    public MenuDemo() {
        //...for each JMenuItem instance:
        menuItem.addActionListener(this);
        ...
        //for each JRadioButtonMenuItem:
        rbMenuItem.addActionListener(this);
        ...
        //for each JCheckBoxMenuItem:
        cbMenuItem.addItemListener(this);
        ...
    }

    public void actionPerformed(ActionEvent e) {
        //...Get information from the action event...
        //...Display it in the text area...
    }

    public void itemStateChanged(ItemEvent e) {
        //...Get information from the item event...
        //...Display it in the text area...
    }
```

For examples of handling action and item events, see the button, radio button, and check box sections, as well as the list of examples at the end of this section.

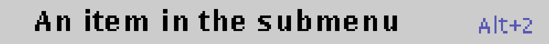
Enabling Keyboard Operation

Menus support two kinds of keyboard alternatives: mnemonics and accelerators. *Mnemonics* offer a way to use the keyboard to navigate the menu hierarchy, increasing the accessibility of programs. *Accelerators*, on the other hand, offer keyboard shortcuts to *bypass* navigating the menu hierarchy. Mnemonics are for all users; accelerators are for power users.

A mnemonic is a key that makes an already visible menu item be chosen. For example, in `MenuDemo` the first menu has the mnemonic A, and its second menu item has the mnemonic B. This means that, when you run `MenuDemo` with the Java Look & Feel, pressing the Alt and A keys makes the first menu appear. While the first menu is visible, pressing the B key (with or without Alt) makes the second menu item be chosen. A menu item generally displays its mnemonic by underlining the first occurrence of the mnemonic character in the menu item's text, as the following snapshot shows.



An accelerator is a key combination that causes a menu item to be chosen, whether or not it's visible. For example, pressing the Alt and 2 keys in `MenuDemo` makes the first item in the first menu's submenu be chosen, without bringing up any menus. Only leaf menu items -- menus that don't bring up other menus -- can have accelerators. The following snapshot shows how the Java Look & Feel displays a menu item that has an accelerator.



You can specify a mnemonic either when constructing the menu item or with the `setMnemonic` method. To specify an accelerator, use the `setAccelerator` method. Here are examples of setting mnemonics and accelerators:

```
//Setting the mnemonic when constructing a menu item:
menuItem = new JMenuItem("A text-only menu item",
                         KeyEvent.VK_T);

//Setting the mnemonic after creation time:
menuItem.setMnemonic(KeyEvent.VK_T);

//Setting the accelerator:
menuItem.setAccelerator(KeyStroke.getKeyStroke(
        KeyEvent.VK_T, ActionEvent.ALT_MASK));
```

As you can see, you set a mnemonic by specifying the `KeyEvent` constant corresponding to the key the user should press. To specify an accelerator you must use a `KeyStroke` object, which combines a key (specified by a `KeyEvent` constant) and a modifier-key mask (specified by an `ActionEvent` constant).

Bringing Up a Popup Menu

To bring up a popup menu (`JPopupMenu`), you must register a mouse listener on each component that the popup menu should be associated with. The mouse listener must detect user requests that the popup menu be brought up. On Windows and Motif platforms, the user brings up a popup menu by pressing the right mouse button while the cursor is over a component that is popup-enabled.

The mouse listener brings up the popup menu by invoking the `show` method on the appropriate `JPopupMenu` instance. The following code, taken from `PopupMenuDemo.java`, shows how to create and show popup menus:

```
//...where instance variables are declared:
JPopupMenu popup;

    //...where the GUI is constructed:
    //Create the popup menu.
    popup = new JPopupMenu();
    menuItem = new JMenuItem("A popup menu item");
    menuItem.addActionListener(this);
    popup.add(menuItem);
    menuItem = new JMenuItem("Another popup menu item");
    menuItem.addActionListener(this);
    popup.add(menuItem);

    //Add listener to components that can bring up popup menus.
    MouseListener popupListener = new PopupListener();
    output.addMouseListener(popupListener);
    menuBar.addMouseListener(popupListener);
...
class PopupListener extends MouseAdapter {
    public void mousePressed(MouseEvent e) {
        maybeShowPopup(e);
    }

    public void mouseReleased(MouseEvent e) {
```

```
                maybeShowPopup(e);
            }

            private void maybeShowPopup(MouseEvent e) {
                if (e.isPopupTrigger()) {
                    popup.show(e.getComponent(),
                               e.getX(), e.getY());
                }
            }
        }
```

Popup menus have a few interesting implementation details. One is that every menu has an associated popup menu. When the menu is activated, it uses its associated popup menu to show its menu items.

Another detail is that a popup menu itself uses another component to implement the window containing the menu items. Depending on the circumstances under which the popup menu is displayed, the popup menu might implement its "window" using a lightweight component (such as a `JPanel`), a "mediumweight" component (such as a `Panel`), or a heavyweight window (something that inherits from `Window`).

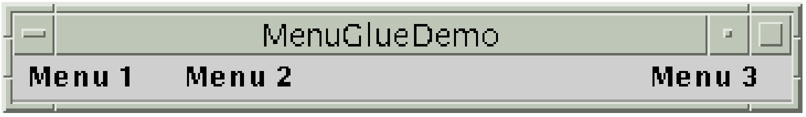
Lightweight popup windows are more efficient than heavyweight windows, but they don't work well if you have any heavyweight components inside your GUI. Specifically, when the lightweight popup's display area intersects the heavyweight component's display area, the heavyweight component is drawn on top. This is one of the reasons we recommend against mixing heavyweight and lightweight components. If you absolutely need to use a heavyweight component in your GUI, then you can invoke `JPopupMenu.setLightWeightPopupEnabled(false)` to disable lightweight popup windows. For details, see Mixing Heavy and Light Components, an article in The Swing Connection.

Customizing Menu Layout

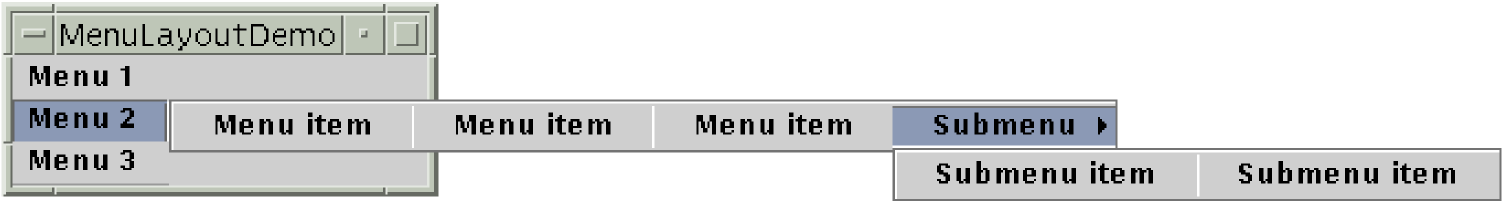
Because menus are made up of ordinary Swing components, you can easily customize them. For example, you can add any lightweight component to a `JMenu` or `JMenuBar`. And because `JMenuBar` uses `BoxLayout`, you can customize a menu bar's layout just by adding invisible components to it. Here is an example of adding a glue component to a menu bar, so that the last menu is at the right edge of the menu bar:

```
//...create and add some menus...
menuBar.add(Box.createHorizontalGlue());
//...create the rightmost menu...
menuBar.add(rightMenu);
```

Here is a picture of the result, which you can duplicate by compiling and running `MenuGlueDemo.java`:



Another way of changing the look of menus is to change the layout managers used to control them. For example, you can change a menu bar's layout manager from the default left-to-right `BoxLayout` to something such as `GridLayout`. You can also change how an activated menu or other popup menu lays out its items, as `MenuLayoutDemo.java` demonstrates. Here's a picture of the menu layout that `MenuLayoutDemo` creates:



The Menu API

The following tables list the commonly used menu constructors and methods. The API for using menus falls into these categories:

- Creating and Setting Up Menu Bars
- Creating and Populating Menus
- Creating, Populating, and Controlling Popup Menus
- Implementing Menu Items

Creating and Setting Up Menu Bars

Constructor or Method	Purpose
`JMenuBar()`	Creates a menu bar.
`JMenu add(JMenu)`	Creates a menu bar.

`void setJMenuBar(JMenuBar)`
`JMenuBar getJMenuBar()`
(in `JApplet`, `JDialog`, `JFrame`, `JInternalFrame`, `JRootPane`)
	Sets or gets the menu bar of an applet, dialog, frame, internal frame, or root pane.

Creating and Populating Menus

Constructor or Method	Purpose

`JMenu()`
`JMenu(String)`
	Creates a menu. The string specifies the text to display for the menu.

`JMenuItem add(JMenuItem)`
`JMenuItem add(Action)`
`JMenuItem add(String)`
	Adds a menu item to the current end of the menu. If the argument is an `Action` object, then the menu creates a menu item as described in How to Use Actions. If the argument is a string, then the menu automatically creates a `JMenuItem` object that displays the specified text.

`void addSeparator()`	Adds a separator to the current end of the menu.

`JMenuItem insert(JMenuItem, int)`
`JMenuItem insert(Action, int)`
`void insert(String, int)`
`void insertSeparator(int)`
	Inserts a menu item or separator into the menu at the specified position. The first menu item is at position 0, the second at position 1, and so on. The `JMenuItem`, `Action`, and `String` arguments are treated the same as in the corresponding `add` methods.

`void remove(JMenuItem)`
`void remove(int)`
`void removeAll()`
	Removes the specified item(s) from the menu. If the argument is an integer, then it specifies the position of the menu item to be removed.

Creating, Populating, and Controlling Popup Menus

Constructor or Method	Purpose

`JPopupMenu()`
`JPopupMenu(String)`
	Creates a popup menu. The optional string argument specifies the title that a look and feel might display as part of the popup window.

`JMenuItem add(JMenuItem)`
`JMenuItem add(Action)`
`JMenuItem add(String)`
	Adds a menu item to the current end of the popup menu. If the argument is an `Action` object, then the popup menu creates a menu item as described in How to Use Actions. If the argument is a string, then the menu automatically creates a `JMenuItem` object that displays the specified text.

`void addSeparator()`	Adds a separator to the current end of the popup menu.
`void insert(Component, int)`	Inserts a menu item into the menu at the specified position. The first menu item is at position 0, the second at position 1, and so on. The `Component` argument specifies the menu item to add.

`void remove(JMenuItem)`
`void remove(int)`
`void removeAll()`
	Removes the specified item(s) from the menu. If the argument is an integer, then it specifies the position of the menu item to be removed.

`static void setLightWeightPopupEnabled(boolean)`	By default, Swing implements a menu's window using a lightweight component. This can cause problems if you use any heavyweight components in your Swing program, as described in Bringing Up a Popup Menu. (This is one of several reasons to avoid using heavyweight components.) As a workaround, invoke `JPopupMenu.setLightWeightPopupEnabled(false)`.
`void show(Component, int, int)`	Display the popup menu at the specified X,Y position (specified in that order by the integer arguments) in the coordinate system of the specified component.

Implementing Menu Items

Constructor or Method	**Purpose**

`JMenuItem()`
`JMenuItem(String)`
`JMenuItem(Icon)`
`JMenuItem(String, Icon)`
`JMenuItem(String, int)`
	Creates an ordinary menu item. The icon argument, if present, specifies the icon that the menu item should display. Similarly, the string argument specifies the text that the menu item should display. The integer argument specifies the keyboard mnemonic to use. You can specify any of the relevant VK constants defined in the `KeyEvent` class. For example, to specify the A key, use `KeyEvent.VK_A`.

`JCheckBoxMenuItem()`
`JCheckBoxMenuItem(String)`
`JCheckBoxMenuItem(Icon)`
`JCheckBoxMenuItem(String, Icon)`
`JCheckBoxMenuItem(String, boolean)`
`JCheckBoxMenuItem(String, Icon, boolean)`
	Creates a menu item that looks and acts like a check box. The string argument, if any, specifies the text that the menu item should display. If you specify `true` for the boolean argument, then the menu item is initially selected (checked). Otherwise, the menu item is initially unselected.

`JRadioButtonMenuItem()`
`JRadioButtonMenuItem(String)`
`JRadioButtonMenuItem(Icon)`
`JRadioButtonMenuItem(String, Icon)`
`JRadioButtonMenuItem(String, boolean)`
`JRadioButtonMenuItem(Icon, boolean)`
`JRadioButtonMenuItem(String, Icon, boolean)`
	Creates a menu item that looks and acts like a radio button. The string argument, if any, specifies the text that the menu item should display. If you specify `true` for the boolean argument, then the menu item is initially selected. Otherwise, the menu item is initially unselected.

`void setState(boolean)`
`boolean getState()`
(in `JCheckBoxMenuItem`)
	Set or get the selection state of a check box menu item.

`void setEnabled(boolean)`	If the argument is true, enable the menu item. Otherwise, disable the menu item.
`void setMnemonic(int)`	Set the mnemonic that enables keyboard navigation to the menu or menu item. Use one of the VK constants defined in the `KeyEvent` class.
`void setAccelerator(KeyStroke)`	Set the accelerator that activates the menu item.
`void setActionCommand(String)`	Set the name of the action performed by the menu item.

`void addActionListener(ActionListener)`
`void addItemListener(ItemListener)`
	Add an event listener to the menu item. See Handling Events from Menu Items for details.

Many of the preceding methods are inherited from `AbstractButton`. See The Button API for information about other useful methods that `AbstractButton` provides.	

Examples that Use Menus

Menus are used in a few Swing examples.

Example	Where Described	Notes
`MenuLookDemo`	This section (Creating Menus)	A simple example that creates all kinds of menus except popup menus, but doesn't handle events from the menu items.
`MenuDemo`	This section (Handling Events from Menu Items)	Adds event handling to `MenuLookDemo`.
`MenuGlueDemo`	This section (Customizing Menu Layout)	Demonstrates affecting menu layout by adding an invisible components to the menu bar.
`MenuLayoutDemo`	This section (Customizing Menu Layout)	Implements sideways-opening menus arranged in a vertical menu bar.
`ActionDemo`	How to Use Actions	Uses `Action` objects to implement menu items that duplicate functionality provided by tool bar buttons.
`Framework`	--	Brings up multiple identical frames, each with a menu in its menu bar.
`InternalFrameDemo`	How to Use Internal Frames	Uses a menu item to create windows.

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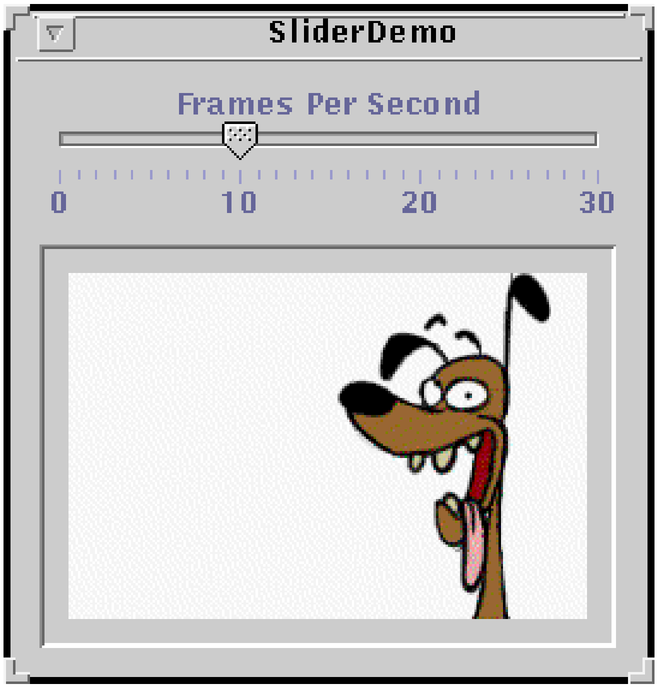
How to Use Sliders

Use a `JSlider` to let the user enter a numeric value bounded by a minimum and maximum value. By using a slider instead of a text field, you eliminate input errors.

Here's a picture of an application that uses a slider to control animation speed:



Try this:

1. Compile and run the application. The source file is `SliderDemo.java`. You will also need the image files that compose the animation. See the examples index for links to all the files required by this example.
   See Getting Started with Swing if you need help compiling or running this application.
2. Use the slider to adjust the animation speed.
3. Push the slider to 0 to stop the animation.

Below is the code from `SliderDemo.java` that creates the slider in the previous example.

```
JSlider framesPerSecond = new JSlider(JSlider.HORIZONTAL,
                                      0, 30, FPS_INIT);
framesPerSecond.addChangeListener(new SliderListener());
framesPerSecond.setMajorTickSpacing(10);
framesPerSecond.setMinorTickSpacing(1);
framesPerSecond.setPaintTicks(true);
framesPerSecond.setPaintLabels(true);
framesPerSecond.setBorder(BorderFactory.createEmptyBorder(0,0,10,0));
. . .
//add the slider to the content pane
contentPane.add(framesPerSecond);
```

By default, spacing for major and minor tick marks is zero. To see tick marks, you must explicitly set the spacing for either major or minor tick marks (or both) to a non-zero value and call `setPaintTicks(true)`. Just calling `setPaintTicks(true)` is not enough. To display standard, numeric labels at major tick mark locations, set the major tick spacing, then call `setPaintLabels(true)`. The example program provides labels for its slider this way. But you don't have to settle for these labels. Customizing Labels on a Slider shows you how to customize slider labels.

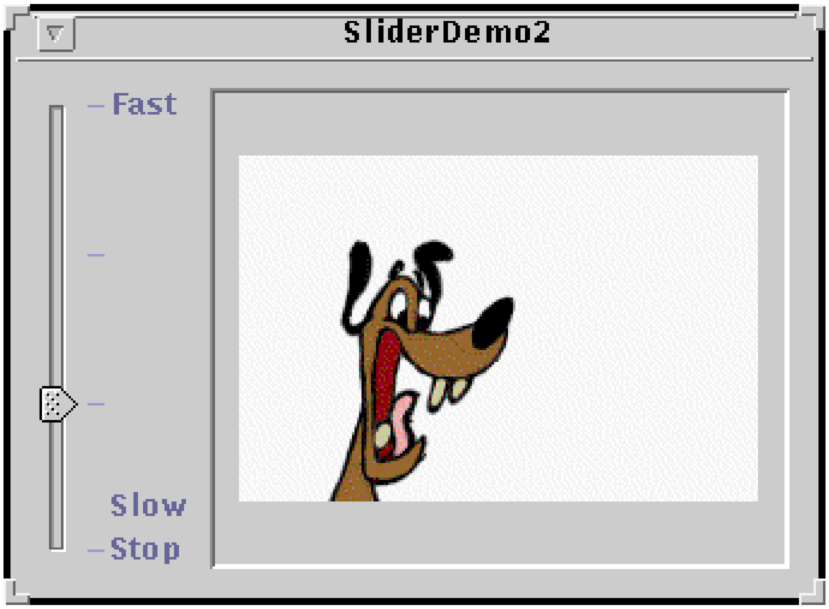
When you move the slider's knob, the `stateChanged` method of the slider's `ChangeListener` is called. For information about change listeners, refer to How to Write a Change Listener. Here is the code for this example's change listener:

```
class SliderListener implements ChangeListener {
    public void stateChanged(ChangeEvent e) {
        JSlider source = (JSlider)e.getSource();
        if (!source.getValueIsAdjusting()) {
            int fps = (int)source.getValue();
            if (fps == 0) {
                if (!frozen) stopAnimation();
            } else {
                delay = 1000 / fps;
                timer.setDelay(delay);
                timer.setInitialDelay(delay * 10);
                if (frozen) startAnimation();
            }
        }
    }
}
```

Notice that our `stateChanged` method changes the animation speed only if `getValueIsAdjusting` returns `false`. Many change events are fired as the user moves the slider knob. This program is interested only in the final result of the user's action.

Customizing Labels on a Slider

Shown below is a modified version of the previous program that uses a slider with custom labels:



You can find the source for this program in `SliderDemo2.java`. As with the other example, you also need the image files that compose the animation. See the examples index for links to all the files required by this example.

The following code creates the slider and customizes its labels:

```
//Create the slider
JSlider framesPerSecond = new JSlider(JSlider.VERTICAL,
                                      0, 30, FPS_INIT);
framesPerSecond.addChangeListener(new SliderListener());
framesPerSecond.setMajorTickSpacing(10);
framesPerSecond.setPaintTicks(true);

//Create the label table
Hashtable labelTable = new Hashtable();
labelTable.put( new Integer( 0 ), new JLabel("Stop") );
labelTable.put( new Integer( 3 ), new JLabel("Slow") );
labelTable.put( new Integer( 30 ), new JLabel("Fast") );
framesPerSecond.setLabelTable( labelTable );

framesPerSecond.setPaintLabels(true);
framesPerSecond.setBorder(BorderFactory.createEmptyBorder(0,0,0,10));
```

Each key-value pair in a `Hashtable` specifies the position and the value of one label. The hashtable key must be an `Integer` and is a value within the slider's range at which to place the label. The hashtable value must be a `Component`. This program uses `JLabel` instances with text only. An interesting variation would be to use `JLabel` instances with icons, or perhaps buttons that move the knob to the label's position.

If you want a set of numeric labels positioned at a specific interval, you can use `JSlider`'s `createStandardLabels` method to create the `Hashtable` for you. You can also modify the table returned by `createStandardLabels` to then customize it.

The Slider API

The following tables list the commonly used `JSlider` constructors and methods. See The JComponent Class for tables of commonly used inherited methods.

The API for using sliders falls into these categories:

- Creating the Slider
- Fine Tuning the Slider's Appearance
- Watching the Slider Operate

Creating the Slider

Constructor	Purpose
`JSlider()`	Creates a horizontal slider with the range 0 to 100 and an initial value of 50.

`JSlider(int min, int max)`
`JSlider(int min, int max, int value)`
	Creates a horizontal slider with the specified minimum and maximum values. The third `int` argument, when present, specifies the slider's initial value.

`JSlider(int orientation)`
`JSlider(int orientation, int min, int max, int value)`
	Creates a slider with the specified orientation, which must be either `JSlider.HORIZONTAL` or `JSlider.VERTICAL`. The last three `int` arguments, when present, specify the slider's minimum, maximum, and initial values, respectively.

`JSlider( BoundedRangeModel◆)`	Creates a horizontal slider with the specified model, which manages the slider's minimum, maximum, and current values and their relationship.

Fine Tuning the Slider's Appearance

Method	Purpose

`void setValue(int)`
`int getValue()`
	Set or get the slider's current value. This method also positions the slider's knob.

`void setOrientation(int)`
`int getOrientation()`
	Set or get the orientation of the slider. Possible values are `JSlider.HORIZONTAL` or `JSlider.VERTICAL`.

`void setInverted(boolean)`
`boolean getInverted()`
	Set or get whether the maximum is shown at the left of a horizontal slider or at the bottom of a vertical one, thereby inverting the slider's range.

`void setMinimum(int)`
`int getMinimum()`
`void setMaximum(int)`
`int getMaximum()`
	Set or get the minimum or maximum values of the slider. Together, these methods set or get the slider's range.

`void setMajorTickSpacing(int)`
`int getMajorTickSpacing()`
`void setMinorTickSpacing(int)`
`int getMinorTickSpacing()`
	Set or get the range between major and minor ticks. You must call `setPaintTicks(true)` for the tick marks to appear.

`void setPaintTicks(boolean)`
`boolean getPaintTicks()`
	Set or get whether tick marks are painted on the slider.

`void setPaintLabels(boolean)`
`boolean getPaintLabels()`
	Set or get whether labels are painted on the slider. You can provide custom labels with `setLabelTable` or get automatic labels by setting the major tick spacing to a non-zero value.

`void setLabelTable(Dictionary)`
`Dictionary getLabelTable()`
	Set or get the labels for the slider. You must call `setPaintLabels(true)` for the labels to appear. `createStandardLabels` is a convenience method for creating a standard set of labels.

`Hashtable createStandardLabels(int)`
`Hashtable createStandardLabels(int, int)`
	Create a standard set of numeric labels. The first `int` argument specifies the increment, the second `int` argument specifies the starting point. When left unspecified, the slider's minimum is used as the starting point.

Watching the Slider Operate

Method	Purpose
`void addChangeListener(ChangeListener)`	Register a change listener with the slider.
`boolean getValueIsAdjusting()`	Determine whether the user gesture to move the slider's knob is complete.

Examples that Use Sliders

This table shows the examples that use `JSlider` and where those examples are described.

Example	Where Described	Notes
`SliderDemo`	This section	Shows a slider with labels at major tick marks.
`SliderDemo2`	This section	Shows a vertical slider with custom labels.

`Converter` and other files	The Anatomy of a Swing-Based Program	Classes used by the `Converter` example, which features two sliders that share data and have a custom `BoundedRangeModel`.

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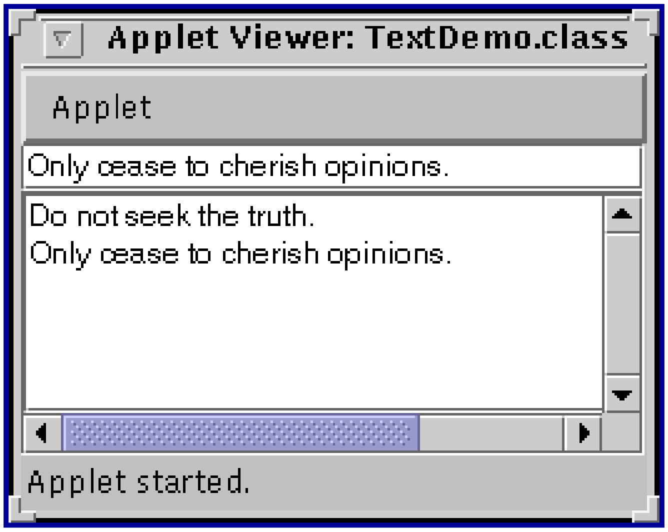
How to Use Text Fields

A text field is a basic text control that lets the user enter a small amount of text. When the user indicates that text entry is complete (usually by pressing Return), the text field fires an action event◆. Generally you use the `JTextField`◆ class to provide text fields. If you need to provide a *password field* -- an editable text field that doesn't show the characters the user types -- use the `JPasswordField` class instead. This section discusses both text fields and password fields.

If you want a text field that also provides a menu of strings to choose from, consider using an editable combo box. If you need to obtain more than one line of input from the user, then you should use one of the classes that implements a general-purpose text area.

The applet below displays a basic text field and a text area. The text field is editable; the text area isn't. When the user presses Return in the text field, the applet copies the text field's contents to the text area, and then selects all the text in the text field.



Only cease to cherish opinions.

Do not seek the truth.
Only cease to cherish opinions.

This is a picture of the applet's GUI. To run the applet, click the picture. The applet will appear in a new browser window.

You can find the source for the program in `TextDemo.java`◆. Here's the code from `TextDemo` that creates the text field in the applet:

```
textField = new JTextField(20);
textField.addActionListener(this);
...
```

```
        contentPane.add(textField);
```

The integer argument passed to the `JTextField` constructor, `20` in the example, indicates the number of columns in the field. This number is used along with metrics provided by the field's current font to calculate the field's preferred width. It does not limit the number of characters the user can enter. To do that, you need to implement a custom document, as described in General Rules for Using Text Components.

The next lines of code register the applet as an action listener for the text field and add the text field to the applet's content pane. Here's the `actionPerformed` method that handles action events from the text field:

```
public void actionPerformed(ActionEvent evt) {
    String text = textField.getText();
    textArea.append(text + newline);
    textField.selectAll();
}
```

Notice the use of `JTextField`'s `getText` method to retrieve the text currently contained by the text field. The text returned by this method does *not* include a newline character for the Return key that fired the action event.

This example illustrates using a basic, off-the-shelf text field for entering textual data and performing a task when the text field fires an action event. This is sufficient for many programs. Other programs, however, need more advanced behavior. As a subclass of `JTextComponent`◆, `JTextField` can be configured and customized. One common customization is to provide a text field whose contents are validated.

This section covers the following advanced text field topics. To get most out of the information, you need to understand the material presented in the previous section, General Rules for Using Text Components.

- Creating a Validated Text Field
- Using a Document Listener on a Text Field
- Laying Out Label-Text Field Pairs
- Providing a Password Field
- The Text Field and Password Field API
- Examples that Use Text Fields and Password Fields

Creating a Validated Text Field

Many programs require users to enter textual data of a certain type or format. For example, a program might provide a text field for entering a date, a decimal number, or a phone number. The contents of such a text field must be validated before being used for any purpose. A text field can be *action*-validated or *change*-validated.

The data in an action-validated field is checked each time the field fires an action event (each time the user presses the Return key). An action-validated field might, at any given point in time, contain invalid data. However, the data is validated before it's used for anything. To create an action-validated field, provide an action listener for your field and implement its `actionPerformed` method as follows:

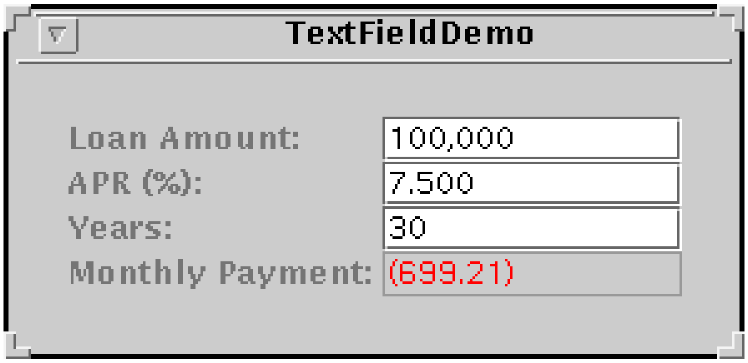
- Use `getText` to get the contents of the text field, or `getPassword` if you're using a password field.
- Evaluate the value returned.
- If the value is valid, do whatever task or calculation is required. If the value is invalid, report an error and return without performing a task or calculation.

`PasswordDemo`, described later in this section, action-validates a password field in this manner.

The data in a change-validated field is checked each time the field changes. A field that is change-validated can never contain invalid data because every change (keystroke, cut, copy, and so on) that might cause the data to be invalid is rejected. To create a change-validated text field you need to provide a custom document for your text field. If you aren't familiar with documents yet, see Concepts: About Documents.

Warning: Do not use a document listener for change validation. By the time a document listener has been notified of a change, it's too late, the change has already taken place. See the last couple of paragraphs in Listening for Changes on a Document for more information.

The application shown in the following figure has three change-validated text fields. The user enters loan information into the first three text fields. Each time the user types a character, the program validates the input and updates the result in the fourth text field.



Loan Amount: 100,000
APR (%): 7.500
Years: 30
Monthly Payment: (699.21)

Try this:

1. Compile and run the application. The source file is `TextFieldDemo.java`. You will also need `WholeNumberField.java`, `DecimalField.java`, and `FormattedDocument.java`.
   See Getting Started with Swing if you need help compiling or running this application.
2. Enter information into the text fields and see the results.
   If you attempt to enter invalid data, the program beeps.
3. Try to type into the fourth text field.
   You can't because it isn't editable. However, you can select the text.
4. Resize the window.
   Note how the labels and text fields remain aligned. Laying Out Label-Text Field Pairs talks more about this feature of the program.

The **Years** field is an instance of `WholeNumberField`, which is a subclass of `JTextField`. By overriding the `createDefaultModel` method, `WholeNumberField` establishes a custom `Document` subclass -- an instance of `WholeNumberDocument` -- as the document for each `WholeNumberField` created:

```
protected Document createDefaultModel() {
    return new WholeNumberDocument();
}
```

Here's the implementation of `WholeNumberDocument`:

```
protected class WholeNumberDocument extends PlainDocument {

    public void insertString(int offs, String str, AttributeSet a)
                    throws BadLocationException {

        char[] source = str.toCharArray();
        char[] result = new char[source.length];
        int j = 0;

        for (int i = 0; i < result.length; i++) {
            if (Character.isDigit(source[i]))
                result[j++] = source[i];
            else {
                toolkit.beep();
                System.err.println("insertString: " + source[i]);
            }
        }
        super.insertString(offs, new String(result, 0, j), a);
    }
}
```

This class overrides the `insertString` method, which is called every time any string or character is about to be inserted into the document. `WholeNumberDocument`'s implementation of `insertString` evaluates each character to be inserted into the text field. If the character is a digit, the document allows it to be inserted. Otherwise, the method beeps and prints an error message. Thus `WholeNumberDocument` allows the numbers in the range 0, 1, 2, ...

An interesting implementation detail is that our custom document class does not have to override the `remove` method. The `remove` method is called each time a character or group of characters is removed from the text field. Because removing a digit from an integer cannot produce an invalid result, this class does not pay attention to removals.

The other two input fields in the example, as well as the uneditable **Monthly Payment** field, are all instances of `DecimalField`, a custom `JTextField` subclass. `DecimalField` uses a custom document, `FormattedDocument`, that allows only data of a particular format to be entered.

`FormattedDocument` has no knowledge of the actual format of its content. Instead, `FormattedDocument` relies on a format, an instance of a subclass of `Format`, to accept or reject a proposed change. The text field that uses the `FormattedDocument` must specify which format the `FormattedDocument` uses.

The **Loan Amount** and **Monthly Payment** text fields use a `NumberFormat` object created like this:

```
moneyFormat = NumberFormat.getNumberInstance();
```

The following code creates the **APR** text field's format:

```
percentFormat = NumberFormat.getNumberInstance();
percentFormat.setMinimumFractionDigits(3);
```

As the code shows, the same class (`NumberFormat`) can support different formats. Furthermore, `Format` and its subclasses are locale-sensitive, so a decimal field can be made to support formats for specific countries and regions. Refer to Formatting in the internationalization trail for detailed information about formats.

Here is `FormattedDocument`'s implementation of `insertString`:

```
public void insertString(int offs, String str, AttributeSet a)
```

```
                        throws BadLocationException {

            String currentText = getText(0, getLength());
            String beforeOffset = currentText.substring(0, offs);
            String afterOffset = currentText.substring(offs,
                                                       currentText.length());
            String proposedResult = beforeOffset + str + afterOffset;

            try {
                format.parseObject(proposedResult);
                super.insertString(offs, str, a);
            } catch (ParseException e) {
                Toolkit.getDefaultToolkit().beep();
                System.err.println("insertString: could not parse: "
                                   + proposedResult);
            }
        }
```

The method uses the format to parse the result of the proposed insertion. If the result is properly formatted, this method calls its superclass's `insert` method to do the insertion. If the result is not properly formatted, the program beeps.

In addition to overriding `insertString`, `FormattedDocument` also overrides the `remove` method. Recall that the `remove` method is called each time a character or group of characters is to be removed from the document.

```
        public void remove(int offs, int len)
            throws BadLocationException
        {
            String currentText = getText(0, getLength());
            String beforeOffset = currentText.substring(0, offs);
            String afterOffset = currentText.substring(len + offs,
                                                       currentText.length());
            String proposedResult = beforeOffset + afterOffset;

            try {
                if (proposedResult.length() != 0)
                    format.parseObject(proposedResult);
                super.remove(offs, len);
            } catch (ParseException e) {
                Toolkit.getDefaultToolkit().beep();
                System.err.println("remove: could not parse: "
                                   + proposedResult);
            }
        }
```

The `FormattedDocument` implementation of the `remove` method is similar to its implementation of the `insertString` method. The format parses the result of the proposed change and performs the removal or not, depending on whether the result is valid.

Note: The solution provided by this example is not a general solution for all types of formats. Some formats -- most notably `DateFormat` -- can't be change-validated simply by calling the `parseObject` method. Here's an example to help you understand why. Suppose you have a text field that contains the date "May 25, 1996" and want to change it to "June 11, 1996". You would select May and begin typing "June". As soon as you've typed the "J", the field won't parse because "J 25, 1996" is not a valid date even though it's a valid change. A number of solutions are possible for dates and other types of data where a partially completed change creates an invalid result. You can change the change-validation such that it rejects all definitely invalid changes (typing "X" into a date for example) but allows all possibly valid changes. Or you can switch to an action-validated field.

Using a Document Listener on a Text Field

If you can't use a document listener for field validation, what can you use it for? Use it to listen to, but not interfere with, changes to the document's content. The loan calculator uses the following document listener to update the monthly payment after every change:

```
class MyDocumentListener implements DocumentListener {
    public void insertUpdate(DocumentEvent e) {
        calculateValue(e);
    }
    public void removeUpdate(DocumentEvent e) {
        calculateValue(e);
    }
    public void changedUpdate(DocumentEvent e) {
        // we won't ever get this with a PlainDocument
    }
    private void calculateValue(DocumentEvent e) {
        Document whatsup = e.getDocument();
        if (whatsup.getProperty("name").equals("amount"))
            amount = amountField.getValue();
        else if (whatsup.getProperty("name").equals("rate"))
            rate = rateField.getValue();
        else if (whatsup.getProperty("name").equals("numPeriods"))
            numPeriods = numPeriodsField.getValue();
        payment = computePayment(amount, rate, numPeriods);
        paymentField.setValue(payment);
    }
}
```

This is an appropriate use of a document listener. For general information about document listeners, see Listening for Changes on a Document and How to Write a Document Listener◆.

Laying Out Label-Text Field Pairs

This section describes how the label and the text fields in the example are aligned and requires some knowledge of layout managers.

Rows of label and text field pairs such as those found in the loan calculator are quite common on preference panels and panels that implement forms. Here's the code that lays out the label and text field pairs.

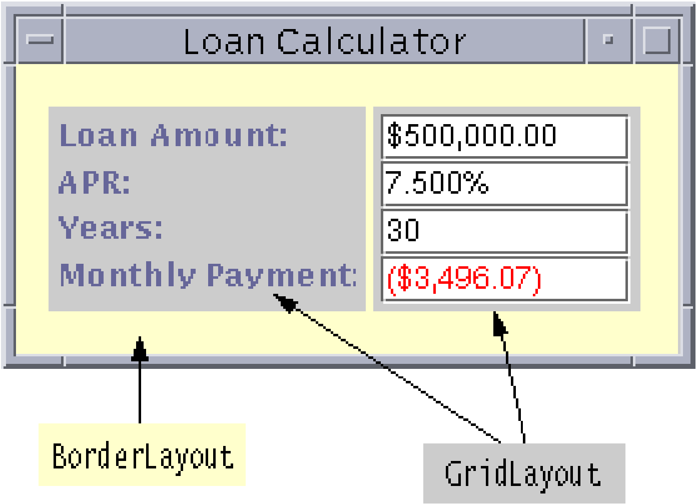
```
. . .
//Layout the labels in a panel
JPanel labelPane = new JPanel();
labelPane.setLayout(new GridLayout(0, 1));
labelPane.add(amountLabel);
labelPane.add(rateLabel);
labelPane.add(numPeriodsLabel);
labelPane.add(paymentLabel);

//Layout the text fields in a panel
JPanel fieldPane = new JPanel();
fieldPane.setLayout(new GridLayout(0, 1));
fieldPane.add(amountField);
fieldPane.add(rateField);
fieldPane.add(numPeriodsField);
fieldPane.add(paymentField);

//Put the panels in another panel, labels on left,
//text fields on right
JPanel contentPane = new JPanel();
contentPane.setBorder(BorderFactory.createEmptyBorder(20, 20,
                                                      20, 20));
contentPane.setLayout(new BorderLayout());
contentPane.add(labelPane, BorderLayout.CENTER);
contentPane.add(fieldPane, BorderLayout.EAST);

setContentPane(contentPane);
. . .
```

You may be surprised to find that the labels are laid out without reference to the text fields and, in fact, are in a different panel, yet align correctly with them. This is a side effect of the layout managers used by the program.



Loan Calculator

Loan Amount: $500,000.00
APR: 7.500%
Years: 30
Monthly Payment: ($3,496.07)

As the diagram illustrates, the program uses two `GridLayout` managers, one to lay out the column of labels and one for the column of text fields. `GridLayout` guarantees that all of its components are the same size, so all of the text fields are the same height and all of the labels are the same height. But the text fields are not the same height as the labels. This is achieved with a third layout manager, a `BorderLayout`. With just two components at East and Center, `BorderLayout` guarantees the columns are the same height. Now the labels and text fields are the same height, and thus, they are aligned.

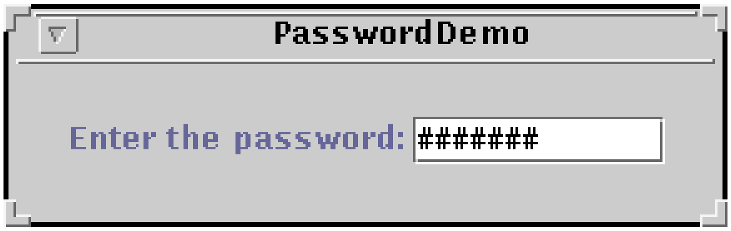
Another way to get labels and text fields to align is to use the AWT's most flexible, complex layout manager: `GridBagLayout`. Refer to the `TextSamplerDemo` program for an example. In particular, look at this handy method, which you can probably copy verbatim into your programs:

```
addLabelTextRows(JLabel[] labels,
                 JTextField[] textFields,
                 GridBagLayout gridbag,
                 Container container)
```

Providing a Password Field

Swing provides the `JPasswordField` class, a subclass of `JTextField`, to use in place of a text field for password entry. For security reasons, a password field doesn't show the characters the user types. Instead the field displays another character such as an asterisk '*'. As another security precaution, the password field stores its value as an array of characters, rather than as a string.

`PasswordDemo` brings up a small window to prompt the user to type in a password:



Here's the code from `PasswordDemo` that creates and sets up the password field.

```
JPasswordField passwordField = new JPasswordField(10);
passwordField.setEchoChar('#');
passwordField.addActionListener(new ActionListener() {
    ...
});
```

As with text fields, the argument passed into the `JPasswordField` constructor indicates that the field should be 10 columns wide. By default a password field displays an asterisk '*' for each character typed. The call to `setEchoChar` changes it to a pound sign '#'. Finally, the code adds an action listener to the password field, which action-validates the value typed in by the user. Here's the implementation of the action listener's `actionPerformed` method:

```
public void actionPerformed(ActionEvent e) {
    JPasswordField input = (JPasswordField)e.getSource();
    char[] password = input.getPassword();
    if (isPasswordCorrect(password)) {
        JOptionPane.showMessageDialog(f,
            "Success! You typed the right password.");
    } else {
        JOptionPane.showMessageDialog(f,
            "Invalid password. Try again.",
            "Error Message",
            JOptionPane.ERROR_MESSAGE);
    }
}
```

The `getPassword` returns a character array. Password information should not be stored or passed around in strings because strings are not secure.

A program using a password field typically validates the password before completing any actions requiring the password. This program calls a private method, `isPasswordCorrect`, that compares the value returned by `getPassword` to a value stored in a character array.

Note: The `getPassword` method did not exist in Swing 1.0.3 and earlier releases. In those releases, you have to use `getText`. In that case, your program should convert the value returned from `getText` to a character array upon return.

You should not store the value in a `String`. In releases that contain the `getPassword` method, `getText` has been deprecated.

The Text Field and Password Field API

The following tables list the commonly used `JTextField` and `JPasswordField` constructors and methods. Other methods you are likely to call are defined in `JTextComponent`. Refer to the API tables in Summary of Text.

You might also invoke methods on a text field or password field that it inherits from its other ancestors, such as `setPreferredSize`, `setForeground`, `setBackground`, `setFont`, and so on. See The JComponent Class for tables of commonly used inherited methods.

The API for using text fields and password fields falls into these categories:

- Setting or Getting the Field's Contents
- Fine Tuning the Field's Appearance
- Implementing the Field's Functionality

Setting or Getting the Field's Contents

Method or Constructor	**Purpose**

`JTextField()`
`JTextField(String)`
`JTextField(String, int)`
`JTextField(int)`
`JTextField(Document, String, int)`
	Create a text field. When present, the `int` argument specifies the desired width in columns. The `String` argument contains the field's initial text. The `Document` argument provides a custom document for the field.

`JPasswordField()`
`JPasswordField(String)`
`JPasswordField(String, int)`
`JPasswordField(int)`
`JPasswordField(Document, String, int)`
	Create a password field. When present, the `int` argument specifies the desired width in columns. The `String` argument contains the field's initial text. The `Document` argument provides a custom document for the field.

`void setText(String)`
`String getText()`
	Set or get the text displayed by the text field. Note that `getText` is deprecated for password fields in Swing 1.0.3 and higher releases.

`char[] getPassword()` *(in `JPasswordField`)*	Set or get the text displayed by the text field. Note that this method does not exist in Swing 1.0.3 and lower releases.

Fine Tuning the Field's Appearance

Method or Constructor	**Purpose**

`void setEditable(boolean)`
`boolean isEditable()`
	Set or get whether the user can edit the text in the text field.

`void setColumns(int);`
`int getColumns()`
	Set or get the number of columns displayed by the text field. This is really just a hint for computing the field's preferred width.

`int getColumnWidth()`	Get the width of the text field's columns. This value is established implicitly by the font.

`void setHorizontalAlignment(int);`
`int getHorizontalAlignment()`
	Set or get how the text is aligned horizontally within its area. You can use `JTextField.LEFT`, `JTextField.CENTER`, and `JTextField.RIGHT` for arguments.

`void setEchoChar(char)`
`char getEchoChar()`
(in `JPasswordField`)
	Set or get the echo character -- the character displayed instead of the actual characters typed by the user.

Implementing the Field's Functionality

Method or Constructor	**Purpose**

`void addActionListener(ActionListener)`
`void removeActionListener(ActionListener)`
	Add or remove an action listener.

`Document createDefaultModel()`	Override this method to provide a subclass with a custom document.

Examples that Use Text Fields and Password Fields

This table shows the examples that use `JTextField` or `JPasswordField` and where those examples are described.

Example	**Where Described**	**Notes**
`TextDemo`	This section	An applet that uses a basic text field with an action listener.
`TextFieldDemo`	This section	Uses and provides implementations for two different types of change-validated fields.
`PasswordDemo`	This section	Uses an action-validated password field.
`ControlPane`◆, `Utilities`◆	Let's Play!◆	Uses a grid bag layout to align labels with text fields. See the `addParameterRow` method in `Utilities`◆. Part of the BINGO player application.

`CustomDialog.java`	How to Make Dialogs	Includes a text field whose value is checked. Part of `DialogDemo` (under the More Dialogs tab).

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Trail: Creating a GUI with JFC/Swing
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How to Monitor Progress

Sometimes a task running within a program might take a while to complete. A user-friendly program provides some indication to the user about how long the task might take and how much work has already been done. Swing provides three classes to help you create GUIs that monitor and display the progress of a long-running task:

`JProgressBar`◆
: A visible component to graphically display how much of a total task has completed. See How to Use Progress Bars for information and an example of using a progress bar.

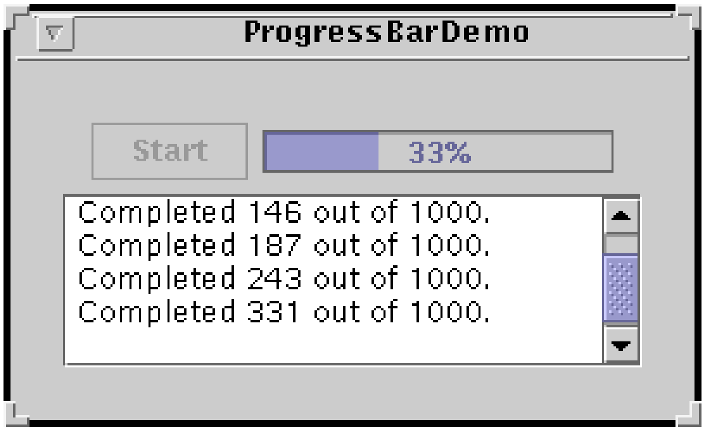
`ProgressMonitor`◆
: *Not* a visible component. Instead, an instance of this class monitors the progress of a task and pops up a dialog if necessary. See How to Use Progress Monitors for details and an example of using a progress monitor.

`ProgressMonitorInputStream`◆
: An input stream with an attached progress monitor, which monitors reading from the stream. You use an instance of this stream like any of the other input streams described in I/O: Reading and Writing (but no 'rithmetic)◆. You can get the stream's progress monitor with a call to `getProgressMonitor` and configure it as described in How to Use Progress Monitors.

After you see a progress bar and a progress monitor in action, Deciding Whether to Use a Progress Bar or a Progress Monitor can help you figure out which is appropriate for your application.

How to Use Progress Bars

Here's a picture of a small demo application that uses a progress bar to measure the progress of a task that runs in its own thread:



```
Completed 146 out of 1000.
Completed 187 out of 1000.
Completed 243 out of 1000.
Completed 331 out of 1000.
```

Try this:

1. Compile and run the application. The main source file is `ProgressBarDemo.java`. You will also need `LongTask.java` and `SwingWorker.java`.
   See Getting Started with Swing if you need help compiling or running this application.

2. Push the **Start** button. Watch the progress bar as the task makes progress. The task displays its output in the text area at the bottom of the window.

Below is the code from `ProgressBarDemo.java` that creates and sets up the progress bar:

```
//Where member variables are declared:
JProgressBar progressBar;
    //...in the constructor for the demo's frame:
    progressBar = new JProgressBar(0, task.getLengthOfTask());
    progressBar.setValue(0);
    progressBar.setStringPainted(true);
```

The constructor that creates the progress bar sets the progress bar's minimum and maximum values. You can also set these values with `setMinimum` and `setMaximum`. The minimum and maximum values used in this program are 0 and the length of the task, which is typical of many programs and tasks. However, a progress bar's minimum and maximum values can be any value, even negative. The code snippet also sets the progress bar's current value to 0.

The call to `setStringPainted` causes the progress bar to display, within its bounds, a textual indication of the percentage of the task that has completed. By default, the progress bar displays the value returned by its `getPercentComplete` method formatted as a percent, such as **33%**. Alternatively, you can replace the default with a different string by calling `setString`. For example,

```
if (/*...half way done...*/)
    progressBar.setString("Half way there!");
```

You start this example's task by clicking the **Start** button. Once the task has begun, a timer (an instance of the `Timer` class) fires an action event every second. Here's the `ActionPerformed` method of the timer's action listener:

```
public void actionPerformed(ActionEvent evt) {
    progressBar.setValue(task.getCurrent());
    taskOutput.append(task.getMessage() + newline);
    taskOutput.setCaretPosition(taskOutput.getDocument().getLength());
    if (task.done()) {
```

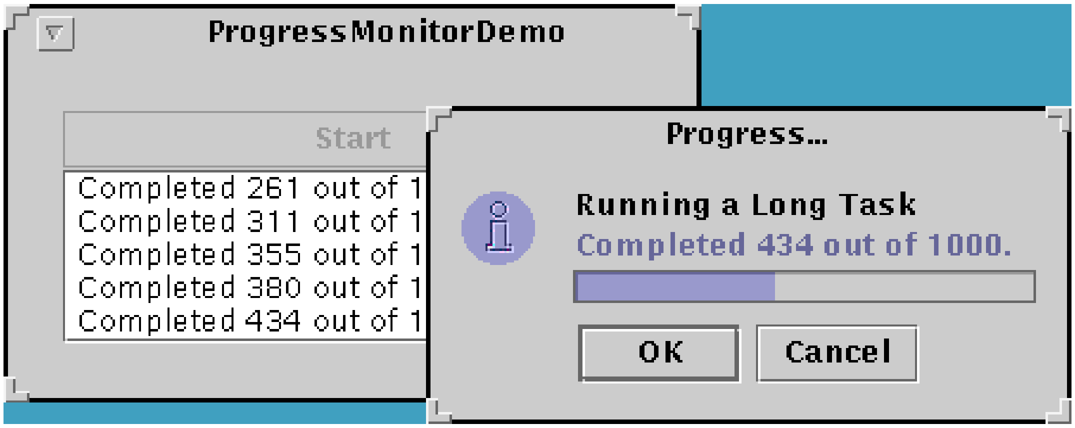
```
                Toolkit.getDefaultToolkit().beep();
                timer.stop();
                startButton.setEnabled(true);
                progressBar.setValue(progressBar.getMinimum());
            }
        }
```

The bold line of code gets the amount of work completed by the task and updates the progress bar with that value. So this example's progress bar measures the progress made by the task each second, *not* the elapsed time. The rest of the code appends a message to the output log (a text area named `taskOutput`) and, if the task is done, turns the timer off and resets the other controls.

As mentioned, the long-running task in this program runs in a separate thread. Generally, it's a good idea to isolate a potentially long-running task in its own thread so that the task doesn't block the rest of the program. The long-running task is implemented by `LongTask.java`, which uses a `SwingWorker` to ensure that the thread runs safely. See Using the SwingWorker Class in Threads and Swing for information about the `SwingWorker` class.

How to Use Progress Monitors

Now let's rewrite the previous example to use a progress monitor instead of a progress bar. Here's a picture of the new demo program, `ProgressMonitorDemo.java`:



```
Completed 261 out of 1
Completed 311 out of 1
Completed 355 out of 1
Completed 380 out of 1
Completed 434 out of 1
```

Running a Long Task
Completed 434 out of 1000.

Try this:

1. Compile and run the application. The main source file is `ProgressMonitorDemo.java`. You will also need `LongTask.java` and `SwingWorker.java`.
   See Getting Started with Swing if you need help compiling or running this application.
2. Push the **Start** button. After a certain amount of time, the program displays a progress dialog.
3. Click the **OK** button. Note that the task continues even though the dialog is gone.
4. Start another task. After the dialog pops up, click the **Cancel** button. The dialog

goes away and the task stops.

A progress monitor cannot be used again, so a new one must be created each time a new task is started. This program creates a progress monitor each time the user starts a new task with the **Start** button.

Here's the statement that creates the progress monitor:

```
progressMonitor = new ProgressMonitor(ProgressMonitorDemo.this,
                                      "Running a Long Task",
                                      "", 0, task.getLengthOfTask());
```

This code uses `ProgressMonitor`'s only constructor to create the monitor and initialize several arguments:

- The first argument provides the parent component to the dialog popped up by the progress monitor.
- The second argument is a string that describes the nature of the task being monitored. This string is displayed on the dialog. see The Progress Monitoring API for details about this argument.
- The third argument is another string that provides a changeable status note. The example uses an empty string to indicate that the dialog should make space for a changeable status note, but that the note is initially empty. If you provide `null` for this argument, the note is omitted from the dialog. The example updates the note each time the timer fires an action event. It updates the monitor's current value at the same time:

  ```
  progressMonitor.setNote(task.getMessage());
  progressMonitor.setProgress(task.getCurrent());
  ```

- The last two arguments provide the minimum and maximum values, respectively, for the progress bar displayed in the dialog.

After the example creates the progress monitor, it configures the monitor further:

```
progressMonitor.setProgress(0);
progressMonitor.setMillisToDecideToPopup(2 * ONE_SECOND);
```

The first line sets the current position of the progress bar on the dialog. The second tells the progress monitor to wait two seconds before deciding whether to bring up a dialog. If, after two seconds, the progress monitor's progress is less than its maximum, the monitor will bring up the dialog.

By the simple fact that this example uses a progress monitor, it adds a feature that wasn't present in the version of the program that uses a progress bar. The user can cancel the task by clicking the **Cancel** button on the dialog. Here's the code in the example that checks to see if the user canceled the task or if the task exited normally:

```
if (progressMonitor.isCanceled() || task.done()) {
```

```
            progressMonitor.close();
            task.stop();
            Toolkit.getDefaultToolkit().beep();
            timer.stop();
            startButton.setEnabled(true);
        }
```

Note that the progress monitor doesn't itself cancel the task. It provides the GUI and API to allow the program to do so easily.

Deciding Whether to Use a Progress Bar or a Progress Monitor

Use a *progress bar* if:

- You want more control over the configuration of the progress bar. If you are working directly with a progress bar, you can make it display vertically, you can provide a string for it to display, you can register change listeners on it, and you can provide it with a bounded range model to control the progress bar's minimum, maximum, and current values.
- The program needs to display other components along with the progress bar.
- You need more than one progress bar. With some tasks, you need to monitor more than one parameter. For example, an installation program might monitor disk space usage in addition to how many files have been successfully installed.
- You need to reuse the progress bar. A progress bar can be reused; a progress monitor cannot. Once the progress monitor has decided to display a dialog (or not), the progress monitor cannot do it again.

Use a *progress monitor* if:

- You want an easy way to display progress in a dialog.
- The running task is secondary and the user might not be interested in the progress of the task. Progress monitor provides a way for the user to dismiss the dialog while the task is still running.
- The task can be cancelled. Progress monitor provides a GUI for the user to cancel the task. All you have to do is call progress monitor's `isCanceled` method to find out if the user pressed the **Cancel** button.
- Your task displays a short message periodically while running. The progress monitor dialog provides the `setNote` method so that the task can provide further information about what it's doing. For example, an installation task might report the name of each file as it's installed.
- The task might not take a long time to complete. You decide at what point a running task is taking long enough to warrant letting the user know about it. Progress monitor won't pop up a dialog if the task completes within the timeframe you set.

If you decide to use a progress monitor *and* the task you are monitoring is reading from an input stream, use the `ProgressMonitorInputStream` class.

The Progress Monitoring API

The following tables list the commonly used API for using progress bars and progress monitors.

Because `JProgressBar` is a subclass of `JComponent`, other methods you are likely to call on a `JProgressBar` are listed in The JComponent Class. Note that `ProgressMonitor` is a subclass of `Object` and is not a visual component.

The API for monitoring progress falls into these categories:

- Creating the Progress Bar
- Setting or Getting the Progress Bar's Constraints/Values
- Fine Tuning the Progress Bar's Appearance
- Creating the Progress Monitor
- Configuring the Progress Monitor
- Terminating the Progress Monitor

Creating the Progress Bar

Constructor	**Purpose**

`JProgressBar()`
`JProgressBar(int min, int max)`
	Create a horizontal progress bar. The default constructor initializes the progress bar with a minimum and initial value of 0 and a maximum of 100. Use the *`min`* and *`max`* arguments to specify other values.

`JProgressBar(int orientation)`
`JProgressBar(int orientation, int min, int max)`
	Create a progress bar with the specified orientation, which can be either `JProgressBar.HORIZONTAL` or `JProgressBar.VERTICAL`. Use the *`min`* and *`max`* arguments to specify minimum and maximum values.

`JProgressBar(BoundedRangeModel)`	Create a horizontal progress bar with the specified range model.

Setting or Getting the Progress Bar's Constraints/Values

Method or Constructor	**Purpose**

`void setValue(int)`
`int getValue()`
	Set or get the current value of the progress bar. The value is constrained by the minimum and maximum values.

`double getPercentComplete()`	Get the percent complete for the progress bar.

`void setMinimum(int)`
`int getMinimum()`
	Set or get the minimum value of the progress bar.

`void setMaximum(int)`
`int getMaximum()`
	Set or get the maximum value of the progress bar.

`void setModel(BoundedRangeModel)`
`BoundedRangeModel getMaximum()`
	Set or get the model used by the progress bar. The model establishes the progress bar's constraints and values. So you can use this method as an alternative to using the individual set/get methods listed above.

Fine Tuning the Progress Bar's Appearance

Method	Purpose

`void setOrientation(int)`
`int getOrientation()`
	Set or get whether the progress bar is vertical or horizontal. Acceptable values are `JProgressBar.VERTICAL` or `JProgressBar.HORIZONTAL`.

`void setBorderPainted(boolean)`
`boolean isBorderPainted()`
	Set or get whether the progress bar has a border.

`void setStringPainted(boolean)`
`boolean isStringPainted()`
	Set or get whether the progress bar displays a percent string. By default, the value of the percent string is the value returned by `getPercentComplete` formatted as a percent. You can set the string to be displayed with `setString`.

`void setString(String)`
`String getString()`
	Set or get the percent string.

Creating the Progress Monitor

Method or Constructor	Purpose
`ProgressMonitor(Component, Object, String, int, int)`	Create a progress monitor. The `Component` argument is the parent for the monitor's dialog. The `Object` argument is a message to put on the option pane within the dialog. The value of this object is typically a `String`. The `String` argument is a changeable status note. The final two `int` arguments set the minimum and maximum values, respectively, for the progress bar used in the dialog.
`ProgressMonitor getProgressMonitor()` *(in `ProgressMonitorInputStream`)*	Gets a progress monitor that monitors reading from an input stream.

Configuring the Progress Monitor

Method	Purpose

`void setMinimum(int)`
`int getMinimum()`
	Set or get the minimum value of the progress monitor. This value is used by the monitor to set up the progress bar in the dialog.

`void setMaximum(int)`
`int getMaximum()`
	Set or get the maximum value of the progress monitor. This value is used by the monitor to set up the progress bar in the dialog.

`void setProgress(int)`	Update the monitor's progress.

`void setNote(String)`
`String getNote()`
	Set or get the status note. This note is displayed on the dialog. To omit the status note from the dialog, provide `null` as the third argument to the monitor's constructor.

`void setMillisToDecideToPopup(int)`
`int getMillisToDecideToPopup()`
	Set or get the time after which the monitor should decide whether to popup a dialog.

Terminating the Progress Monitor

Method	**Purpose**
`close()`	Close the progress monitor. This disposes of the dialog.
`boolean isCanceled()`	Determine whether the user pressed the **Cancel** button.

Examples that Monitor Progress

This table shows the examples that use `JProgressBar`, `ProgressMonitor`, or `ProgressMonitorInputStream`, and where those examples are described.

Example	**Where Described**	**Notes**
`ProgressBarDemo`	This section and How to Use Timers	Uses a basic progress bar to show progress on a task running in a separate thread.
`ProgressMonitorDemo`	This section	Modification of the previous example that uses a progress monitor instead of a progress bar.

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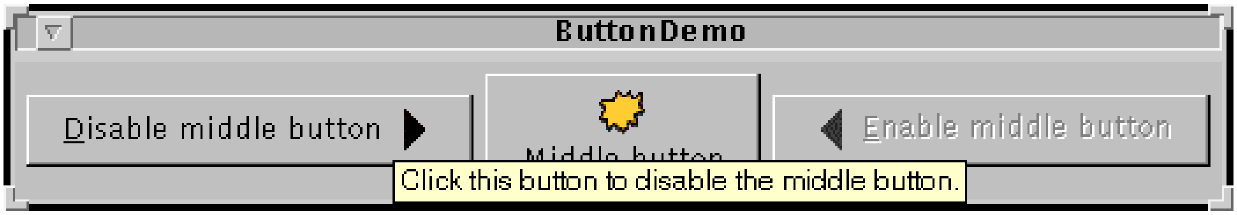
How to Use Tool Tips

Creating a tool tip for any `JComponent` is easy. You just use the `setToolTipText` method to set up a tool tip for the component. For example, to add tool tips to three buttons, you add only three lines of code:

```
b1.setToolTipText("Click this button to disable the middle button.");
b2.setToolTipText("This middle button does nothing when you click it.");
b3.setToolTipText("Click this button to enable the middle button.");
```

When the user of the program pauses with the cursor over any of the program's buttons, the tool tip for the button comes up. You can see this by running the `ButtonDemo` example, which is explained in How to Use Buttons, Check Boxes, and Radio Buttons. Here's a picture of the tool tip that appears when the cursor pauses over the left button in `ButtonDemo`:



[Please imagine a cursor over the left button. Thank you.]

For components such as tabbed panes that have multiple parts, it often makes sense to vary the tool-tip text to reflect the part of the component under the cursor. For example, a tabbed pane might use this feature to explain what will happen when you click the tab under the cursor. When you implement a tabbed pane, you specify the tab-specific tool-tip text in an argument to the `addTab` method.

Even in components that have no API for setting part-specific tool-tip text, you can generally do the job yourself. If the component supports renderers, then you can set the tool tip text on a custom renderer. An alternative that works for all `JComponent`s is creating a subclass of the component and overriding its `getToolTipText(MouseEvent)` method.

The Tool Tip API

Most of the API you need to set up tool tips is in the `JComponent` class, and thus is inherited by most Swing components. More tool-tip API is in individual classes such as `JTabbedPane`. In general, those APIs are sufficient for specifying and displaying tool tips; you usually don't need to deal directly with the implementing classes, `JToolTip`◆ and `ToolTipManager`◆.

The following table lists the `JComponent` tool tip API. For information on individual components' support for tool tips, see the how-to section for the component in question.

Tool Tip API in `JComponent`

Method	Purpose
`setToolTipText(String)` (in `JComponent`)	If the specified string is non-null, then this method registers the component as having a tool tip and makes the tool tip (when displayed) have the specified text. If the argument is null, then this method turns off tool tips for this component.
`String getToolTipText()` (in `JComponent`)	Returns the string that was previously specified with `setToolTipText`.
`String getToolTipText(MouseEvent)` (in `JComponent`)	By default, returns the same value returned by `getToolTipText()`. Multi-part components such as `JTabbedPane`, `JTable`, and `JTree` override this method to return a string associated with the mouse event location. For example, each tab in a tabbed pane can have different tool-tip text.
`Point getToolTipLocation(MouseEvent)` (in `JComponent`)	Get the location (in the receiving component's coordinate system) where the upper left corner of the component's tool tip will appear. The argument is the event that caused the tool tip to be shown. The default return value is null, which tells the Swing system to choose a location.

Examples that Use Tool Tips

This table shows some examples that use tool tips and where those examples are described.

Example	Where Described	Notes
`ButtonDemo`	This section and How to Use Buttons, Check Boxes, and Radio Buttons	Uses a tool tip to provide instructions for a button.
`IconDemoApplet`	How to Use Icons	Uses a tool tip in a label to provide name and size information for an image.
`TabbedPaneDemo`	How to Use Tabbed Panes	Uses an argument to the `addTab` method to specify tool tip text for each tab.
`TableRenderDemo`	Further Customizing Table Display and Event Handling	Adds tool tips to a table using custom renderers and editors.
`TreeIconDemo2`	Customizing a Tree's Display	Adds tool tips to a tree using a custom renderer.
`ActionDemo`	How to Use Actions	Adds tool tips to buttons created using `Action`s.

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Trail: Creating a GUI with JFC/Swing
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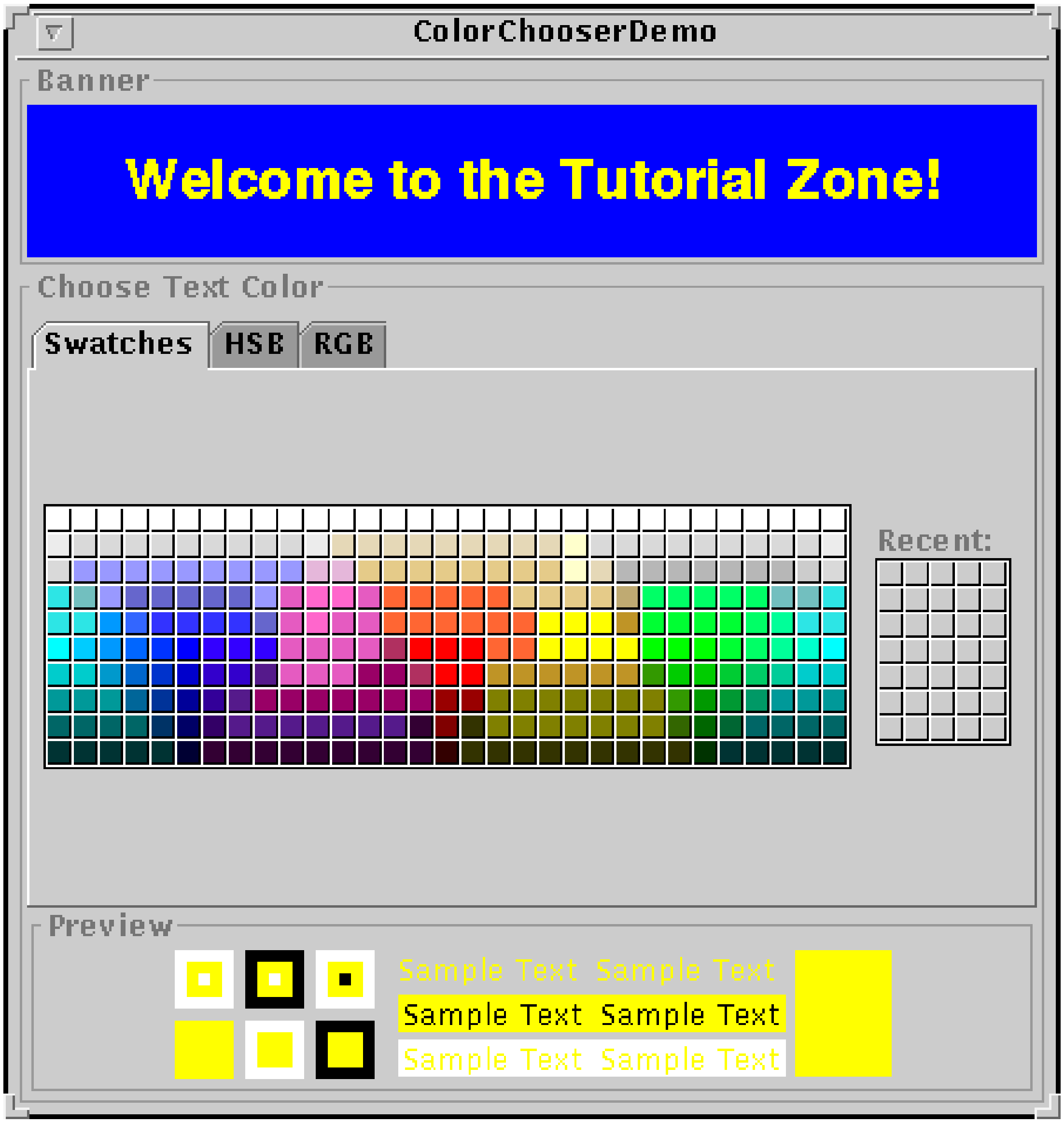
How to Use Color Choosers

Use the `JColorChooser` class to provide users with a palette of colors to choose from. A color chooser is a component that you can place anywhere within your program's GUI. The `JColorChooser` API also makes it easy to bring up a dialog (modal or not) that contains a color chooser.

Here's a picture of an application that uses a color chooser to set the text color in a banner:



The source code for the program is in `ColorChooserDemo.java`.

The color chooser consists of everything within the box labeled **Choose Text Color**. This is what a standard color chooser looks like in the Java Look & Feel. It contains two parts, a tabbed pane and a preview panel. The three tabs in the tabbed pane select *chooser panels*. The *preview panel* below the tabbed pane displays the currently selected color.

Here's the code from the example that creates a `JColorChooser` instance and adds it to the demo's window:

```
final JLabel banner = new JLabel("Welcome to the Tutorial Zone!",
                                 JLabel.CENTER);
banner.setForeground(Color.yellow);
...
final JColorChooser tcc = new JColorChooser(banner.getForeground());
...
getContentPane().add(tcc, BorderLayout.CENTER);
```

The `ColorChooser` constructor in the previous code snippet takes a `Color` argument, which specifies the chooser's initially selected color. If you don't specify the initial color, then the color chooser displays `Color.white`. See the `Color` API documentation for a list of color constants you can use.

A color chooser uses an instance of `ColorSelectionModel` to contain and manage the current selection. The color selection model fires a change event whenever the user changes the color in the color chooser. The example program registers a change listener with the color selection model so that it can update the banner at the top of the window. The following code registers and implements the change listener:

```
tcc.getSelectionModel().addChangeListener(
    new ChangeListener() {
        public void stateChanged(ChangeEvent e) {
            Color newColor = tcc.getColor();
            banner.setForeground(newColor);
        }
    }
);
```

See How to Write a Change Listener for general information about change listeners and change events.

A basic color chooser, like the one used in the example program, is sufficient for many programs. However, the color chooser API allows you to customize a color chooser by providing it with a preview panel of your own design, by adding your own chooser panels to it, or by removing existing chooser panels from the color chooser. Additionally, the `JColorChooser` class provides two methods that make it easy to use a color chooser within a dialog.

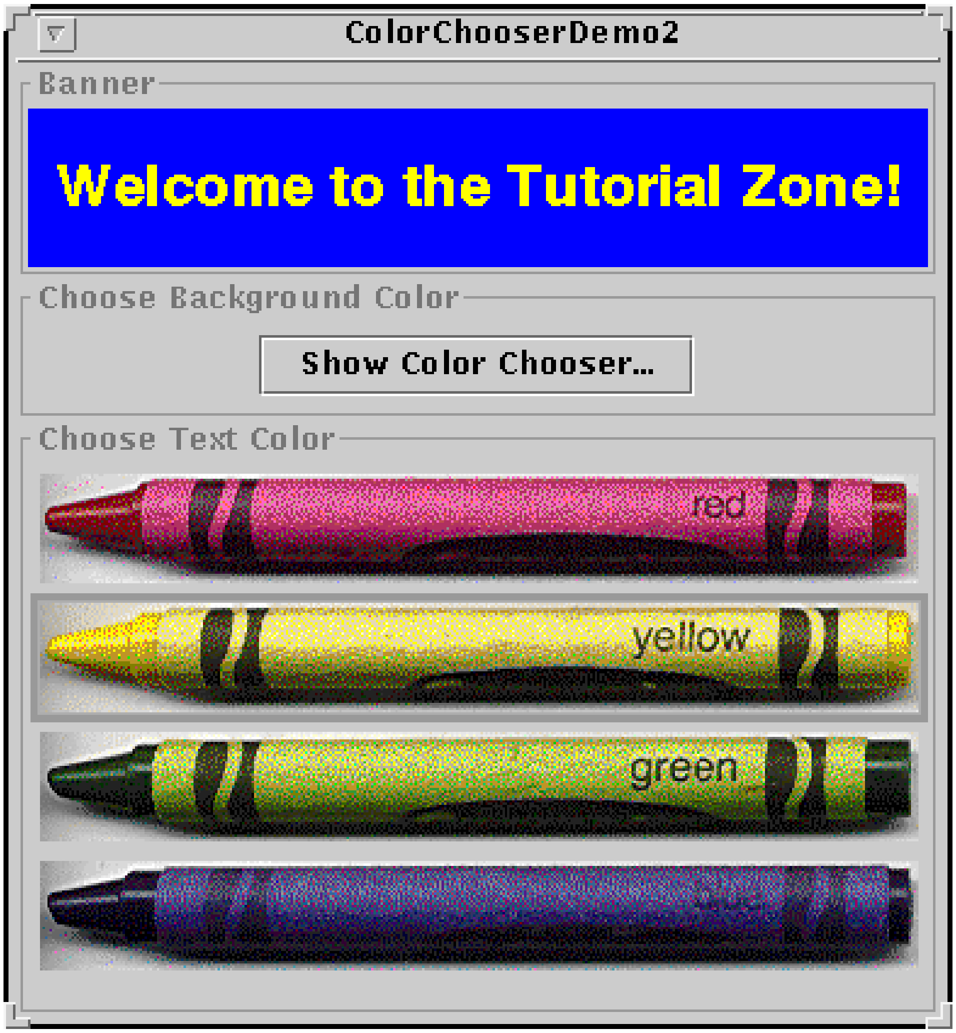
The rest of this section discusses these topics:

- Another Example: ColorChooserDemo2
- Showing a Color Chooser in a Dialog
- Removing or Replacing the Preview Panel
- Creating a Custom Chooser Panel
- The Color Chooser API
- Examples that Use Color Choosers

Another Example: ColorChooserDemo2

Now turn your attention to `ColorChooserDemo2.java`, a modified version of the previous demo program that uses more of the `JColorChooser` API. In addition to the main source file, this example needs one other source file and the crayon images. See the examples index for links to all the files required by this example.

Here's a picture of `ColorChooserDemo2`:



Additionally, this program customizes the banner's text color chooser in these ways:

- Removes the preview panel
- Removes all of the default chooser panels
- Adds a custom chooser panel

Removing or Replacing the Preview Panel covers the first customization. Creating a Custom Chooser Panel discusses the last two.

This program also adds a button that brings up a color chooser in a dialog, which you can use to set the banner's background color.

Showing a Color Chooser in a Dialog

The `JColorChooser` class provides two class methods to make it easy to use a color chooser in a dialog. `ColorChooserDemo2` uses one of these methods, `showDialog`, to display the background color chooser when the user clicks the **Show Color Chooser...** button. Here's the single line of code from the example that brings up the background color chooser in a dialog:

```
Color newColor = JColorChooser.showDialog(
                     ColorChooserDemo2.this,
                     "Choose Background Color",
                     banner.getBackground());
```

The first argument is the parent for the dialog, the second is the dialog's title, and the third is the initially selected color.

The dialog disappears under three conditions: the user chooses a color and clicks the **OK** button, the user cancels the operation with the **Cancel** button, or the user dismisses the dialog with a frame control. If the user chooses a color, the `showDialog` method returns the new color. If the user cancels the operation or dismisses the window, the method returns `null`. Here's the code from the example that updates the banner's background color according to the value returned by `showDialog`:

```
if (newColor != null) {
    banner.setBackground(newColor);
}
```

The dialog created by `showDialog` is modal. If you want a non-modal dialog, you can use `JColorChooser`'s `createDialog` method to create the dialog. This method also lets you specify action listeners for the **OK** and **Cancel** buttons in the dialog window. Use `JDialog`'s `show` method to display the dialog created by this method. For an example that uses this method, see Specifying Other Editors in the How to Use Tables section.

Removing or Replacing the Preview Panel

By default, the color chooser displays a preview panel. The example program removes the text color chooser's preview panel with this line of code:

```
tcc.setPreviewPanel(new JPanel());
```

This effectively removes the preview panel because a plain `JPanel` has no size and no default view. To set the preview panel back to the default, use `null` as the argument to `setPreviewPanel`.

To provide a custom preview panel, you also use `setPreviewPanel`. The component you pass into the method should inherit from `JComponent`, specify a reasonable size, and provide a customized view of the current color. To get notified when the user changes the color in the color chooser, the preview panel must register as a change listener on the color chooser's color selection model as described previously.

Creating a Custom Chooser Panel

The default color chooser provides three chooser panels:

- Swatches -- for choosing a color from a collection of swatches.
- HSB -- for choosing a color using the Hue-Saturation-Brightness color model.
- RGB -- for choosing a color using the Red-Green-Blue color model.

You can extend the default color chooser by adding chooser panels of your own design with `addChooserPanel`, or you can limit it by removing chooser panels with `removeChooserPanel`.

If you want to remove all of the default chooser panels and add one or more of your own, you can do this with a single call to `setChooserPanels`. `ColorChooserDemo2` uses this method to replace the default chooser panels with an instance of `CrayonPanel`, a custom chooser panel. Here's the call to `setChooserPanels` from that example:

```
//Override the chooser panels with our own.
AbstractColorChooserPanel panels[] = { new CrayonPanel() };
tcc.setChooserPanels(panels);
```

The code is straighforward: it creates an array containing the `CrayonPanel`. Next the code calls `setChooserPanels` to set the contents of the array as the color chooser's chooser panels.

`CrayonPanel` is a subclass of `AbstractColorChooserPanel` and overrides the five abstract methods defined in its superclass:

`void buildChooser()`
: Creates the GUI that comprises the chooser panel. The example creates four toggle buttons -- one for each crayon -- and adds them to the chooser panel.

`void updateChooser()`
: This method is called whenever the chooser panel is displayed. The example's implementation

of this method selects the toggle button that represents the currently selected color.

```
public void updateChooser() {
    Color color = getColorFromModel();
    if (color.equals(Color.red)) {
        redCrayon.setSelected(true);
    } else if (color.equals(Color.yellow)) {
        yellowCrayon.setSelected(true);
    } else if (color.equals(Color.green)) {
        greenCrayon.setSelected(true);
    } else if (color.equals(Color.blue)) {
        blueCrayon.setSelected(true);
    }
}
```

`String getDisplayName()`

Returns the display name of the chooser panel. The name is used on the tab for the chooser panel. Here's the example's `getDisplayName` method:

```
public String getDisplayName() {
    return "Crayons";
}
```

`Icon getSmallDisplayIcon()`

Returns a small icon to represent this chooser panel. This is currently unused. Future versions of the color chooser might use this icon or the large one to represent this chooser panel in the display. The example's implementation of this method returns `null`.

`Icon getLargeDisplayIcon()`

Returns a large icon to represent this chooser panel. This is currently unused. Future versions of the color chooser might use this icon or the small one to represent this chooser panel in the display. The example's implementation of this method returns `null`.

The Color Chooser API

The following tables list the commonly used `JColorChooser` constructors and methods. Other methods you might call are listed in the API tables in The JComponent Class. The API for using color choosers falls into these categories:

- Creating and Displaying the Color Chooser
- Customizing the Color Chooser's GUI
- Setting or Getting the Current Color

Creating and Displaying the Color Chooser

Method	**Purpose**

`JColorChooser()`
`JColorChooser(Color)`
`JColorChooser(ColorSelectionModel)`
	Create a color chooser. The default constructor creates a color chooser with an initial color of `Color.white`. Use the second constructor to specify a different initial color. The `ColorSelectionModel` argument, when present, provides the color chooser with a color selection model.

`Color showDialog(Component, String, Color)`	Create and show a color chooser in a modal dialog. The `Component` argument is the dialog's parent, the `String` argument specifies the dialog's title, and the `Color` argument specifies the chooser's initial color.

`JDialog createDialog(Component, String,`
`boolean, JColorChooser,`
`ActionListener, ActionListener)`
	Create a dialog for the specified color chooser. As with `showDialog`, the `Component` argument is the dialog's parent and the `String` argument specifies the dialog's title. The other arguments are as follows: the `boolean` specifies whether the dialog is modal, the `JColorChooser` is the color chooser to display in the dialog, the first `ActionListener` is for the **OK button, and the second is for the Cancel button.**

Customizing the Color Chooser's GUI

Method	**Purpose**

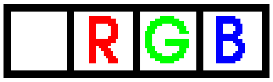
`void setPreviewPanel(JComponent)`
`JComponent getPreviewPanel()`
	Set or get the component used to preview the color selection. To remove the preview panel, use `new JPanel()` as an argument. To specify the default preview panel, use `null`.

`void setChooserPanels(AbstractColorChooserPanel[])`
`AbstractColorChooserPanel[] getChooserPanels()`
	Set or get the chooser panels in the color chooser.

`void addChooserPanel(AbstractColorChooserPanel)`
`AbstractColorChooserPanel`
`removeChooserPanel(AbstractColorChooserPanel)`
	Add a chooser panel to the color chooser or remove a chooser panel from it.

Setting or Getting the Current Color

Method	**Purpose**

`void setColor(Color)`
`void setColor(int, int, int)`
`void setColor(int)`
`Color getColor()`
	Set or get the currently selected color. The three integer version of the `setColor` method interprets the three integers together as an RGB color. The single integer version of the `setColor` method divides the integer into four 8-bit bytes and interprets the integer as an RGB color as follows: 

`void setSelectionModel(ColorSelectionModel)`
`ColorSelectionModel getSelectionModel()`
	Set or get the selection model for the color chooser. This object contains the current selection and fires change events to registered listeners whenever the selection changes.

Examples that Use Color Choosers

This table shows the examples that use `JColorChooser` and where those examples are described.

Example	Where Described	Notes
`ColorChooserDemo`	This section	Uses a standard color chooser.
`ColorChooserDemo2`	This section	Uses one customized color chooser and one standard color chooser in a dialog created with `showDialog`.
`TableDialogEditDemo`	How to Use Tables	Shows how to use a color chooser as a custom cell editor in a table. The color chooser used by this example is created with `createDialog`.

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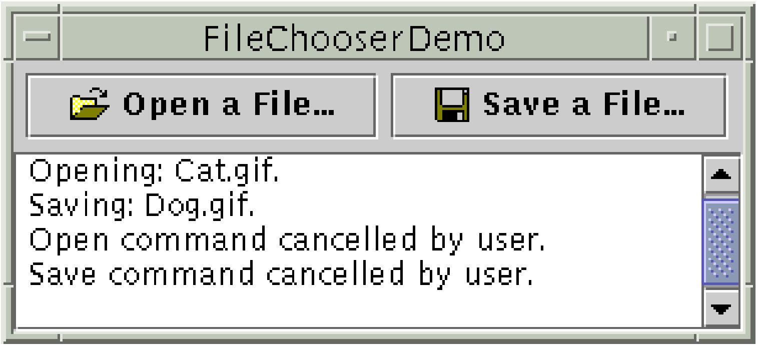
How to Use File Choosers

File choosers provide a GUI for navigating the file system, and then either choosing a file or directory from a list or entering a file name or directory name. To display a file chooser, you can either add an instance of `JFileChooser` to a container, or use the `JFileChooser` API to show a modal dialog that contains a file chooser. File choosers often appear within modal dialogs because file operations can be sensitive to changes within a program,

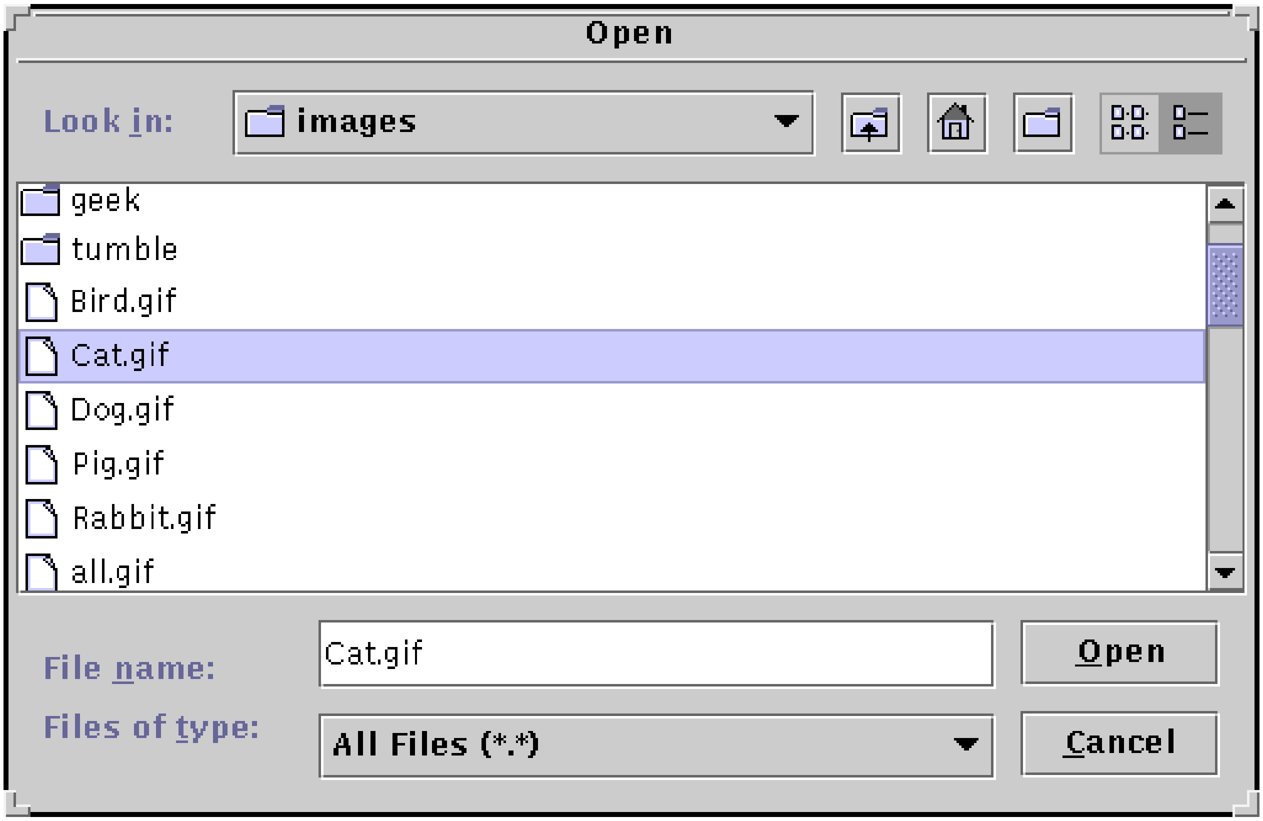
A `JFileChooser` object only presents the GUI for choosing files. Your program is responsible for doing something with the chosen file, such as opening or saving it.

Here's a snapshot of an application that brings up an open file chooser and a save file chooser:



```
Opening: Cat.gif.
Saving: Dog.gif.
Open command cancelled by user.
Save command cancelled by user.
```

And here's a picture of the file chooser that appears when the user clicks the **Open a File...** button. This is the Java Look & Feel's standard open file chooser.



The look and feel determine what the open and save dialogs look like and how they differ. In the Java Look & Feel, the save file chooser looks the same as the open file chooser, except for the title on the dialog's window and the text on the button that approves the operation.

Try this:

1. Compile and run the program: `FileChooserDemo.java`. You will also need to put two image files in a directory named `images`: `open.gif`, and `save.gif`.
   See Getting Started with Swing if you need help compiling or running this application.
2. Click the **Open a File...** button. Navigate around the file chooser, choose a file, and click the dialog's **Open** button.
3. Use the **Save a File...** button to bring up a save file chooser. Try to use all of the controls on the file chooser.

Bringing up a standard open file chooser requires only two lines of code:

```
//Create a file chooser
final JFileChooser fc = new JFileChooser();
...
//In response to a button click:
```

```
int returnVal = fc.showOpenDialog(aComponent);
```

The argument to the `showOpenDialog` method specifies the parent component for the dialog. The parent component affects the position of the dialog and the frame that the dialog depends on. For example, the Java Look & Feel places the dialog directly over the parent component. If the parent component is in a frame, then the dialog is dependent on that frame, disappearing when the frame is iconified and reappearing when the frame is deiconified.

By default, a file chooser that hasn't been shown before displays all files in the user's home directory. You can specify the file chooser's initial directory using one of `JFileChooser`'s other constructors, or you can set the directory with the `setCurrentDirectory` method.

The call to `showOpenDialog` appears in the `actionPerformed` method of the **Open a File...** button's action listener, shown in full here:

```
public void actionPerformed(ActionEvent e) {
    int returnVal = fc.showOpenDialog(FileChooserDemo.this);

    if (returnVal == JFileChooser.APPROVE_OPTION) {
        File file = fc.getSelectedFile();
        //this is where a real application would open the file.
        log.append("Opening: " + file.getName() + "." + newline);
    } else {
        log.append("Open command cancelled by user." + newline);
    }
}
```

The `showOpenDialog` methods return an integer that indicates whether the user selected a file. The value returned is either `CANCEL_OPTION` or `APPROVE_OPTION`, both constants defined by `JFileChooser`. Use the return value to determine whether to perform the required operation. To get the chosen file, call `getSelectedFile` on the file chooser. This method returns an instance of `File`◆.

The example gets the name of the file and uses it in the log message. You can call other methods on the `File` object, such as `getPath`, `isDirectory`, or `exists` to get information about the file. You can also call other methods such as `delete` and `rename` to change the file in some way. Of course, you might also want to open or save the file using one of the reader or writer classes provided by the JDK. See I/O: Reading and Writing (but no 'rithmetic)◆ for information about using readers and writers to read and write data to the file system.

The example program uses the same instance of `JFileChooser` to display a standard save file chooser. This time the program calls `showSaveDialog`:

```
int returnVal = fc.showSaveDialog(FileChooserDemo.this);
```

By using the same file chooser instance to display its open and save file choosers, the program reaps these benefits:

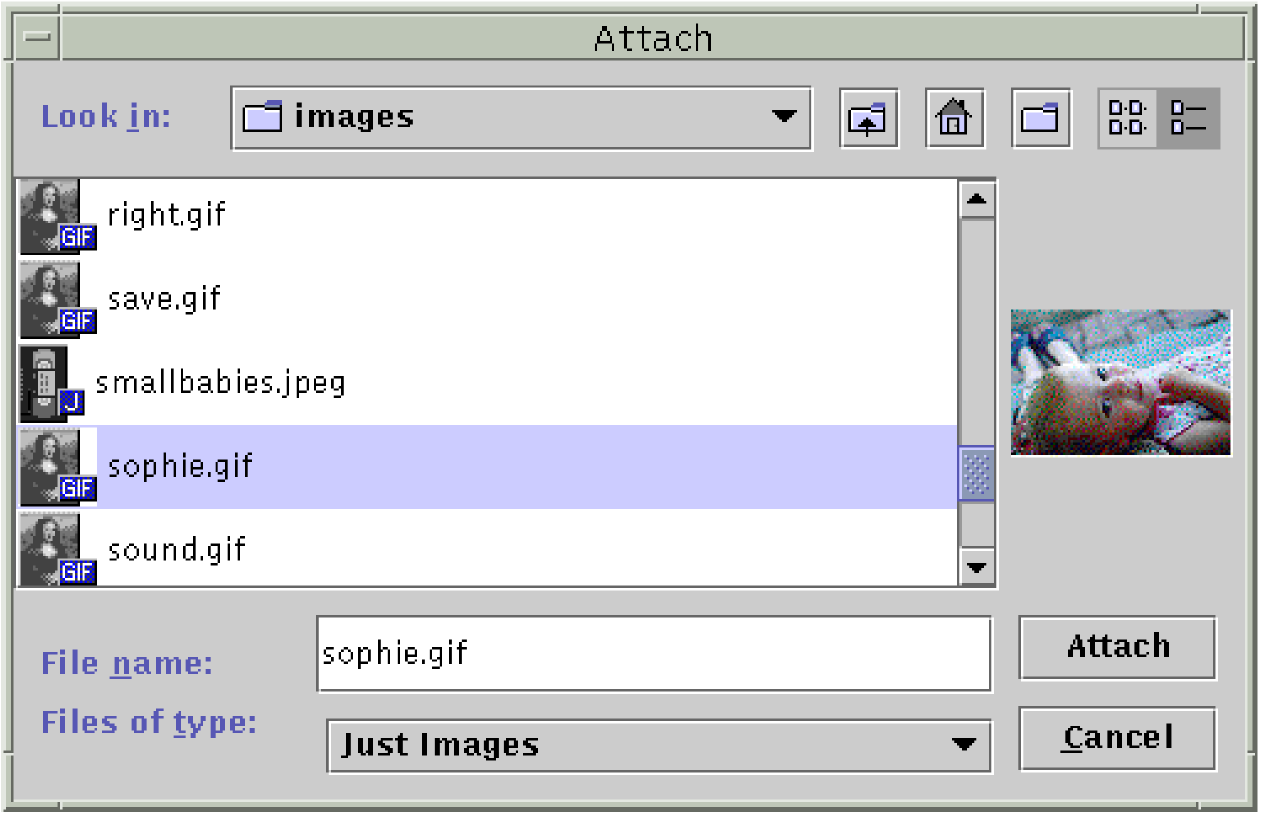
- The chooser remembers the current directory between uses so the open and save versions automatically share the same current directory.
- You have to customize only one file chooser, and the customizations apply to both the open and save versions of it.

If you want to create a file chooser for a task other than opening or saving, or if you want to customize the file chooser, keep reading. This page goes on to discuss the following topics:

- Another Example: FileChooserDemo2
- Using a File Chooser for a Custom Task
- Filtering the List of Files
- Customizing the File View
- Providing an Accessory Component
- The File Chooser API
- Examples that Use File Choosers

Another Example: FileChooserDemo2

Let's look at `FileChooserDemo2`, a modified version of the previous demo program that uses more of the `JFileChooser` API. This example uses a file chooser that has been customized in several ways. Like the original example, the user invokes a file chooser with the push of a button. Here's a picture of the file chooser:



You need several source and image files to run this example. See the examples index for links to all the files required by this example.

As the figure shows, this file chooser has been customized for a special task (attaching), provides a user-choosable file filter, uses a special file view for image files, and has an accessory component that displays a thumbnail sketch of the currently selected image file.

The remainder of this section shows you the code that creates and customizes this file chooser.

Using a File Chooser for a Custom Task

As you've seen, `JFileChooser` provides `showOpenDialog` for displaying an open file chooser and `showSaveDialog` for displaying a save file chooser.

The class has another method, `showDialog`, for displaying a file chooser for a custom task in a dialog. In the Java Look & Feel, the only difference between this file chooser and the others is the title on the dialog window and the label on the approve button. Here's the code from `FileChooserDemo2` that brings up the file chooser dialog for the **Attach** task:

```
JFileChooser fc = new JFileChooser();
int returnVal = fc.showDialog(FileChooserDemo2.this, "Attach");
```

The first argument to the `showDialog` method is the parent component for the dialog. The second argument is a `String` that provides both the title for the dialog window and the label for the approve button.

Once again, the file chooser doesn't do anything with the selected file. The program is responsible for implementing the custom task for which the file chooser was created.

Filtering the List of Files

By default, a file chooser displays all of the files and directories that it detects, except hidden files. A program can apply one or more *file filters* to a file chooser so that the chooser shows only some files. The file chooser calls the filter's `accept` method for each file to determine whether it should be displayed. A file filter accepts or rejects a file based on some criteria such as file type, size, ownership, and so on. Filters affect the list of files displayed by the file chooser. The user can enter the name of any file even if it's not displayed.

`JFileChooser` supports three different kinds of filtering. The filters are checked in the order listed here. So a filter of the second type can filter only those files accepted by the first, and so on.

Built-in filtering

Filtering is set up through specific method calls on a file chooser. Currently the only built-in filter available is for hidden files, such as those that begin with period (.) on UNIX systems.

By default, hidden files are not shown. Call `setFileHidingEnabled(false)` to show hidden files.

Application-controlled filtering

The application determines which files are shown. Create a custom subclass of `FileFilter`, instantiate it, and use the instance as an argument to `setFileFilter`. The file chooser shows only those files that the filter accepts.

User-choosable filtering

The file chooser GUI provides a list of filters that the user can choose from. When the user chooses a filter, the file chooser shows only those file accepted by that filter. `FileChooserDemo2` adds a custom file filter to the list of user-choosable filters:

```
fc.addChoosableFileFilter(new ImageFilter());
```

The custom file filter is implemented in `ImageFilter.java`and is a subclass of `FileFilter`. The `ImageFilter`class implements the `getDescription`method to return a string to put in the list of user-choosable filters. `ImageFilter`implements the `accept`method to accept all directories and any file that has a `.jpg`, `.jpeg`, `.gif`, `.tif`, or `.tiff`filename extension.

```
public boolean accept(File f) {
    if (f.isDirectory()) {
        return true;
    }

    String extension = Utils.getExtension(f);
    if (extension != null) {
        if (extension.equals(Utils.tiff) ||
            extension.equals(Utils.tif) ||
            extension.equals(Utils.gif) ||
            extension.equals(Utils.jpeg) ||
            extension.equals(Utils.jpg)) {
                return true;
        } else {
            return false;
        }
    }

    return false;
}
```

By accepting all directories, this filter allows the user to navigate around the file system. If the bold lines were omitted from this method, the user would be limited to the directory with which the chooser was initialized.

The preceding code sample uses the `getExtension` method and several string constants from `Utils.java`, shown here:

```
public class Utils {

    public final static String jpeg = "jpeg";
    public final static String jpg = "jpg";
    public final static String gif = "gif";
    public final static String tiff = "tiff";
    public final static String tif = "tif";

    /*
     * Get the extension of a file.
     */
    public static String getExtension(File f) {
        String ext = null;
        String s = f.getName();
        int i = s.lastIndexOf('.');

        if (i > 0 &&  i < s.length() - 1) {
            ext = s.substring(i+1).toLowerCase();
        }
        return ext;
    }
}
```

Customizing the File View

In the Java Look & Feel, the chooser's list shows each file's name and displays a small icon that represents whether the file is a true file or a directory. You can customize this *file view* by creating a custom subclass of `FileView` and using an instance of the class as an argument to `setFileView`. The example uses an instance of a custom class, implemented in `ImageFileView.java`, as the file chooser's file view.

```
fc.setFileView(new ImageFileView());
```

`ImageFileView` shows a different icon for each type of image accepted by the image filter described previously.

The `ImageFileView` class overrides the five abstract methods defined in `FileView` as follows. Note that some of these methods call `getExtension`, which is a private method to `ImageFileView`.

`String getTypeDescription(File f)`

Returns a description of the file type. This is not yet used by any look and feel. The intent is to provide information about the file's type. Here is `ImageFileView`'s implementation of this method:

```
public String getTypeDescription(File f) {
        String extension = Utils.getExtension(f);
        String type = null;

        if (extension != null) {
            if (extension.equals(Utils.jpeg) ||
                extension.equals(Utils.jpg)) {
                type = "JPEG Image";
            } else if (extension.equals(Utils.gif)){
                type = "GIF Image";
            } else if (extension.equals(Utils.tiff) ||
                       extension.equals(Utils.tif)) {
                type = "TIFF Image";
            }
        }
        return type;
}
```

`Icon getIcon(File f)`

Returns an icon representing the file or its type. Here is `ImageFileView`'s implementation of this method:

```
public Icon getIcon(File f) {
        String extension = Utils.getExtension(f);
        Icon icon = null;

        if (extension != null) {
            if (extension.equals(Utils.jpeg) ||
                extension.equals(Utils.jpg)) {
                icon = jpgIcon;
            } else if (extension.equals(Utils.gif)) {
                icon = gifIcon;
            } else if (extension.equals(Utils.tiff) ||
                       extension.equals(Utils.tif)) {
                icon = tiffIcon;
            }
        }
        return icon;
    }
}
```

`String getName(File f)`

Returns the name of the file. Most implementations of this method should return `null` to indicate that the look and feel should figure it out. Another common implementation returns `f.getName()`.

`String getDescription(File f)`

Returns a description of the file. This is not yet used by any look and feel. The intent is to describe individual files more specifically. A common implementation of this method returns `null` to indicate that the look and feel should figure it out.

`Boolean isTraversable(File f)`

Returns whether a directory is traversable. Most implementations of this method should return `null` to indicate that the look and feel should figure it out. Some applications might want to prevent users from descending into a certain type of directory because it represents a compound document. The `isTraversable` method should never return `true` for a non-directory.

Providing an Accessory Component

The customized file chooser in `FileChooserDemo2` has an accessory component. If the currently selected item is a JPEG, TIFF, or GIF image, the accessory component displays a thumbnail sketch of the image. Otherwise, the accessory component is empty. Aside from a previewer, probably the most common use for the accessory component is a panel with more controls on it -- say, checkboxes that toggle some features.

The example calls the `setAccessory` method to establish an instance of the `ImagePreview` class, implemented in `ImagePreview.java`◆, as the chooser's accessory component:

```
fc.setAccessory(new ImagePreview(fc));
```

Any object that inherits from `JComponent` can be an accessory component. The component should have a preferred size that looks good in the file chooser.

The file chooser fires a property change event when the user selects an item in the list. So, a program with an accessory component must register to receive these events to update the accessory component whenever the selection changes. In the example, the `ImagePreview` object itself registers for these events. This keeps all the code related to the accessory component together in one class.

Here is the example's implementation of the `propertyChange` method, which is the method called when a property change event is fired:

```
//where member variables are declared
File file = null;
...
public void propertyChange(PropertyChangeEvent e) {
    String prop = e.getPropertyName();
    if (prop.equals(JFileChooser.SELECTED_FILE_CHANGED_PROPERTY)) {
        file = (File) e.getNewValue();
        if (isShowing()) {
            loadImage();
```

```
                    repaint();
                }
            }
        }
```

If SELECTED_FILE_CHANGED_PROPERTY is the property that changed, this method gets a File object from the file chooser. The loadImage and repaint methods use the File to load the image and repaint the accessory component.

The File Chooser API

The API for using file choosers falls into these categories:

- Creating and Showing the File Chooser
- Selecting Files and Directories
- Navigating the File Chooser's List
- Customizing the File Chooser

Creating and Showing the File Chooser

Method	Purpose

JFileChooser()
JFileChooser(File)
JFileChooser(String)
	Create a file chooser instance. The File and String arguments, when present, provide the initial directory.

int showOpenDialog(Component) int showSaveDialog(Component) int showDialog(Component, String)	Show a modal dialog containing the file chooser. These methods return APPROVE_OPTION if the user approved the operation and CANCEL_OPTION if the user cancelled it.

Selecting Files and Directories

Method	Purpose
void setSelectedFile(File) File getSelectedFile()	Set or get the currently selected file.
void setSelectedFiles(File[]) File[] getSelectedFiles()	Set or get the currently selected files. Multiple selection is not yet implemented by any look and feel. Calling these methods might produce unpredictable results.
void setFileSelectionMode(int) int getFileSelectionMode() boolean isDirectorySelectionEnabled() boolean isFileSelectionEnabled()	Set the file selection mode. Acceptable values are FILES_ONLY (the default), DIRECTORIES_ONLY, and FILES_AND_DIRECTORIES.

`void setMultiSelectionEnabled(boolean)`
`boolean isMultiSelectionEnabled()`
	Set or get whether multiple files can be selected at once. By default, a user can choose only one file. Multiple selection is not yet implemented by any look and feel.

Navigating the File Chooser's List

Method	**Purpose**
`void ensureFileIsVisible(File)`	Scroll the file chooser's list such that the indicated file is visible.

`void setCurrentDirectory(File)`
`File getCurrentDirectory()`
	Set or get the directory whose files are displayed in the file chooser's list.

`void changeToParentDirectory()`	Change the list to display the current directory's parent.
`void rescanCurrentDirectory()`	Check the file system and update the chooser's list.

Customizing the File Chooser

Method	**Purpose**

`JComponent getAccessory()`
`void setAccessory(JComponent)`
	Set or get the file chooser's accessory component.

`void setFileFilter(FileFilter)`
`FileFilter getFileFilter()`
	Set or get the file chooser's primary file filter.

`void setFileView(FileView)`
`FileView getFileView()`
	Set or get the chooser's file view.

`FileFilter[] getChoosableFileFilters()`
`void setChoosableFileFilters(FileFilter[])`
`void addChoosableFileFilter(FileFilter)`
`boolean removeChoosableFileFilter(FileFilter)`
`void resetChoosable(FileFilter)`
`FileFilter getAcceptAllFileFilter()`
	Set, get, or modify the list of user-choosable file filters.

`void setFileHidingEnabled(boolean)`
`boolean isFileHidingEnabled()`
	Set or get whether hidden files are displayed.

Examples that Use File Choosers

This table shows the examples that use `JFileChooser` and where those examples are described.

Example	**Where Described**	**Notes**
`FileChooserDemo`	This section	Displays an open file chooser and a save file chooser.
`FileChooserDemo2`	This section	Uses a file chooser with custom filtering, a custom file view, and an accessory component.

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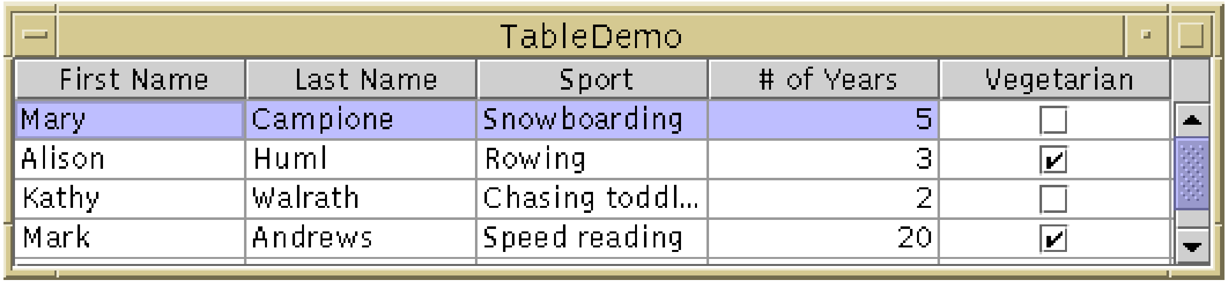
How to Use Tables

With the `JTable` class you can display tables of data, optionally allowing the user to edit the data. `JTable` doesn't contain or cache data; it's simply a view of your data. Here's a picture of a typical table displayed within a scroll pane:

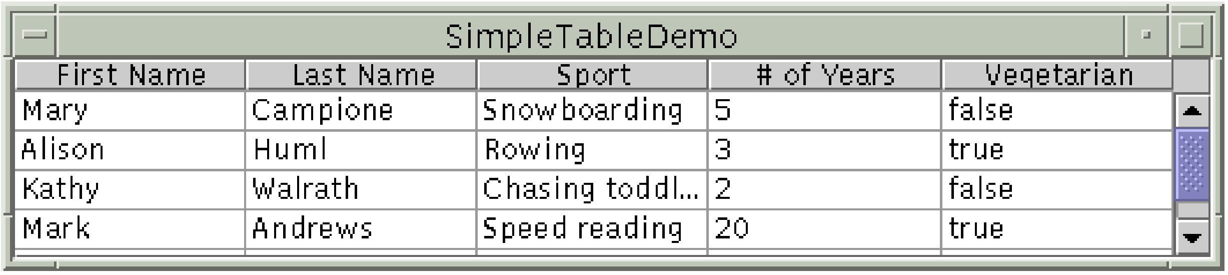


First Name	Last Name	Sport	# of Years	Vegetarian
Mary	Campione	Snowboarding	5	□
Alison	Huml	Rowing	3	☑
Kathy	Walrath	Chasing toddl...	2	□
Mark	Andrews	Speed reading	20	☑

The rest of this section tells you how to accomplish some common table-related tasks. Here are the topics this section covers:

- Creating a Simple Table
- Adding a Table to a Container
- Setting and Changing Column Widths
- Detecting User Selections
- Creating a Table Model
- Detecting Data Changes
- Concepts: Cell Editors and Renderers
- Validating User-Entered Text
- Using a Combo Box as an Editor
- Specifying Other Editors
- Further Customizing Table Display and Event Handling
- Sorting and Otherwise Manipulating Data
- The Table API
- Examples that Use Tables

Creating a Simple Table



First Name	Last Name	Sport	# of Years	Vegetarian
Mary	Campione	Snowboarding	5	false
Alison	Huml	Rowing	3	true
Kathy	Walrath	Chasing toddl...	2	false
Mark	Andrews	Speed reading	20	true

Try this:

1. Compile and run `SimpleTableDemo`. The source file is `SimpleTableDemo.java`.
   See Getting Started with Swing if you need help compiling or running this application.
2. Click the cell that contains "Snowboarding".
   The entire first row is selected, indicating that you have selected Mary Campione's data. A special highlight indicates that the "Snowboarding" cell is editable. Generally, you begin editing a text cell by double-clicking it.
3. Position the cursor over "First Name". Now press the mouse button and drag to the right.
   As you can see, users can rearrange columns in tables.
4. Position the cursor just to the right of a column header. Now press the mouse button and drag to the right or left.
   The column changes size, and the other columns adjust to fill the remaining space.
5. Resize the window containing the table so that it's bigger than necessary to display the whole table.
   All the table cells become larger, expanding to fill the extra space.

Here is the code that implements the table in `SimpleTableDemo.java`:

```
Object[][] data = {
    {"Mary", "Campione",
     "Snowboarding", new Integer(5), new Boolean(false)},
    {"Alison", "Huml",
     "Rowing", new Integer(3), new Boolean(true)},
    {"Kathy", "Walrath",
     "Chasing toddlers", new Integer(2), new Boolean(false)},
    {"Mark", "Andrews",
     "Speed reading", new Integer(20), new Boolean(true)},
    {"Angela", "Lih",
     "Teaching high school", new Integer(4), new Boolean(false)}
};

String[] columnNames = {"First Name",
                        "Last Name",
                        "Sport",
                        "# of Years",
                        "Vegetarian"};

final JTable table = new JTable(data, columnNames);
```

The `SimpleTableDemo` example uses one of two `JTable` constructors that directly accept data:

- `JTable(Object[][] rowData, Object[] columnNames)`
- `JTable(Vector rowData, Vector columnNames)`

The advantage of these constructors is that they're easy to use. However, these constructors also have disadvantages:

- They automatically make every cell editable.
- They treat all data types the same. For example, if a table column has `Boolean` data, the table can display the data in a check box. However, if you use one of the two `JTable` constructors listed previously, your `Boolean` data will be displayed as a string. You can see this difference in the last column of the two previous pictures of tables.
- They require that you put all of the table's data in an array or vector, which isn't appropriate for some data. For example, if you're instantiating a set of objects from a database, you might want to query the objects directly for their values, rather than copying all their values into an array or vector.

If you want to get around these restrictions, you need to implement your own table model, as described in Creating a Table Model.

Adding a Table to a Container

It's easy to put a table in a scroll pane. You need just one or two lines of code:

```
JScrollPane scrollPane = new JScrollPane(table);
table.setPreferredScrollableViewportSize(new Dimension(500, 70));
```

The scroll pane automatically gets the table's header, which displays the column names, and puts it on top of the table. Even when the user scrolls down, the column names remain visible at the top of the viewing area. The scroll table also tries to make its viewing area the same as the table's preferred viewing size. The previous code snippet sets the table's preferred viewing size with the `setPreferredScrollableViewportSize` method.

Note: Before Swing 1.0.2, the scroll pane didn't get the table header unless you created the scroll pane using the `JTable.createScrollPaneForTable` method. Here are examples of the recommended code, before and after Swing 1.0.2:

```
//1.0.1 code (causes deprecation warning
//in 1.0.2 and later releases):
scrollPane = JTable.createScrollPaneForTable(table);

//Recommended code (causes missing column names in 1.0.1):
```

```
scrollPane = new JScrollPane(table);
```

If you're using a table without a scroll pane, then you must get the table header component and place it yourself. For example:

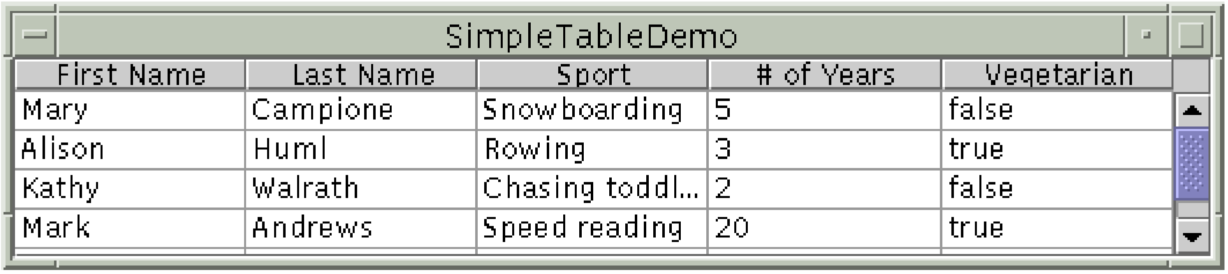
```
container.setLayout(new BorderLayout());
container.add(table.getTableHeader(), BorderLayout.NORTH);
container.add(table, BorderLayout.CENTER);
```

Setting and Changing Column Widths

By default, all columns in a table start out with equal width, and the columns automatically fill the entire width of the table. When the table becomes wider or narrower (which might happen when the user resizes the window containing the table), all the column widths change appropriately.

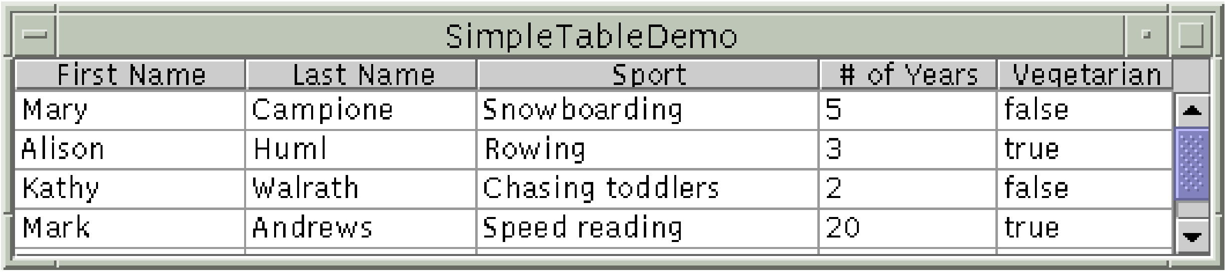
When the user resizes a column by dragging its right border, then either other columns must change size, or the table's size must change. By default, the table's size remains the same, and all columns to the right of the drag point resize to accommodate space added or removed from the column to the left of the drag point.

The following figures illustrate the default resizing behavior.



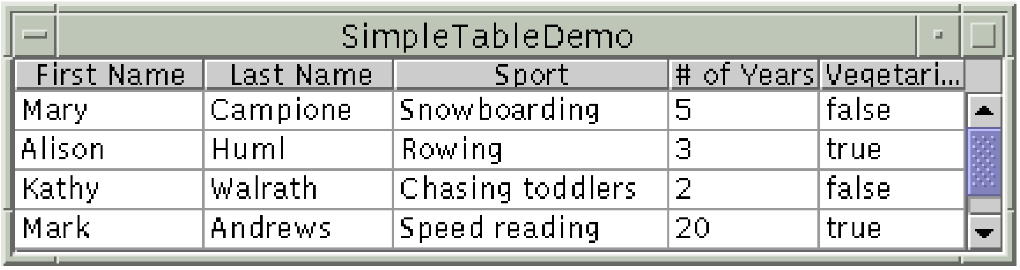
First Name	Last Name	Sport	# of Years	Vegetarian
Mary	Campione	Snowboarding	5	false
Alison	Huml	Rowing	3	true
Kathy	Walrath	Chasing toddl...	2	false
Mark	Andrews	Speed reading	20	true

Initially, the columns have equal width.



First Name	Last Name	Sport	# of Years	Vegetarian
Mary	Campione	Snowboarding	5	false
Alison	Huml	Rowing	3	true
Kathy	Walrath	Chasing toddlers	2	false
Mark	Andrews	Speed reading	20	true

When the user resizes a column, some of the other columns must adjust size for the table to stay the same size.



First Name	Last Name	Sport	# of Years	Vegetari...
Mary	Campione	Snowboarding	5	false
Alison	Huml	Rowing	3	true
Kathy	Walrath	Chasing toddlers	2	false
Mark	Andrews	Speed reading	20	true

When the entire table is resized, all the columns are resized.

To customize initial column widths, you can invoke `setPreferredWidth` on each of your table's columns. This sets both the preferred widths of the columns and their approximate relative widths. For example, adding the following code to `SimpleTableDemo` makes its third column bigger than the other columns:

```
TableColumn column = null;
for (int i = 0; i < 5; i++) {
    column = table.getColumnModel().getColumn(i);
    if (i == 2) {
        column.setPreferredWidth(100); //sport column is bigger
    } else {
        column.setPreferredWidth(50);
    }
}
```

> **Note:** The `setPreferredWidth` method was first introduced in Swing 1.1 Beta 2. For previous releases, you must use `setMinWidth` instead, making sure to invoke it on every column. (Otherwise, the columns you miss will be very thin.)

As the preceding code shows, each column in a table is represented by a `TableColumn` object. Besides `setPreferredWidth`, `TableColumn` also supplies methods for getting and setting the minimum, current, and maximum width of a column. For an example of setting cell widths based on the actual amount of space needed to draw the cells' contents, see the `initColumnSizes` method in `TableRenderDemo.java`, which is discussed in Further Customizing Table Display and Event Handling.

When the user explicitly resizes columns, the new sizes become not only the columns' new *current* widths, but also the columns' new *preferred* widths, However, when columns are resized as the result of the table width changing, the columns' preferred widths do not change.

You can change a table's resize behavior by invoking the `setAutoResizeMode` method. The method's argument should have one of these values (defined as constants in `JTable`):

`AUTO_RESIZE_SUBSEQUENT_COLUMNS`
: The default. In addition to resizing the column to the left of the drag point, adjusts the sizes of all columns to the right of the drag point.

`AUTO_RESIZE_NEXT_COLUMN`
: Adjusts only the columns immediately to the left and right of the drag point.

`AUTO_RESIZE_OFF`
: Adjust the table size instead.

> **Note:** Before the Swing 1.1 Beta release, the default resize mode was `AUTO_RESIZE_ALL_COLUMNS`. However, that mode isn't intuitive, so we changed the default mode to a mode added in Swing 1.1 Beta:

AUTO_RESIZE_SUBSEQUENT_COLUMNS.

Detecting User Selections

The following code snippet shows how to detect when the user selects a table row. By default, a table allows the user to select multiple rows -- not columns or individual cells -- and the selected rows need not be next to each other. Using the `setSelectionMode` method, the following code specifies that only one row at a time can be selected. You can find the entire program in `SimpleTableSelectionDemo.java`.

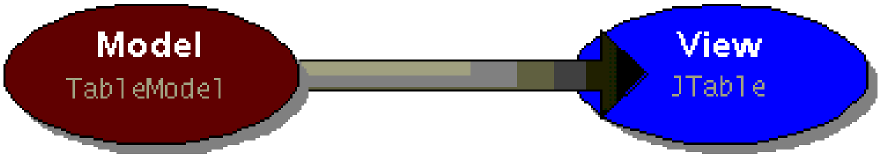
```
table.setSelectionMode(ListSelectionModel.SINGLE_SELECTION);
...
ListSelectionModel rowSM = table.getSelectionModel();
rowSM.addListSelectionListener(new ListSelectionListener() {
    public void valueChanged(ListSelectionEvent e) {
        //Ignore extra messages.
        if (e.getValueIsAdjusting()) return;

        ListSelectionModel lsm =
            (ListSelectionModel)e.getSource();
        if (lsm.isSelectionEmpty()) {
            ...//no rows are selected
        } else {
            int selectedRow = lsm.getMinSelectionIndex();
            ...//selectedRow is selected
        }
    }
});
```

`SimpleTableSelectionDemo.java` also has code (not included in the preceding snippet) that changes the table's selection orientation. By changing a couple of boolean values, you can make the table allow either column selections or individual cell selections, instead of row selections.

For more information and examples of implementing selection, see How to Write a List Selection Listener.

Creating a Table Model

As the following figure shows, every table gets its data from an object that implements the `TableModel` interface.



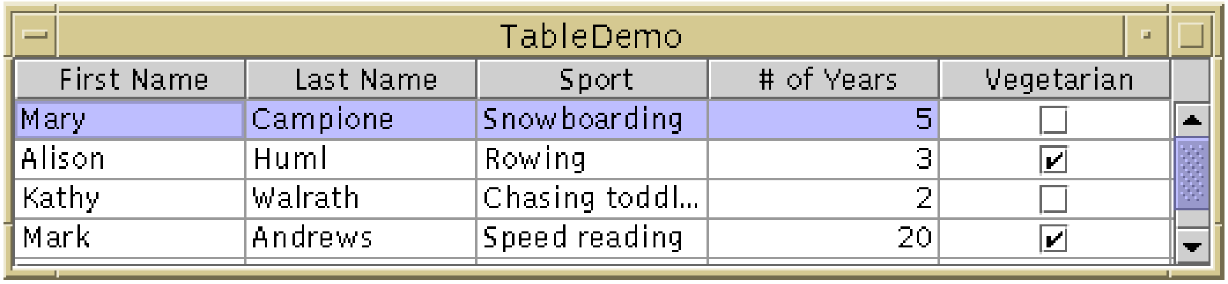
The `JTable` constructor used by `SimpleTableDemo` creates its table model with code like this:

```
        new AbstractTableModel() {
            public String getColumnName(int col) {
                return columnNames[col].toString();
            }
            public int getRowCount() { return rowData.length; }
            public int getColumnCount() { return columnNames.length; }
            public Object getValueAt(int row, int col) {
                return rowData[row][col];
            }
            public boolean isCellEditable(int row, int col)
                { return true; }
            public void setValueAt(Object value, int row, int col) {
                rowData[row][col] = value;
                fireTableCellUpdated(row, col);
            }
        }
```

As the preceding code shows, implementing a table model can be simple. Generally, you implement your table model in a subclass of the `AbstractTableModel` class.

Your model might hold its data in an array, vector, or hashtable, or it might get the data from an outside source such as a database. It might even generate the data at execution time. For examples of getting data from a database, see the table examples provided as part of the JFC/Swing and Java 2 Standard Edition SDK releases. In JFC/Swing-only releases (for use with JDK 1.1) the table examples are in the `examples/Table` directory. In J2SE v 1.2, the table examples are in `demo/jfc/Table` directory. In J2SE v 1.3, the examples move to the `demo/jfc/TableExamples` directory.

Here again is a picture of a table implemented by `TableDemo`, which has a custom table model:



First Name	Last Name	Sport	# of Years	Vegetarian
Mary	Campione	Snowboarding	5	☐
Alison	Huml	Rowing	3	☑
Kathy	Walrath	Chasing toddl...	2	☐
Mark	Andrews	Speed reading	20	☑

This table is different from the `SimpleTableDemo` table in the following ways:

- `SimpleTableDemo`'s table model, having been created automatically by `JTable`, isn't smart enough to know that the **# of Years** column contains numbers (which should generally be right aligned). It also doesn't know that the `Vegetarian` column contains boolean values, which can be represented by check boxes. `TableDemo`'s custom table model, even though it's simple, can easily determine the data's type, helping the `JTable` display the data in the best format.
- In `SimpleTableDemo`, all cells are editable. In `TableDemo`, we implemented the custom table model so that it doesn't let you edit the name columns; it does, however, let you edit the other columns.

Below is the code from `TableDemo.java` that is different from the code in

SimpleTableDemo.java. Bold font indicates the code that makes this table's model different from the table model defined automatically in `SimpleTableDemo`.

```
public TableDemo() {
    ...
    MyTableModel myModel = new MyTableModel();
    JTable table = new JTable(myModel);
    table.setPreferredScrollableViewportSize(
              new Dimension(500, 70));

    //Create the scroll pane and add the table to it.
    JScrollPane scrollPane = new JScrollPane(table);

    //Add the scroll pane to this window.
    setContentPane(scrollPane);
    ...
}

class MyTableModel extends AbstractTableModel {
    final String[] columnNames = ...//same as before...
    final Object[][] data = ...//same as before...

    public int getColumnCount() {
        return columnNames.length;
    }

    public int getRowCount() {
        return data.length;
    }

    public String getColumnName(int col) {
        return columnNames[col];
    }

    public Object getValueAt(int row, int col) {
        return data[row][col];
    }

    public Class getColumnClass(int c) {
        return getValueAt(0, c).getClass();
    }

    /*
     * Don't need to implement this method unless your table's
     * editable.
     */
    public boolean isCellEditable(int row, int col) {
        //Note that the data/cell address is constant,
        //no matter where the cell appears onscreen.
        if (col < 2) {
            return false;
        } else {
            return true;
        }
    }

    /*
     * Don't need to implement this method unless your table's
     * data can change.
     */
    public void setValueAt(Object value, int row, int col) {
        ...//debugging code not shown...
        ...//ugly special handling of Integers not shown...
        data[row][col] = value;
        fireTableCellUpdated(row, col);
        ...//debugging code not shown...
    }
    ...
```

Detecting Data Changes

A table and its model automatically detect whenever the user edits the table's data. However, if the data changes for another reason, you must take special steps to notify the table and its model of the data change. Also, if you don't implement a table model, as in `SimpleTableDemo`, then you must take special steps to find out when the user edits the table's data.

An example of updating a table's data without directly editing it is in the BINGO application. The BINGO application, which is presented in BINGO!◆, has a table that displays some information about each user who is signed up to play the game. When a new user signs up to play BINGO, the table needs to add a new row for that user. More precisely, the table model needs to get the data for the new user, and then the table model needs to tell the table to display the new data.

To notify the table model about a new user, the BINGO application invokes the table model's `updatePlayer` method. You can see the code for that method in `PlayerInfoModel`◆, which contains the implementation of the table model. The `updatePlayer` method records the new user's data and fires a table-model event. Because every table listens for table-model events from its model, the user-information table automatically detects the change and displays the new data.

To fire the table-model event, the model invokes the `fireTableRowsInserted` method, which is defined by the `AbstractTableModel` class. Other `fire`*`Xxxx`* methods that `AbstractTableModel` defines to help you fire table-model events are `fireTableCellUpdated`, `fireTableChanged`, `fireTableDataChanged`, `fireTableRowsDeleted`, `fireTableRowsInserted`, `fireTableRowsUpdated`, and `fireTableStructureChanged`.

If you have a class such as `SimpleTableDemo` that isn't a table or table model, but needs to react to changes in a table model, then you need to do something special to find out when the user edits the table's data. Specifically, you need to register a table-model listener on the table model. Adding the bold code in the following snippet makes `SimpleTableDemo` react to table data changes.

```
public class SimpleTableDemo ... implements TableModelListener {
        ...
        public SimpleTableDemo() {
            ...
            model = table.getModel();
            model.addTableModelListener(this);
            ...
        }

        public void tableChanged(TableModelEvent e) {
            ...
            int row = e.getFirstRow();
            int column = e.getColumn();
            String columnName = model.getColumnName(column);
            Object data = model.getValueAt(row, column);

            ...// Do something with the data...
        }
        ...
    }
```

Concepts: Cell Editors and Renderers

Before you go on to the next few tasks, you need to understand how tables draw their cells. You might expect each cell in a table to be a component. However, for performance reasons, Swing tables aren't implemented that way.

Instead, a single *cell renderer* is used to draw all of the cells in a column. Often, this cell renderer is shared between all columns that contain the same type of data. You can think of the renderer as a configurable ink stamp that the table uses to stamp appropriately formatted data onto each cell. When the user starts to edit a cell's data, a *cell editor* takes over the cell, controlling the cell's editing behavior.

For example, each cell in the **# of Years** column in `TableDemo` contains `Number` data -- specifically, an `Integer` object. By default, the cell renderer for a `Number`-containing column uses a single `JLabel` instance to draw the appropriate numbers, right-aligned, on the column's cells. If the user begins editing one of the cells, the default cell editor uses a right-aligned `JTextField` to control the cell editing.

To choose the renderer that displays the cells in a column, a table first determines whether the you specified a renderer for that particular column. (We'll tell you how to specify renderers a bit later.) If you didn't, then the table invokes the table model's `getColumnClass` method, which gets the data type of the column's cells. Next, the table compares the column's data type with a list of data types for which cell renderers are registered. This list is initialized by the table, but you can add to it or change it. Currently, tables put the following types of data in the list:

- `Boolean` -- rendered with a check box.
- `Number` -- rendered by a right-aligned label.
- `ImageIcon` -- rendered by a centered label.
- `Object` -- rendered by a label that displays the object's string value.

The table chooses cell editors using a similar algorithm.

Remember that if you let a table create its own model, it uses `Object` as the type of every column. `TableDemo.java` shows how to specify more precise column types.

The next few sections tell you how to customize cell display and editing by specifying cell renderers and editors either by column or by data type,

Validating User-Entered Text

In the table examples you've seen so far, the user can enter any text into the **# of Years** column. `SimpleTableDemo` doesn't check the data's value, at all. The `TableDemo` example is slightly improved in that when the user is done editing, the code checks whether the entry can be parsed as an integer. However, `TableDemo` must use a bit of ugly code to convert the string returned by the default cell editor into an `Integer`. If it didn't do the conversion, then the actual type of the data would change from `Integer` to `String`.

1.3 Note: As of v 1.3, the ugly conversion code is unnecessary because the default text cell editor automatically converts the data into the proper type.

What we'd really like to do is to check the user's input *while* the user is typing, and to have the cell editor return an `Integer` instead of a string. You can accomplish one or both of these tasks by using a custom text field to control the cell editing.

A custom text field can check the user's input either while the user is typing, or after the user has indicated the end of typing (such as by pressing return). We call these two types of checking *change*-validation and *action*-validation, respectively.

The following code, taken from `TableEditDemo.java`, sets up a change-validated text field. The bold line of code makes the text field the editor for all columns that contain data of type `Integer`.

```
final WholeNumberField integerField = new WholeNumberField(0, 5);
integerField.setHorizontalAlignment(WholeNumberField.RIGHT);

DefaultCellEditor integerEditor =
    new DefaultCellEditor(integerField) {
        //Override DefaultCellEditor's getCellEditorValue method
        //to return an Integer, not a String:
        public Object getCellEditorValue() {
            return new Integer(integerField.getValue());
        }
    };
table.setDefaultEditor(Integer.class, integerEditor);
```

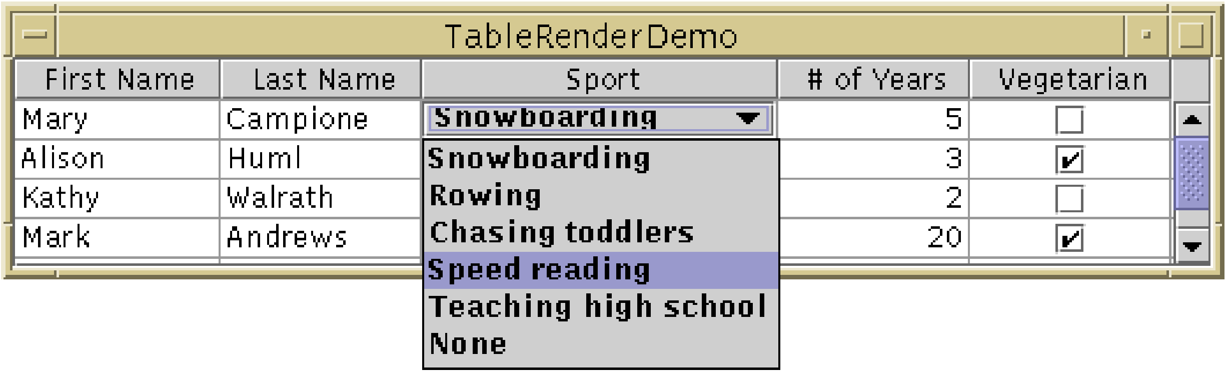
The `WholeNumberField` class used above is a custom `JTextField` subclass that allows the user to enter only digits. The `getValue` method returns the `int` value of the `WholeNumberField`'s contents. See How to Use Text Fields for more information about `WholeNumberField`. That section also provides a more general-purpose validating text field, called `DecimalField`, that you can customize so that it validates any number format that you specify.

Using a Combo Box as an Editor

Here is an example of setting up a combo box editor. The bold line of code sets up the combo box as the editor for a column, rather than for a specific data type.

```
TableColumn sportColumn = table.getColumnModel().getColumn(2);
...
JComboBox comboBox = new JComboBox();
comboBox.addItem("Snowboarding");
comboBox.addItem("Rowing");
comboBox.addItem("Chasing toddlers");
comboBox.addItem("Speed reading");
comboBox.addItem("Teaching high school");
comboBox.addItem("None");
sportColumn.setCellEditor(new DefaultCellEditor(comboBox));
```

Here is a picture of the combo box editor in use:



First Name	Last Name	Sport	# of Years	Vegetarian
Mary	Campione	Snowboarding	5	☐
Alison	Huml		3	☑
Kathy	Walrath		2	☐
Mark	Andrews		20	☑

The combo box editor is implemented in `TableRenderDemo.java`, which is discussed some more in Further Customizing Table Display and Event Handling.

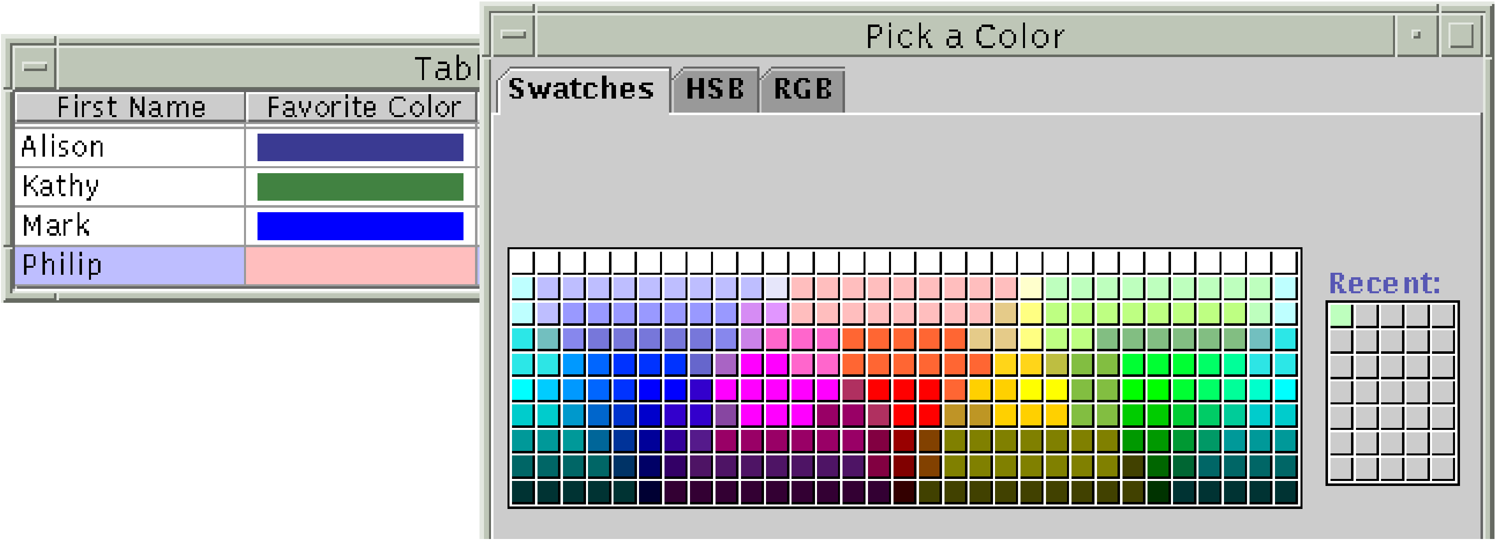
Specifying Other Editors

As the previous sections showed, you can set the editor for an entire column using the `TableColumn` `setCellEditor` method, or for a specific type of data using the `JTable` `setDefaultEditor` method. For both methods, you must specify an argument that implements the `TableCellEditor` interface. Fortunately, the `DefaultCellEditor` class implements this interface and provides constructors to let you specify an editing component that's a `JTextField`, `JCheckBox`, or `JComboBox`. You usually don't have to explicitly specify a check box as an editor, since columns with `Boolean` data automatically use a check box renderer and editor.

What if you want to specify an editor that isn't a text field, check box, or combo box? Well, because `DefaultCellEditor` doesn't support other types of components, you must do a little more work. You need to create a subclass of the desired editor component, and the subclass must implement the `TableCellEditor` interface. Then you set up the component as an editor for a data type or column, using the `setDefaultEditor` or `setCellEditor` method, respectively.

1.3 Note: The `AbstractCellEditor` class, which was added in v 1.3, makes it much easier to add support for non-standard editor components. We plan to add an example of using it. For now, you can find information in the JTable release document and the API documentation for `AbstractCellEditor`.

Here is a picture of a table with a dialog that serves, indirectly, as a cell editor. When the user begins editing a cell in the **Favorite Color** column, a button (the true cell editor) appears and brings up the dialog, with which the user can choose a different color.



First Name	Favorite Color
Alison	🟦
Kathy	🟩
Mark	🟦
Philip	🟥

You can find the code in `TableDialogEditDemo.java`. The example also requires `WholeNumberField.java`.

Further Customizing Table Display and Event Handling

You've already seen how to specify cell *editors*. You can also specify *renderers* for cells and for column headers. Customizing renderers lets you display data in custom ways and specify tool tip text for the table to display.

Although renderers determine how each cell or column header looks, they don't handle events. To pick up the events that take place inside a table, you should choose the appropriate technique for the sort of event you're interested in. For a cell that's being edited, the editor should process events. To detect row/column/cell selections and deselections, use a selection listener as described in Detecting User Selections. To detect mouse clicks on a column header, you can register a mouse listener on the table header. (See `TableSorter.java` for an example.) To detect other events, you can register the appropriate listener on the `JTable` object.

Creating a custom renderer can be as easy as creating a subclass of an existing component and then implementing the single method in the `TableCellRenderer` interface. In the preceding figure, the color renderer used for **Favorite Color** cells is a subclass of `JLabel`. You can find the code for the renderer in the `ColorRenderer` inner class in `TableDialogEditDemo.java`. Here is the code that registers a `ColorRenderer` instance as the default renderer for all `Color` data:

```
table.setDefaultRenderer(Color.class, new ColorRenderer(true));
```

You can even specify a cell-specific renderer, if you like. To do this, you need to define a `JTable` subclass that overrides the `getCellRenderer` method. For example, the following code makes the first cell in the first column of the table use a custom renderer:

```
TableCellRenderer weirdRenderer = new WeirdRenderer();
table = new JTable(...) {
    public TableCellRenderer getCellRenderer(int row, int column) {
        if ((row == 0) && (column == 0)) {
            return weirdRenderer;
        }
        // else...
        return super.getCellRenderer(row, column);
    }
};
```

To add tool tips to cells or column headers, you need to get or create the cell or header renderer, and then use the `setToolTipText` method of the renderer's component. `TableRenderDemo.java` adds tool tips to both the cells and header for the **Sport** column with the following code:

```
//Set up tool tips for the sport cells.
DefaultTableCellRenderer renderer =
        new DefaultTableCellRenderer();
renderer.setToolTipText("Click for combo box");
sportColumn.setCellRenderer(renderer);

//Set up tool tip for the sport column header.
TableCellRenderer headerRenderer = sportColumn.getHeaderRenderer();
if (headerRenderer instanceof DefaultTableCellRenderer) {
    ((DefaultTableCellRenderer)headerRenderer).setToolTipText(
             "Click the sport to see a list of choices");
}
```

1.3 Note: In the 1.3 version of the Java 2 platform, the `getHeaderRenderer` method returns `null` by default. To find the default header renderer, you instead use the new `getDefaultRenderer` method, which is defined in `JTableHeader`. For example, in the preceding snippet the red-colored code should be changed to this:

```
TableCellRenderer headerRenderer = table.getTableHeader().
        getDefaultRenderer();
```

You can find the 1.3 version of `TableRenderDemo.java` in `example-1dot3/TableRenderDemo.java`.

An interesting feature of `TableRenderDemo` is how it determines the sizes of its columns. For each column, `TableRenderDemo` gets the components used to render that column's header and cells. It then asks the components how much space they need. Finally, it uses the space information to set the column's width.

```
TableColumn column = null;
Component comp = null;
int headerWidth = 0;
int cellWidth = 0;
Object[] longValues = model.longValues;

for (int i = 0; i < 5; i++) {
    column = table.getColumnModel().getColumn(i);

    comp = column.getHeaderRenderer().
                     getTableCellRendererComponent(
                         null, column.getHeaderValue(),
                         false, false, 0, 0);
    headerWidth = comp.getPreferredSize().width;

    comp = table.getDefaultRenderer(model.getColumnClass(i)).
                     getTableCellRendererComponent(
                         table, longValues[i],
                         false, false, 0, i);
    cellWidth = comp.getPreferredSize().width;
    ...//debugging code not shown...
    column.setPreferredWidth(Math.max(headerWidth, cellWidth));
}

...//In the model:
public final Object[] longValues = {"Angela", "Andrews",
                                    "Teaching high school",
                                    new Integer(20), Boolean.TRUE};
```

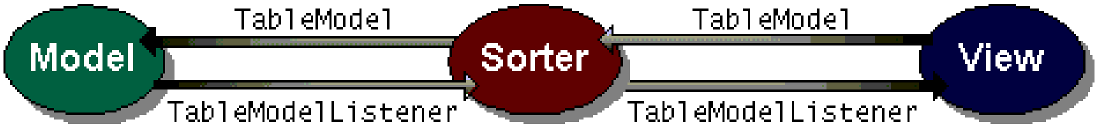
1.3 Note: Because the 1.3 `getHeaderRenderer` method returns `null` by default, you generally use the 1.3 `getDefaultRenderer` method instead. For example, the red code from the previous snippet would be replaced with this:

```
table.getTableHeader().getDefaultRenderer()
```

You can find the 1.3 version of `TableRenderDemo.java` in `example-1dot3/TableRenderDemo.java`.

Sorting and Otherwise Manipulating Data

One way to perform data manipulation such as sorting is to use one or more specialized table models (*data* *manipulators*), in addition to the table model that provides the data (the data model). The data manipulators should sit between the table and the data model, as the following picture shows:

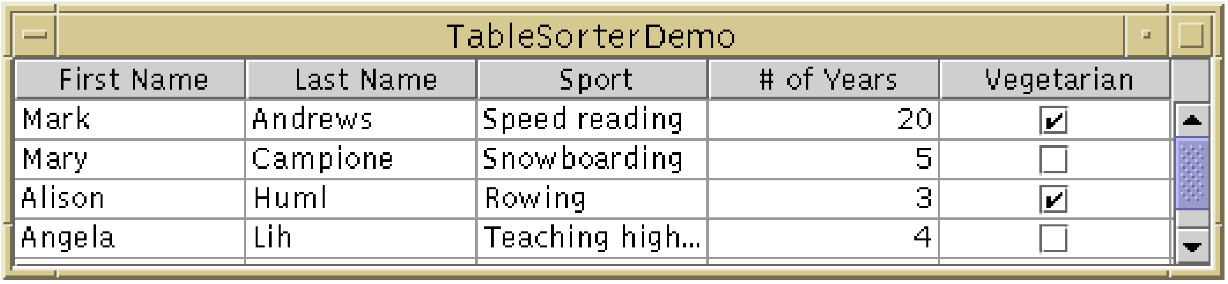


You can use the `TableMap` and `TableSorter` classes when implementing your data manipulator. [`TableMap.java`] implements `TableModel` and serves as a superclass for data manipulators. [`TableSorter.java`] is a `TableMap` subclass that sorts the data provided by another table model. You can either change these classes, using them as a basis for writing your own data manipulator, or use the classes as-is to provide sorting functionality.

To implement sorting with `TableSort`, you need just three lines of code. The following listing shows the differences between `TableDemo` and its sorting cousin, [`TableSorterDemo.java`].

```
TableSorter sorter = new TableSorter(myModel); //ADDED THIS
//JTable table = new JTable(myModel);          //OLD
JTable table = new JTable(sorter);             //NEW
sorter.addMouseListenerToHeaderInTable(table); //ADDED THIS
```

The `addMouseListenerToHeaderInTable` method adds a mouse listener that detects clicks over the column headers. When the listener detects a click, it sorts the rows based on the clicked column. As the following snapshot shows, when you click "Last Name", the rows are reordered so that the row with "Andrews" becomes the first row. When you Shift-click a column header, the rows are sorted in reverse order.



TableSorterDemo

First Name	Last Name	Sport	# of Years	Vegetarian
Mark	Andrews	Speed reading	20	☑
Mary	Campione	Snowboarding	5	□
Alison	Huml	Rowing	3	☑
Angela	Lih	Teaching high...	4	□

The Table API

The tables in this section cover just part of the table API. For more information about the table API, see the API documentation for [`JTable`] and for the various classes and interfaces in the [table package]. Also see [The JComponent Class], which describes the API that `JTable` inherits from `JComponent`. The API for using tables falls into the following categories:

- Table-Related Classes and Interfaces
- Creating and Setting Up a Table
- Manipulating Columns
- Using Editors and Renderers
- Implementing Selection

Table-Related Classes and Interfaces

Class/Interface	**Purpose**
`JTable`	The component that presents the table to the user.
`JTableHeader`	The component that presents the column names to the user. By default, the table generates this component automatically.
`TableModel`, `AbstractTableModel`	Respectively, the interface that a table model must implement and the usual superclass for table model implementations.
`TableCellRenderer`, `DefaultTableCellRenderer`	Respectively, the interface that a table cell renderer must implement and the usual implementation used.
`TableCellEditor`, `DefaultCellEditor`	Respectively, the interface that a table cell editor must implement and the usual implementation used.
`TableColumnModel`, `DefaultTableColumnModel`	Respectively, the interface that a table column model must implement and the usual implementation used. You don't usually need to deal with the table column model directly unless you need to get the column selection model, or get a column index or object.
`TableColumn`	Controls all the attributes of a table column, including resizability; minimum, preferred, current, and maximum widths; and an optional column-specific renderer/editor.
`DefaultTableModel`	A `Vector`-based table model used by `JTable` when you construct a table specifying no data model and no data.

Creating and Setting Up a Table

`JTable` Constructor/Method	**Purpose**

`JTable(TableModel)`
`JTable(TableModel, TableColumnModel)`
`JTable(TableModel, TableColumnModel, ListSelectionModel)`
`JTable()`
`JTable(int, int)`
`JTable(Object[][], Object[])`
`JTable(Vector, Vector)`
	Create a table. The optional `TableModel` argument specifies the model that provides the data to the table. The optional `TableColumnModel` and `ListSelectionModel` arguments let you specify the table column model and the row selection model. As an alternative to specifying a table model, you can supply data and column names, using arrays or vectors. Another option is to specify no data,

	optionally specifying the number of rows and columns (both integers) to be in the table.
`void setPreferredScrollableViewportSize( Dimension)`	Set the size of the visible part of the table when it's viewed within a scroll pane.
`JTableHeader getTableHeader(Dimension)`	Get the component that displays the column names.

Manipulating Columns

Constructor/Method	**Purpose**
`TableColumnModel getColumnModel()` *(in `JTable`)*	Get the table's column model.

`TableColumn getColumn(int)`
`Enumeration getColumns()`
(in `TableColumnModel`)
	Get one or all of the `TableColumn` objects for the table.

`void setMinWidth(int)`
`void setPreferredWidth(int)`
`void setMaxWidth(int)`
(in `TableColumn`)
	Set the minimum, preferred, or maximum width of the column.

`int getMinWidth(int)`
`int getPreferredWidth()`
`int getMaxWidth()`
`int getWidth()`
(in `TableColumn`)
	Get the minimum, preferred, maximum, or current width of the column.

Using Editors and Renderers

Method	**Purpose**

`void setDefaultRenderer(Class, TableCellRenderer)`
`void setDefaultEditor(Class, TableCellEditor)`
(in `JTable`)
	Set the renderer or editor used, by default, for all cells in all columns that return objects of the specified type.

`void setCellRenderer(TableCellRenderer)`
`void setCellEditor(TableCellEditor)`
(in `TableColumn`)
	Set the renderer or editor used for all cells in this column.

`TableCellRenderer getHeaderRenderer()` *(in `TableColumn`)*	Get the header renderer for this column, which you can then customize.

Implementing Selection

`JTable` Method	**Purpose**

`void setSelectionMode(int)`	Set the selection intervals allowed in the table. Valid values are defined in `ListSelectionModel` as `SINGLE_SELECTION`, `SINGLE_INTERVAL_SELECTION`, and `MULTIPLE_INTERVAL_SELECTION` (the default).

`void setSelectionModel(ListSelectionModel)`
`ListSelectionModel getSelectionModel()`
	Set or get the model used to control row selections.

`void setRowSelectionAllowed(boolean)`
`void setColumnSelectionAllowed(boolean)`
`void setCellSelectionEnabled(boolean)`
	Set the table's selection orientation. The boolean argument specifies whether that particular type of selection is allowed. By default, row selection is allowed, and column and cell selection are not.

Examples that Use Tables

This table lists examples that use `JTable` and where those examples are described.

Example	**Where Described**	**Notes**
`SimpleTableDemo`	Creating a Simple Table	A basic table with *no* custom model. Does not include code to specify column widths or detect user editing.
`SimpleTable-SelectionDemo`	Detecting User Selections	Adds single selection and selection detection to `SimpleTableDemo`. By modifying the program's `ALLOW_COLUMN_SELECTION` and `ALLOW_ROW_SELECTION` constants, you can experiment with alternatives to the table default of allowing only rows to be selected.
`TableDemo`	Creating a Table Model	A basic table with a custom model.
`TableEditDemo`, `WholeNumberField.java`	Validating User-Entered Text	Modifies `TableDemo` to use a custom editor (a text field variant) for all `Integer` data.
`TableRenderDemo`	Using a Combo Box as an Editor, Further Customizing Table Display and Event Handling	Modifies `TableDemo` to use a custom editor (a combo box) for all data in the **Sport** column. Also intelligently picks column sizes. Uses renderers to display tool tips for the **Sport** column (both cells and header).

`TableDialogEditDemo`, `WholeNumberField.java`◆	Specifying Other Editors	Modifies `TableEditDemo` to have a cell renderer and editor that display a color and let you choose a new one, using a color chooser dialog.
`TableSorterDemo`	Sorting and Otherwise Manipulating Data	Sorts column data by interposing a data manipulating table model between the data model and the table. Detects user clicks on column headers.
`ListSelectionDemo`	How to Write a List Selection Listener	Shows how to use all list selection modes, using a list selection listener that's shared between a table and list.
`SharedModelDemo`	Nowhere	Builds on `ListSelectionDemo` making the data model be shared between the table and list. If you edit an item in the first column of the table, the new value is reflected in the list.
TreeTable, TreeTable II	Creating TreeTables in Swing, Creating TreeTables: Part 2	Examples that combine a tree and table to show detailed information about a hierarchy such as a file system. The tree is a renderer for the table.

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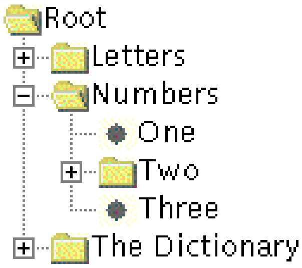
The Java^{TM} Tutorial

Trail: Creating a GUI with JFC/Swing
Lesson: Using Swing Components

How to Use Trees

With the `JTree` class, you can display hierarchical data. A `JTree` object doesn't actually contain your data; it simply provides a view of the data. Like any non-trivial Swing component, the tree gets data by querying its data model. Here's a picture of a tree:



As the preceding figure shows, `JTree` displays its data vertically. Each row displayed by the tree contains exactly one item of data, which is called a *node*. Every tree has a *root* node from which all nodes descend. By default, the tree displays the root node, but you can decree otherwise. A node can either have children or not. We refer to nodes that can have children -- whether or not they currently *have* children -- as *branch* nodes. Nodes that can't have children are *leaf* nodes.

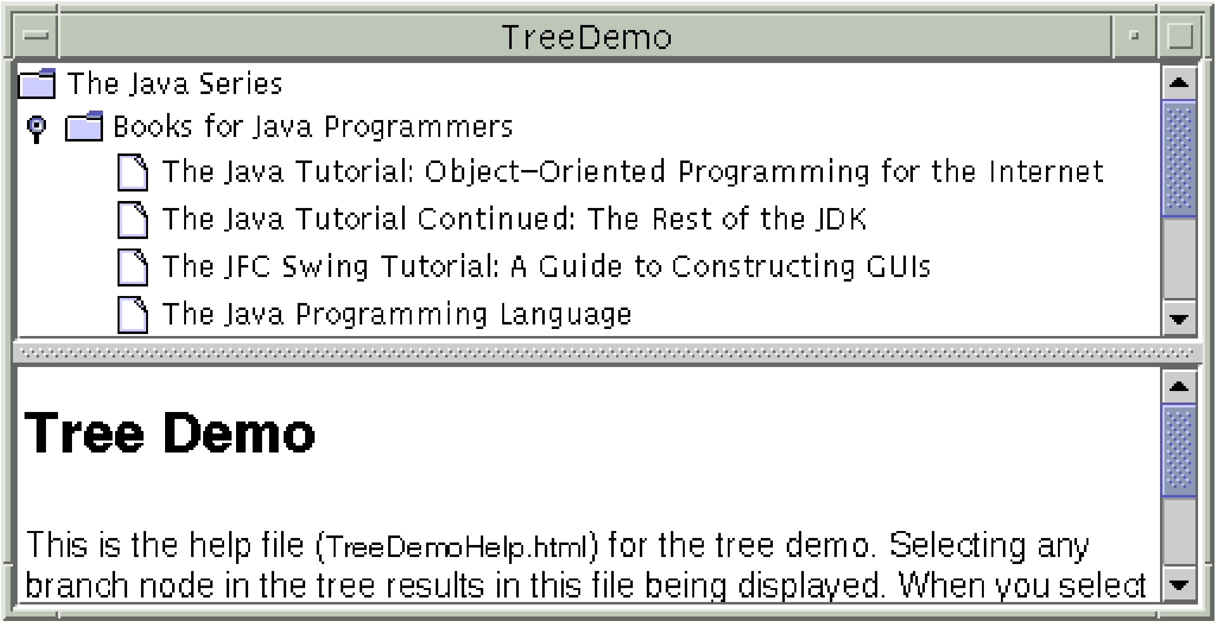
Branch nodes can have any number of children. Typically, the user can expand and collapse branch nodes -- making their children visible or invisible -- by clicking them. By default, all branch nodes except the root node start out collapsed. A program can detect changes in branch nodes' expansion state by listening for tree expansion or tree-will-expand events, as described in How to Write a Tree Expansion Listener and How to Write a Tree-Will-Expand Listener.

The rest of this section discusses the following topics:

- Creating a Tree
- Responding to Node Selection
- Customizing a Tree's Display
- Dynamically Changing a Tree
- Creating a Data Model
- The Tree API
- Examples that Use Trees

Creating a Tree

Here is a picture of an application, the top half of which displays a tree in a scroll pane.



TreeDemo
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The Java Tutorial Continued: The Rest of the JDK
The JFC Swing Tutorial: A Guide to Constructing GUIs
The Java Programming Language

Tree Demo

This is the help file (TreeDemoHelp.html) for the tree demo. Selecting any branch node in the tree results in this file being displayed. When you select

Try this:

1. Compile and run the application. The source file is `TreeDemo.java`. The program also looks for several HTML files. See the examples index for links to all the files required by this example.
   See Getting Started with Swing if you need help compiling or running this application.
2. Expand one or more nodes.
   You can do this by clicking the circle to the left of the item.
3. Collapse a node.
   You do this by clicking the circle to the left of an expanded node.

The following code, taken from `TreeDemo.java`, creates the `JTree` object:

```
DefaultMutableTreeNode top =
    new DefaultMutableTreeNode("The Java Series");
createNodes(top);
final JTree tree = new JTree(top);
...
JScrollPane treeView = new JScrollPane(tree);
```

The code creates an instance of `DefaultMutableTreeNode` to serve as the root node for the tree. It then creates the rest of the nodes in the tree. After that, it creates the tree, specifying the root node as an argument to the `JTree` constructor. Finally, it puts the tree in a scroll pane, a common tactic because showing the full, expanded tree would otherwise require too much space.

Here is the code that creates the nodes under the root node:

```
private void createNodes(DefaultMutableTreeNode top) {
    DefaultMutableTreeNode category = null;
    DefaultMutableTreeNode book = null;

    category = new DefaultMutableTreeNode(
        "Books for Java Programmers");
    top.add(category);

    //original Tutorial
    book = new DefaultMutableTreeNode(new BookInfo
        ("The Java Tutorial: Object-Oriented "
         + "Programming for the Internet",
        "tutorial.html"));
    category.add(book);

    //Tutorial Continued
    book = new DefaultMutableTreeNode(new BookInfo
        ("The Java Tutorial Continued: The Rest of the JDK",
        "tutorialcont.html"));
    category.add(book);

    //JFC Swing Tutorial
    book = new DefaultMutableTreeNode(new BookInfo
        ("The JFC Swing Tutorial: "
         + "A Guide to Constructing GUIs",
        "swingtutorial.html"));
    category.add(book);

    //...add many more books for programmers...

    category = new DefaultMutableTreeNode(
        "Books for Java Implementers");
    top.add(category);

    //VM
    book = new DefaultMutableTreeNode(new BookInfo
        ("The Java Virtual Machine Specification",
         "vm.html"));
    category.add(book);

    //Language Spec
    book = new DefaultMutableTreeNode(new BookInfo
        ("The Java Language Specification",
         "jls.html"));
    category.add(book);
}
```

The argument to the `DefaultMutableTreeNode` constructor is the *user object* -- an object that contains or points to the data associated with the tree node. The user object can be a string, or it can be a custom object. If you implement a custom object, you should implement its `toString` method so that it returns the string to be displayed for that node.

For example, the `BookInfo` class used in the previous code snippet is a custom class that holds two pieces of data: the name of a book, and the URL for an HTML file describing the book. The `toString` method is implemented to return the book name. Thus, each node associated with a `BookInfo` object displays a book name.

Note: Swing 1.1.1 Beta 1 introduced the ability to specify HTML text for the string displayed by tree nodes. See Using HTML on a Label for details.

To summarize, you can create a tree by invoking the `JTree` constructor, specifying the root node as an argument. You should probably put the tree inside a scroll pane, so that the tree won't take up too much space. You don't have to do anything to make the tree nodes expand and collapse in response to user clicks. However, you do have to add some code to make the tree respond when the user selects a node -- by clicking the node, for example.

Responding to Node Selection

Responding to tree node selections is simple. You implement a tree selection listener and register it on the tree, The following code shows the selection-related code from the `TreeDemo` program:

```
tree.getSelectionModel().setSelectionMode
        (TreeSelectionModel.SINGLE_TREE_SELECTION);

//Listen for when the selection changes.
tree.addTreeSelectionListener(new TreeSelectionListener() {
    public void valueChanged(TreeSelectionEvent e) {
        DefaultMutableTreeNode node = (DefaultMutableTreeNode)
                           tree.getLastSelectedPathComponent();

        if (node == null) return;

        Object nodeInfo = node.getUserObject();
        if (node.isLeaf()) {
            BookInfo book = (BookInfo)nodeInfo;
            displayURL(book.bookURL);
        } else {
            displayURL(helpURL);
        }
    }
});
```

The preceding code performs these tasks:

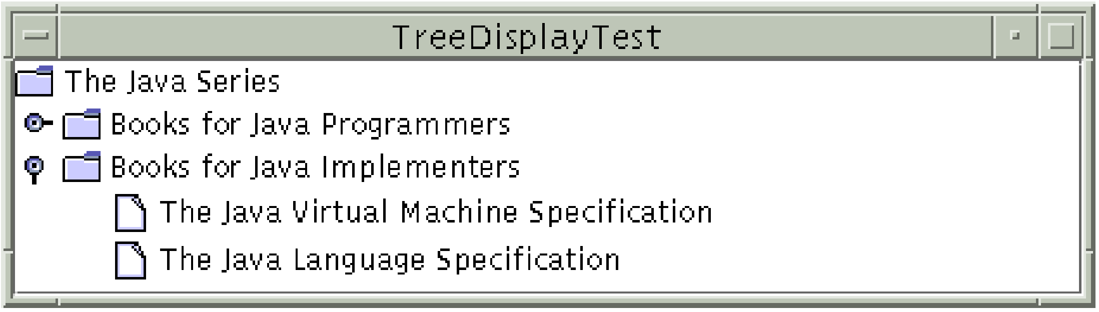
- Gets the default `TreeSelectionModel` for the tree, and then sets it up so that at most one

tree node at a time can be selected.
- Creates an event handler and registers it on the tree. The event handler is an object that implements the `TreeSelectionListener` interface.
- In the event handler, determines which node is selected by invoking the tree's `getLastSelectedPathComponent` method.
- Uses the `getUserObject` method to get the data associated with the node.

For more details about handling tree selection events, see How to Write a Tree Selection Listener.

Customizing a Tree's Display

Here is a picture of some tree nodes, as drawn by the Java, Windows, and Motif Look & Feel implementations.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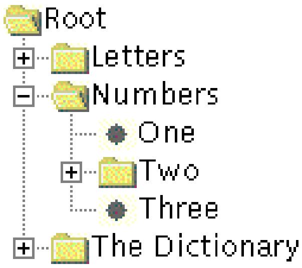
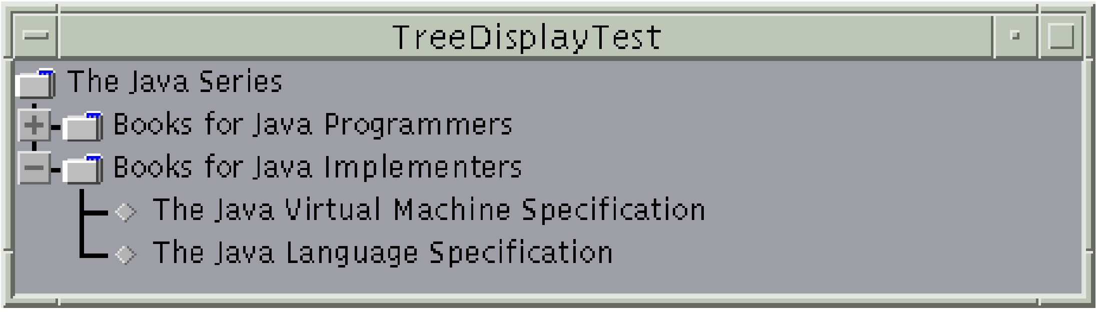
The Java Language Specification

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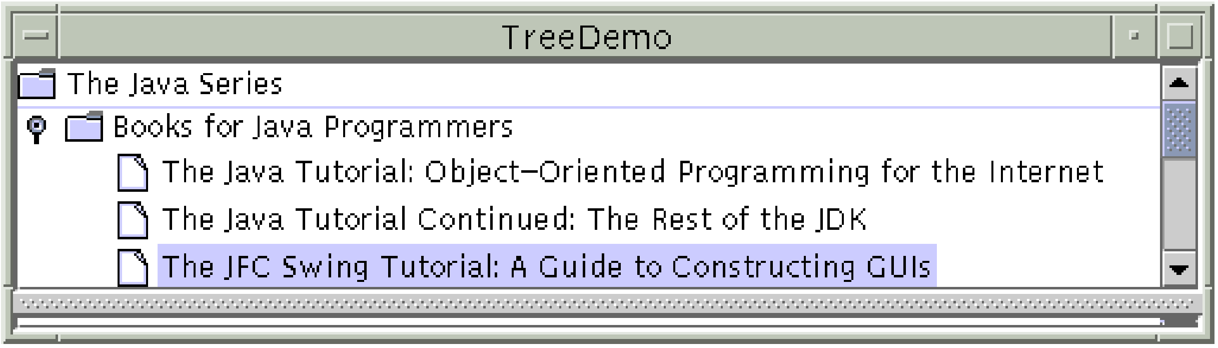
As the preceding figures show, a tree conventionally displays an icon and some text for each node. You can customize these, as we'll show shortly.

A tree typically also performs some look-and-feel-specific painting to indicate relationships between nodes. You can customize this painting in a limited way. First, you can use `tree.setShowsRootHandles(true)` to request that a tree's top-level nodes -- the root node (if it's visible) or its children (if not) -- have handles that let them be expanded or collapsed. Second, if you're using the Java Look & Feel, you can customize whether lines are drawn to show relationships between tree nodes.

By default, the Java Look & Feel draws no lines between nodes. By setting the `JTree.lineStyle` client property of a tree, you can specify a different convention. For example, to request that the Java Look & Feel use horizontal lines to group nodes (as shown in the next figure), use the following code:

```
tree.putClientProperty("JTree.lineStyle", "Horizontal");
```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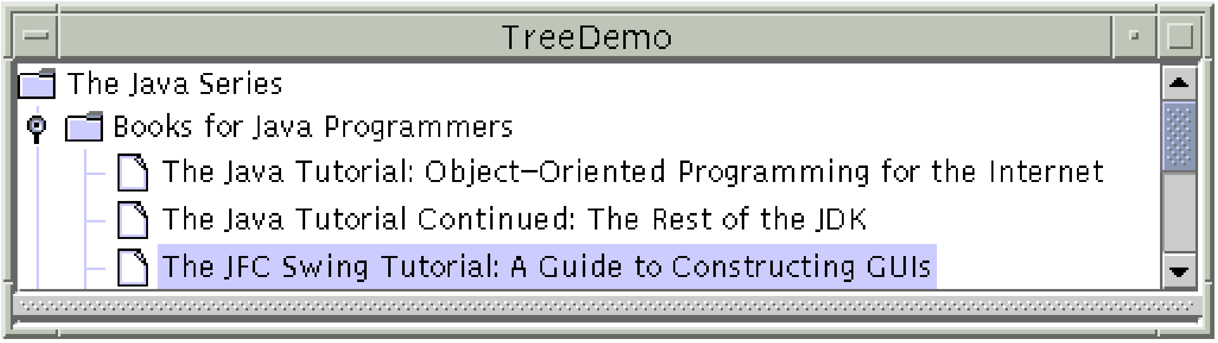
To specify that the Java Look & Feel should draw lines detailing the relationships between nodes (as shown in the next figure), use this code:

```
tree.putClientProperty("JTree.lineStyle", "Angled");
```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No matter what the look and feel, the default icon displayed by a node is determined by whether the node is a leaf and, if not, whether it's expanded. For example, in the Windows and Motif Look & Feel implementations, the default icon for each leaf node is a dot; in the Java Look & Feel, the default leaf icon is a paper-like symbol. In all the look-and-feel implementations we've shown, branch nodes are marked with folder-like symbols. The Windows Look & Feel even has different icons for expanded branches versus collapsed branches.

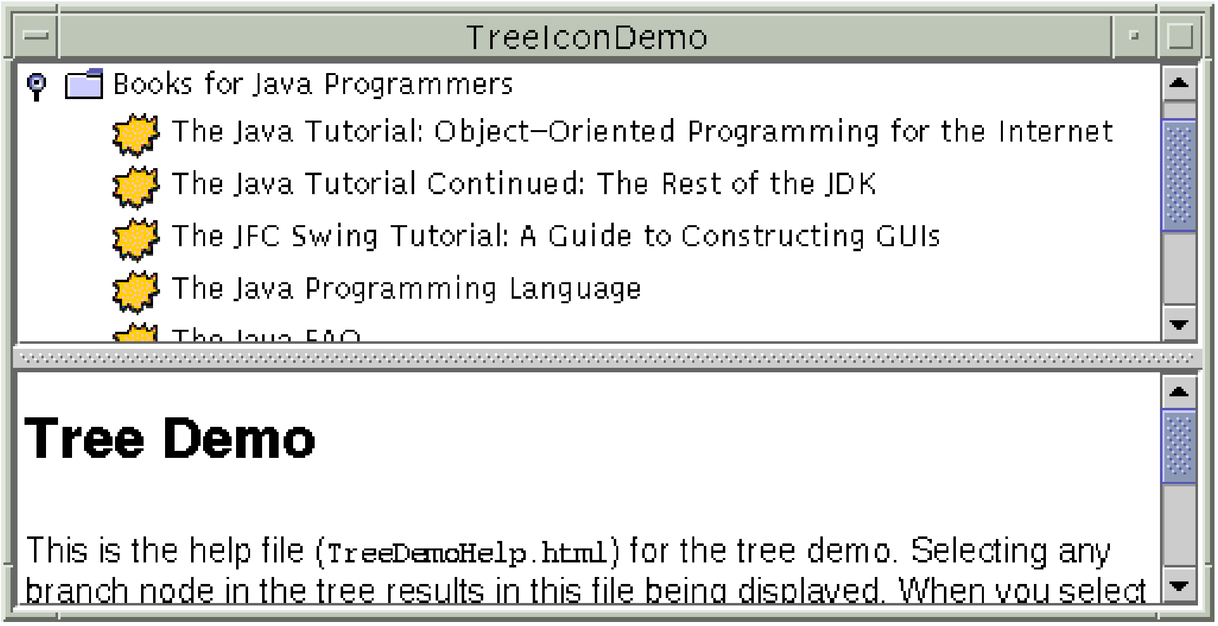
You can easily change the default icon used for leaf, expanded branch, or collapsed branch nodes. To do so, you first create an instance of `DefaultTreeCellRenderer`. Next, specify the icons to use by invoking one or more of the following methods on the renderer: `setLeafIcon` (for leaf nodes), `setOpenIcon` (for expanded branch nodes), `setClosedIcon` (for collapsed branch nodes). If you want the tree to display no icon for a type of node, then specify `null` for the icon. Once you've set up the icons, use the tree's `setCellRenderer` method to specify that the `DefaultTreeCellRenderer` paint its nodes.

> **Note:** In the Swing 1.0 releases, `DefaultTreeCellRenderer` used to be called `BasicTreeCellRenderer` and was part of the `com.sun.java.swing.plaf.basic` package.

Here is an example, taken from `TreeIconDemo.java`:

```
DefaultTreeCellRenderer renderer = new DefaultTreeCellRenderer();
renderer.setLeafIcon(new ImageIcon("images/middle.gif"));
tree.setCellRenderer(renderer);
```

Here is what the resulting UI looks like:



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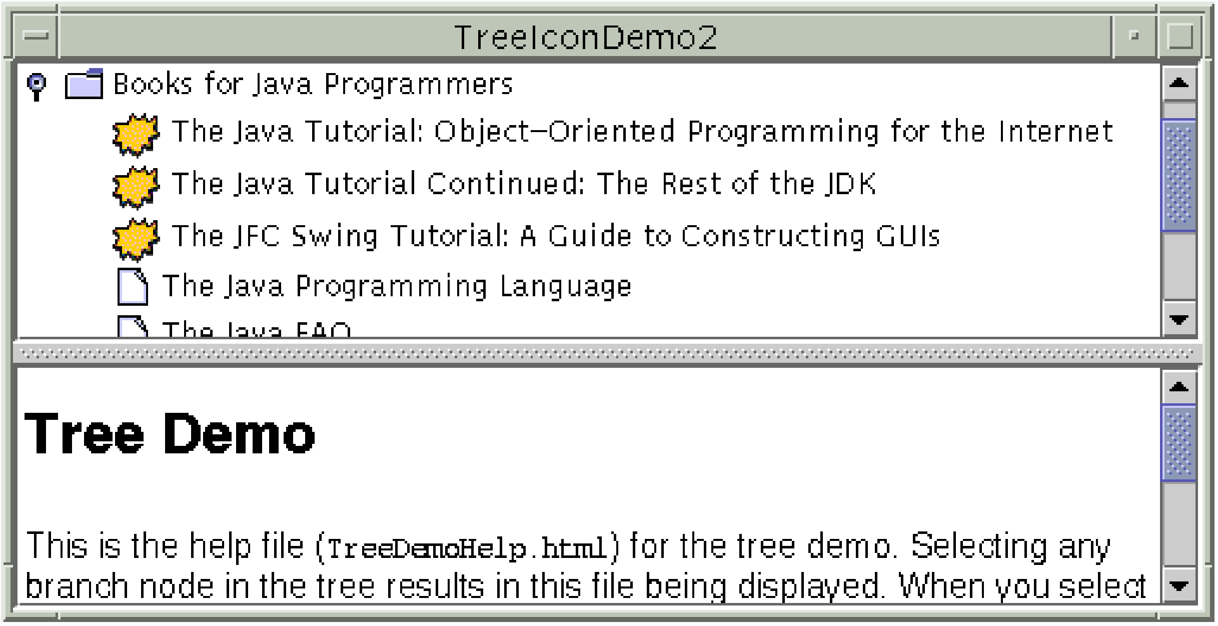
Tree Demo

This is the help file (`TreeDemoHelp.html`) for the tree demo. Selecting any branch node in the tree results in this file being displayed. When you select

If you want finer control over the node icons or you want to provide tool tips, you can do so by creating a subclass of `DefaultTreeCellRenderer` and overriding the `getTreeCellRendererComponent` method. Because `DefaultTreeCellRenderer` is a subclass of `JLabel`, you can use any `JLabel` method -- such as `setIcon` -- to customize the `DefaultTreeCellRenderer`. Here is an example of creating a cell renderer that varies the leaf icon depending on whether the word "Tutorial" is in the node's text data. The renderer also specifies tool-tip text, as the bold lines show. You can find the entire example in `TreeIconDemo2.java`.

```
//...where the tree is initialized:
//Enable tool tips.
ToolTipManager.sharedInstance().registerComponent(tree);
...
tree.setCellRenderer(new MyRenderer());
...
class MyRenderer extends DefaultTreeCellRenderer {
    ImageIcon tutorialIcon;

    public MyRenderer() {
        tutorialIcon = new ImageIcon("images/middle.gif");
    }

    public Component getTreeCellRendererComponent(
                        JTree tree,
                        Object value,
                        boolean sel,
                        boolean expanded,
                        boolean leaf,
                        int row,
                        boolean hasFocus) {

        super.getTreeCellRendererComponent(
                        tree, value, sel,
                        expanded, leaf, row,
                        hasFocus);
        if (leaf && isTutorialBook(value)) {
            setIcon(tutorialIcon);
            setToolTipText("This book is in the Tutorial series.");
        } else {
            setToolTipText(null); //no tool tip
        }

        return this;
    }

    protected boolean isTutorialBook(Object value) {
        DefaultMutableTreeNode node =
                (DefaultMutableTreeNode)value;
        BookInfo nodeInfo =
                (BookInfo)(node.getUserObject());
        String title = nodeInfo.bookName;
        if (title.indexOf("Tutorial") >= 0) {
            return true;
        }

        return false;
    }
}
```

Here is the result: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Tree Demo

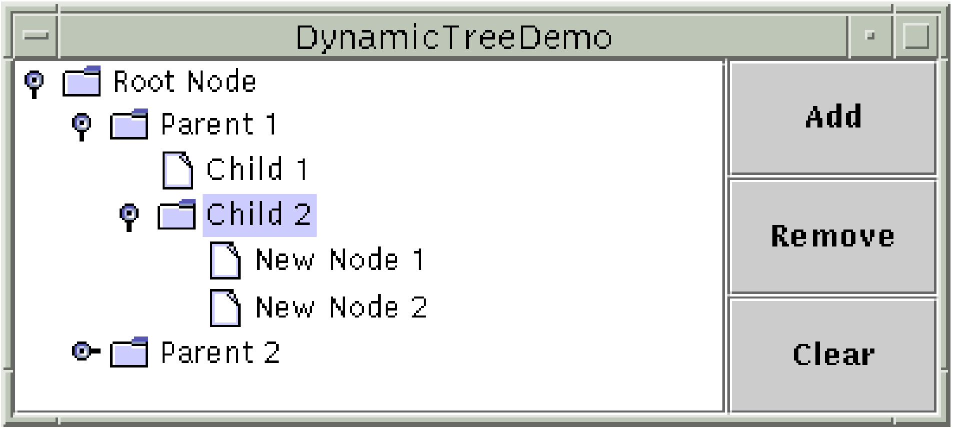
This is the help file (TreeDemoHelp.html) for the tree demo. Selecting any branch node in the tree results in this file being displayed. When you select

You might be wondering how a cell renderer works. When a tree paints each node, neither the `JTree` nor its look-and-feel-specific implementation actually contains the code that paints the node. Instead, the tree uses the cell renderer's painting code to paint the node. For example, to paint a leaf node that has the string "The Java Programming Language", the tree asks its cell renderer to return a component that can paint a leaf node with that string. If the cell renderer is a `DefaultTreeCellRenderer`, then it returns a label that paints the default leaf icon followed by the string.

A cell renderer only paints; it cannot handle events. If you want to add event handling to a tree, you need to register your handler on either the tree or, if the handling occurs only when a node is selected, the tree's *cell editor*. For information about cell editors, see Concepts: Cell Editors and Renderers. That section discusses table cell editors and renderers, which are similar to tree cell editors and renderers.

Dynamically Changing a Tree

The following figure shows an application that lets you add nodes to and remove nodes from a visible tree. You can also edit the text in each node.



The application is based on an example provided by tutorial reader Richard Stanford. You can find the source code in `DynamicTreeDemo.java` and `DynamicTree.java`. Here is the code that initializes the tree:

```
rootNode = new DefaultMutableTreeNode("Root Node");
treeModel = new DefaultTreeModel(rootNode);

tree = new JTree(treeModel);
tree.setEditable(true);
tree.getSelectionModel().setSelectionMode
        (TreeSelectionModel.SINGLE_TREE_SELECTION);
tree.setShowsRootHandles(true);
```

By explicitly creating the tree's model, the code guarantees that the tree's model is an instance of `DefaultTreeModel`. That way, we know all the methods that the tree model supports. For example, we know that we can invoke the model's `insertNodeInto` method, even though that method is not required by the `TreeModel` interface.

To make the text in the tree's nodes editable, we invoke `setEditable(true)` on the tree. When the user has finished editing a node, the model generates a tree model event that tells any listeners that tree nodes have changed. To catch this event, we can implement a `TreeModelListener`. Here is an example of a tree model listener we implemented to detect when the user has typed in a new name for a tree node:

```
...
treeModel.addTreeModelListener(new MyTreeModelListener());
...
class MyTreeModelListener implements TreeModelListener {
    public void treeNodesChanged(TreeModelEvent e) {
        DefaultMutableTreeNode node;
        node = (DefaultMutableTreeNode)
                 (e.getTreePath().getLastPathComponent());

        /*
         * If the event lists children, then the changed
         * node is the child of the node we've already
         * gotten.  Otherwise, the changed node and the
         * specified node are the same.
         */
        try {
            int index = e.getChildIndices()[0];
            node = (DefaultMutableTreeNode)
                   (node.getChildAt(index));
        } catch (NullPointerException exc) {}

        System.out.println("The user has finished editing the node.");
        System.out.println("New value: " + node.getUserObject());
    }
    public void treeNodesInserted(TreeModelEvent e) {
    }
    public void treeNodesRemoved(TreeModelEvent e) {
    }
    public void treeStructureChanged(TreeModelEvent e) {
    }
}
```

Here is the code that the **Add** button's event handler uses to add a new node to the tree:

```
public void actionPerformed(ActionEvent e) {
   treePanel.addObject("New Node " + newNodeSuffix++);
}
...
public DefaultMutableTreeNode addObject(Object child) {
    DefaultMutableTreeNode parentNode = null;
    TreePath parentPath = tree.getSelectionPath();

    if (parentPath == null) {
        //There's no selection. Default to the root node.
        parentNode = rootNode;
    } else {
        parentNode = (DefaultMutableTreeNode)
                     (parentPath.getLastPathComponent());
    }

    return addObject(parentNode, child, true);
}
...
public DefaultMutableTreeNode addObject(DefaultMutableTreeNode parent,
                                        Object child,
                                        boolean shouldBeVisible) {
    DefaultMutableTreeNode childNode =
            new DefaultMutableTreeNode(child);
    ...
    treeModel.insertNodeInto(childNode, parent,
                             parent.getChildCount());

    // Make sure the user can see the lovely new node.
    if (shouldBeVisible) {
        tree.scrollPathToVisible(new TreePath(childNode.getPath()));
    }
    return childNode;
}
```

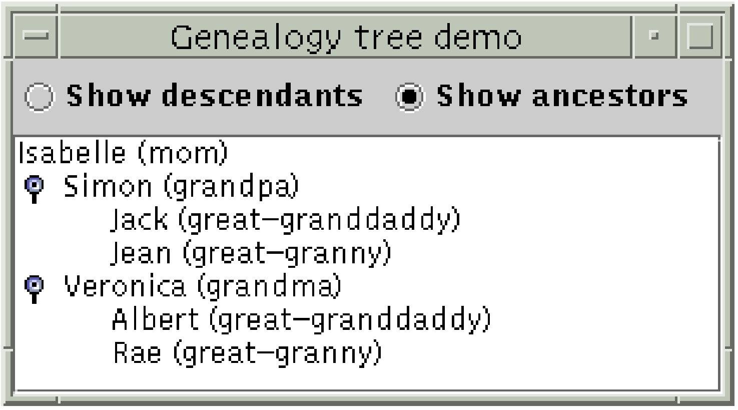
The code creates a node, inserts it into the tree model, and then, if appropriate, requests that the nodes above it be expanded and the tree scrolled so that the new node is visible. To insert the node into the model, the code uses the `insertNodeInto` method provided by the `DefaultTreeModel` class.

Creating a Data Model

If `DefaultTreeModel` doesn't suit your needs, then you'll need to write a custom data model. Your data model must implement the `TreeModel` interface. `TreeModel` specifies methods for getting a particular node of the tree, getting the number of children of a particular node, determining whether a node is a leaf, notifying the model of a change in the tree, and adding and removing tree model listeners.

Interestingly, the `TreeModel` interface accepts any kind of object as a tree node. It doesn't require that nodes be represented by `DefaultMutableTreeNode` objects, or even that nodes implement the `TreeNode` interface. Thus, if the `TreeNode` interface isn't suitable for your tree model, feel free to devise your own representation for tree nodes.

The following figure shows an application that displays the descendents or ancestors of a particular person. (Thanks to tutorial reader Olivier Berlanger for providing this example.)



Isabelle (mom)
Simon (grandpa)
Jack (great-granddaddy)
Jean (great-granny)
Veronica (grandma)
Albert (great-granddaddy)
Rae (great-granny)

You can find the custom tree model implementation in `GenealogyModel.java`. A simple `JTree` subclass that works with `GenealogyModel` is in `GenealogyTree.java`. The tree node class is defined in `Person.java`, and the application's GUI is created by the `main` method in `GenealogyExample.java`.

The Tree API

The tree API is quite extensive. The following tables list just a bit of the API, concentrating on the following categories:

- Tree-Related Classes and Interfaces
- Creating and Setting Up a Tree
- Implementing Selection
- Showing and Hiding Nodes

For more information about the tree API, see the API documentation for `JTree` and for the various classes and interfaces in the tree package. Also refer to The JComponent Class for information on the API `JTree` inherits from its superclass.

Tree-Related Classes and Interfaces

Class/Interface	**Purpose**
`JTree`	The component that presents the tree to the user.
`MutableTreeNode`◆, `DefaultMutableTreeNode`	The interfaces that the default tree model expects its tree nodes to implement, and the implementation used by the default tree model.
`TreeModel`, `DefaultTreeModel`	Respectively, the interface that a tree model must implement and the usual implementation used.
`TreeCellRenderer`◆, `DefaultTreeCellRenderer`	Respectively, the interface that a tree cell renderer must implement and the usual implementation used.
`TreeCellEditor`◆, `DefaultTreeCellEditor`◆	Respectively, the interface that a tree cell editor must implement and the usual implementation used.
`TreeSelectionModel`, `DefaultTreeSelectionModel`◆	Respectively, the interface that the tree's selection model must implement and the usual implementation used.
`TreeSelectionListener`◆, `TreeSelectionEvent`◆	The interface and event type used for detecting tree selection changes. For more information, see How to Write a Tree Selection Listener◆.
`TreeModelListener`◆, `TreeModelEvent`◆	The interface and event type used for detecting tree model changes. For more information, see How to Write a Tree Model Listener◆.
`TreeExpansionListener`◆, `TreeWillExpandListener`◆, `TreeExpansionEvent`◆	The interfaces and event type used for detecting tree expansion and collapse. For more information, see How to Write a Tree Expansion Listener◆ and How to Write a Tree-Will-Expand Listener◆.
`ExpandVetoException`◆	An exception that a `TreeWillExpandListener` can throw to indicate that the impending expansion/collapse should not happen. For more information, see How to Write a Tree-Will-Expand Listener◆.

Creating and Setting Up a Tree

`JTree` Constructor/Method	**Purpose**

`JTree(TreeNode)`
`JTree(TreeNode, boolean)`
`JTree(TreeModel)`
`JTree()`
`JTree(Hashtable)`
`JTree(Object[])`
`JTree(Vector)`
	Create a tree. The `TreeNode` argument specifies the root node, to be managed by the default tree model. The `TreeModel` argument specifies the model that provides the data to the table. The `boolean` argument specifies how the tree should determine whether a node can have children. The no-argument version of this constructor is for use in builders; it creates a tree that contains some sample data. If you specify a `Hashtable`, array of objects, of `Vector` as an argument, then the argument is treated as a list of nodes under the root node (which is not displayed), and a model and tree nodes are constructed accordingly.

`void setCellRenderer(TreeCellRenderer)`	Sets the renderer that draws each node.
`void setEditable(boolean)`, `void setCellEditor(TreeCellEditor)`	The first method sets whether the user can edit tree nodes. By default, tree nodes are not editable. The second sets which customized editor to use.
`void setShowsRootHandles(boolean)`	Sets whether the tree shows handles for its leftmost nodes, letting you expand and collapse the nodes. The default is false. If the tree doesn't show the root node, then you should invoke `setShowsRootHandles(true)`.

Implementing Selection

Method	**Purpose**
`void addTreeSelectionListener( TreeSelectionListener)`	Registers a listener to detect when the a node is selected or deselected.

`void setSelectionModel(TreeSelectionModel)`
`TreeSelectionModel getSelectionModel()`
	Set or get the model used to control node selections. You can turn off node selection completely using `setSelectionModel(null)`.

`void setSelectionMode(int)`
`int getSelectionMode()`
(in `TreeSelectionModel`)
	Set or get the selection mode. The value can be `CONTIGUOUS_TREE_SELECTION`, `DISCONTIGUOUS_TREE_SELECTION`, or `SINGLE_TREE_SELECTION` (all defined in `TreeSelectionModel`).

`Object getLastSelectionPathComponent()`	Get the object representing the currently selected node. This is equivalent to invoking `getLastPathComponent` on the value returned by `tree.getSelectionPath()`.

`void setSelectionPath(TreePath)`
`TreePath getSelectionPath()`
	Set or get the path to the currently selected node.

`void setSelectionPaths(TreePath[])`
`TreePath[] getSelectionPaths()`
	Set or get the paths to the currently selected nodes.

`void setSelectionPath(TreePath)`
`TreePath getSelectionPath()`
	Set or get the path to the currently selected node.

Showing and Hiding Nodes

Method	**Purpose**

`void addTreeExpansionListener(`
`TreeExpansionListener)`
`void addTreeWillExpandListener(`
`TreeWillExpandListener)`
	Register a listener to detect when the tree nodes *have* expanded or collapsed, or *will be* expanded or collapsed, respectively. To veto an impending expansion or collapse, a `TreeWillExpandListener` can throw a `ExpandVetoException`.

`void expandPath(TreePath)`
`void collapsePath(TreePath)`
	Expand or collapse the specified tree path.

`void scrollPathToVisible(TreePath)`	Ensures that the node specified by the path is visible -- that the path leading up to it is expanded and the node is in the scroll pane's viewing area.
`void makeVisible(TreePath)`	Ensures that the node specified by the path is viewable -- that the path leading up to it is expanded. The node might not end up within the viewing area.

`void setScrollsOnExpand(boolean)`
`boolean getScrollsOnExpand()`
	Set or get whether the tree attempts to scroll to show previous hidden nodes. The default value is true.

Examples that Use Trees

This table lists examples that use `JTree` and where those examples are described.

Example	**Where Described**	**Notes**
`TreeDemo`	Creating a Tree, Responding to Node Selection, Customizing a Tree's Display	Creates a tree that responds to user selections. It also has code for customizing the line style for the Java Look & Feel.
`TreeIconDemo`	Customizing a Tree's Display	Adds a custom leaf icon to `TreeDemo`.
`TreeIconDemo2`	Customizing a Tree's Display	Customizes certain leaf icons and also provides tool tips for certain tree nodes.

DynamicTreeDemo	Dynamically Changing a Tree	Illustrates adding and removing nodes from a tree. Also allows editing of node text.
GenealogyTree.java◆, GenealogyModel.java◆	Creating a Data Model	Implements a custom tree model.
TreeExpandEventDemo	How to Write a Tree Expansion Listener◆	Shows how to detect node expansions and collapses.
TreeExpandEventDemo2	How to Write a Tree-Will-Expand Listener◆	Shows how to veto node expansions.
TreeTable, TreeTable II	Creating TreeTables in Swing, Creating TreeTables: Part 2	Examples that combine a tree and table to show detailed information about a hierarchy such as a file system. The tree is a renderer for the table.

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Using Atomic Components

The rest of this lesson discusses the atomic components -- components that exist solely to present and perhaps accept information, rather than to contain other components. Although atomic components sometimes are implemented by combining components -- for example, an editable combo box consists of components such as a text field, button, and menu -- these combinations are look-and-feel-specific and thus not to be relied on or tampered with. An atomic component is a single entity, both to the user and to the programmer who uses its API. To see pictures of all the atomic components, go to A Visual Index to the Swing Components.

All the atomic components descend from the `JComponent` class. Thus, they all support standard features such as tool tips and borders. For more information about the API and features all atomic components support, see The JComponent Class.

The following atomic components exist primarily to get input from the user:

Button, Check Box, Radio Button	Provides easy-to-use, easy-to-customize button implementations.
Combo Box	Provides both uneditable and editable combo boxes -- buttons that bring up menus of choices.
List	Displays a group of items that the user can choose.
Menu	Includes menu bar, menu, and menu item implementations, including specialized menu items such as check box menu items.
Slider	Lets the user choose one of a continuous range of values.
Text Field	Lets the user enter a single line of text data.

Some atomic components exist only to give information:

Label	Presents some text, an icon, or both.

Progress Bar	Displays progress toward a goal.
Tool Tip	Brings up a small window that describes another component.

The rest of the atomic components provide formatted information and a way of editing it:

Color Chooser	A UI for choosing colors; can be used inside or outside a dialog.
File Chooser	A UI for choosing files and directories.
Table	An extremely flexible component that displays data in a grid format.
Text Support	A framework including everything from simple text components, such as text fields, to a full-featured, extensible kit for building text editors.
Tree	A component that displays hierarchical data.

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```
import java.awt.*;
import java.awt.event.*;
import javax.swing.AbstractButton;
import javax.swing.JButton;
import javax.swing.JPanel;
import javax.swing.JFrame;
import javax.swing.ImageIcon;

public class ButtonDemo extends JPanel
                        implements ActionListener {
    protected JButton b1, b2, b3;

    public ButtonDemo() {
        ImageIcon leftButtonIcon = new ImageIcon("images/right.gif");
        ImageIcon middleButtonIcon = new ImageIcon("images/middle.gif");
        ImageIcon rightButtonIcon = new ImageIcon("images/left.gif");

        b1 = new JButton("Disable middle button", leftButtonIcon);
        b1.setVerticalTextPosition(AbstractButton.CENTER);
        b1.setHorizontalTextPosition(AbstractButton.LEFT);
        b1.setMnemonic(KeyEvent.VK_D);
        b1.setActionCommand("disable");

        b2 = new JButton("Middle button", middleButtonIcon);
        b2.setVerticalTextPosition(AbstractButton.BOTTOM);
        b2.setHorizontalTextPosition(AbstractButton.CENTER);
        b2.setMnemonic(KeyEvent.VK_M);

        b3 = new JButton("Enable middle button", rightButtonIcon);
        //Use the default text position of CENTER, RIGHT.
        b3.setMnemonic(KeyEvent.VK_E);
        b3.setActionCommand("enable");
        b3.setEnabled(false);

        //Listen for actions on buttons 1 and 3.
        b1.addActionListener(this);
        b3.addActionListener(this);

        b1.setToolTipText("Click this button to disable the middle button.");
        b2.setToolTipText("This middle button does nothing when you click it.");
        b3.setToolTipText("Click this button to enable the middle button.");

        //Add Components to this container, using the default FlowLayout.
        add(b1);
        add(b2);
        add(b3);
    }

    public void actionPerformed(ActionEvent e) {
        if (e.getActionCommand().equals("disable")) {
            b2.setEnabled(false);
            b1.setEnabled(false);
            b3.setEnabled(true);
        } else {
            b2.setEnabled(true);
            b1.setEnabled(true);
            b3.setEnabled(false);
        }
    }

    public static void main(String[] args) {
        JFrame frame = new JFrame("ButtonDemo");
        frame.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });

        frame.getContentPane().add(new ButtonDemo(), BorderLayout.CENTER);
        frame.pack();
        frame.setVisible(true);
    }
}
```

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Trail: Creating a GUI with JFC/Swing

Lesson: Getting Started with Swing

This lesson gives you a quick introduction to using the JFC Swing packages to create a program's GUI. First, it tells you what the JFC and Swing are. Next, it helps you get the necessary releases and use them to compile and run a Swing program. Then it shows you how to run applets. Finally, it takes you on a whirlwind tour of a simple Swing application.

If you're more interested in learning concepts than in running programs right now, feel free to skip part or all of this lesson and to go to the next lesson, Swing Features and Concepts ◆. Then return here when you're ready to start programming.

About the JFC and Swing

This section gives you a little history about the JFC and Swing. If you've developed programs using AWT components, you'll probably be interested in the description of the differences between AWT and Swing components.

Compiling and Running Swing Programs

To write programs using the Swing components, you must first download the appropriate JDK and JFC releases. Then you can follow this section's instructions to compile and run the small Swing application provided.

Running Swing Applets

To write Swing applets, you must first be able to run them. This section provides two applets, with instructions for running them.

A Quick Tour of a Swing Application's Code

This section takes you through the code for a small Swing application. You'll see the code that a Swing application absolutely must have, and you'll learn about some commonly used

Swing features.

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Trail: Creating a GUI with JFC/Swing
Lesson: Writing Event Listeners

How to Write an Item Listener

Item events are fired by components that implement the `ItemSelectable`◆ interface. Generally, `ItemSelectable` components maintain on/off state for one or more items. The Swing components that fire item events include check boxes◆, check box menu items◆, and combo boxes◆.

Here is some item-event handling code taken from `ComponentEventDemo.java`◆:

```
...
//where initialization occurs
checkbox.addItemListener(this);
...
public void itemStateChanged(ItemEvent e) {
    if (e.getStateChange() == ItemEvent.SELECTED) {
        label.setVisible(true);

        label.revalidate();
        label.repaint();
    } else {
        label.setVisible(false);
    }
}
```

The Item Event API

The `ItemListener`◆ interface has just one method, so it has no corresponding adapter class. Here's the method:

`void itemStateChanged(ItemEvent)`
Called just after a state change in the listened-to component.

The `itemStateChanged` method hod has a single parameter: an `ItemEvent`◆ object. The `ItemEvent` class defines the following handy methods:

`Object getItem()`

Returns the component-specific object associated with the item whose state changed. Often this is a `String` containing the text on the selected item.

`ItemSelectable getItemSelectable()`

Returns the component that fired the item event. You can use this instead of the `getSource` method.

`int getStateChange()`

Returns the new state of the item. The `ItemEvent` class defines two states: `SELECTED` and `DESELECTED`.

Examples that Use Item Listeners

The following table lists some of examples that use item listeners.

Example	Where Described	Notes
`ComponentEventDemo`	This section and How to Write a Component Listener	Listens for item events on a check box, which determines whether a lable is visible.
`CheckBoxDemo`	How to Use Check Boxes◆	Four check boxes share one item listener, which uses `getItemSelected` to determine which check box fired the event.
`MenuDemo`	How to Use Menus◆	Listens for item events on a check box menu item.

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

/**
 * Use this modal dialog to let the user choose one string from a long
 * list.  See the main method for an example of using ListDialog.  The
 * basics:
 * <pre>
    String[] choices = {"A", "long", "array", "of", "strings"};
    ListDialog.initialize(componentInControllingFrame, choices,
                          "Dialog Title",
                          "A description of the list:");
    String selectedName = ListDialog.showDialog(locatorComponent,
                                                initialSelection);
 * </pre>
 */
public class ListDialog extends JDialog {
    private static ListDialog dialog;
    private static String value = "";
    private JList list;

    /**
     * Set up the dialog.  The first argument can be null,
     * but it really should be a component in the dialog's
     * controlling frame.
     */
    public static void initialize(Component comp,
                                  String[] possibleValues,
                                  String title,
                                  String labelText) {
        Frame frame = JOptionPane.getFrameForComponent(comp);
        dialog = new ListDialog(frame, possibleValues,
                                title, labelText);
    }

    /**
     * Show the initialized dialog.  The first argument should
     * be null if you want the dialog to come up in the center
     * of the screen.  Otherwise, the argument should be the
     * component on top of which the dialog should appear.
     */
    public static String showDialog(Component comp, String initialValue) {
        if (dialog != null) {
            dialog.setValue(initialValue);
            dialog.setLocationRelativeTo(comp);
            dialog.setVisible(true);
        } else {
            System.err.println("ListDialog requires you to call initialize "
                               + "before calling showDialog.");
        }
        return value;
    }

    private void setValue(String newValue) {
        value = newValue;
        list.setSelectedValue(value, true);
    }

    private ListDialog(Frame frame, Object[] data, String title,
                       String labelText) {
```

```
        super(frame, title, true);

        //buttons
        JButton cancelButton = new JButton("Cancel");
        final JButton setButton = new JButton("Set");
        cancelButton.addActionListener(new ActionListener() {
            public void actionPerformed(ActionEvent e) {
                ListDialog.dialog.setVisible(false);
            }
        });
        setButton.addActionListener(new ActionListener() {
            public void actionPerformed(ActionEvent e) {
                ListDialog.value = (String)(list.getSelectedValue());
                ListDialog.dialog.setVisible(false);
            }
        });
        getRootPane().setDefaultButton(setButton);

        //main part of the dialog
        list = new JList(data);
        list.setSelectionMode(ListSelectionModel.SINGLE_INTERVAL_SELECTION);
        list.addMouseListener(new MouseAdapter() {
            public void mouseClicked(MouseEvent e) {
                if (e.getClickCount() == 2) {
                    setButton.doClick();
                }
            }
        });
        JScrollPane listScroller = new JScrollPane(list);
        listScroller.setPreferredSize(new Dimension(250, 80));
        //XXX: Must do the following, too, or else the scroller thinks
        //XXX: it's taller than it is:
        listScroller.setMinimumSize(new Dimension(250, 80));
        listScroller.setAlignmentX(LEFT_ALIGNMENT);

        //Create a container so that we can add a title around
        //the scroll pane.  Can't add a title directly to the
        //scroll pane because its background would be white.
        //Lay out the label and scroll pane from top to button.
        JPanel listPane = new JPanel();
        listPane.setLayout(new BoxLayout(listPane, BoxLayout.Y_AXIS));
        JLabel label = new JLabel(labelText);
        label.setLabelFor(list);
        listPane.add(label);
        listPane.add(Box.createRigidArea(new Dimension(0,5)));
        listPane.add(listScroller);
        listPane.setBorder(BorderFactory.createEmptyBorder(10,10,10,10));

        //Lay out the buttons from left to right.
        JPanel buttonPane = new JPanel();
        buttonPane.setLayout(new BoxLayout(buttonPane, BoxLayout.X_AXIS));
        buttonPane.setBorder(BorderFactory.createEmptyBorder(0, 10, 10, 10));
        buttonPane.add(Box.createHorizontalGlue());
        buttonPane.add(cancelButton);
        buttonPane.add(Box.createRigidArea(new Dimension(10, 0)));
        buttonPane.add(setButton);

        //Put everything together, using the content pane's BorderLayout.
        Container contentPane = getContentPane();
        contentPane.add(listPane, BorderLayout.CENTER);
        contentPane.add(buttonPane, BorderLayout.SOUTH);
        pack();
    }

    /**
     * This is here so that you can view ListDialog even if you
     * haven't written the code to include it in a program.
     */
    public static void main(String[] args) {
        String[] names = {"Arlo", "Cosmo", "Elmo", "Hugo",
                          "Jethro", "Laszlo", "Milo", "Nemo",
                          "Otto", "Ringo", "Rocco", "Rollo"};
        JFrame f = new JFrame("Name That Baby");
        f.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                 System.exit(0);
            }
        });

        JLabel intro = new JLabel("The chosen name:");

        final JLabel name = new JLabel("Cosmo");
        intro.setLabelFor(name);
        name.setForeground(Color.black);

        JButton button = new JButton("Pick a new name...");
        ListDialog.initialize(f, names, "Name Chooser",
                              "Baby names ending in O:");
        button.addActionListener(new ActionListener() {
            public void actionPerformed(ActionEvent e) {
                String selectedName = ListDialog.showDialog(null,
                                                            name.getText());
                name.setText(selectedName);
            }
        });

        JPanel contentPane = new JPanel();
        f.setContentPane(contentPane);
        contentPane.setLayout(new BoxLayout(contentPane, BoxLayout.Y_AXIS));
        contentPane.setBorder(BorderFactory.createEmptyBorder(20,20,20,20));

        contentPane.add(intro);
        contentPane.add(name);
        contentPane.add(Box.createRigidArea(new Dimension(0,10)));
        contentPane.add(button);
        intro.setAlignmentX(JComponent.CENTER_ALIGNMENT);
        name.setAlignmentX(JComponent.CENTER_ALIGNMENT);
        button.setAlignmentX(JComponent.CENTER_ALIGNMENT);

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

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

public class CheckBoxDemo extends JPanel {
    JCheckBox chinButton;
    JCheckBox glassesButton;
    JCheckBox hairButton;
    JCheckBox teethButton;

    /*
     * Four accessory choices provide for 16 different
     * combinations. The image for each combination is
     * contained in a separate image file whose name indicates
     * the accessories. The filenames are "geek-XXXX.gif"
     * where XXXX can be one of the following 16 choices.
     * The "choices" StringBuffer contains the string that
     * indicates the current selection and is used to generate
     * the file name of the image to display.

       ----             // zero accessories

       c---             // one accessory
       -g--
       --h-
       ---t

       cg--             // two accessories
       c-h-
       c--t
       -gh-
       -g-t
       --ht

       -ght             // three accessories
       c-ht
       cg-t
       cgh-

       cght             // all accessories
     */

    StringBuffer choices;
    JLabel pictureLabel;

    public CheckBoxDemo() {

        // Create the check boxes
        chinButton = new JCheckBox("Chin");
        chinButton.setMnemonic(KeyEvent.VK_C);
        chinButton.setSelected(true);

        glassesButton = new JCheckBox("Glasses");
        glassesButton.setMnemonic(KeyEvent.VK_G);
        glassesButton.setSelected(true);

        hairButton = new JCheckBox("Hair");
        hairButton.setMnemonic(KeyEvent.VK_H);
        hairButton.setSelected(true);

        teethButton = new JCheckBox("Teeth");
        teethButton.setMnemonic(KeyEvent.VK_T);
        teethButton.setSelected(true);
        // Register a listener for the check boxes.
        CheckBoxListener myListener = new CheckBoxListener();
        chinButton.addItemListener(myListener);
        glassesButton.addItemListener(myListener);
        hairButton.addItemListener(myListener);
        teethButton.addItemListener(myListener);

        // Indicates what's on the geek.
        choices = new StringBuffer("cght");

        // Set up the picture label
        pictureLabel = new JLabel(new ImageIcon(
                                  "images/geek/geek-"
                                   + choices.toString()
                                   + ".gif"));
        pictureLabel.setToolTipText(choices.toString());

        // Put the check boxes in a column in a panel
        JPanel checkPanel = new JPanel();
        checkPanel.setLayout(new GridLayout(0, 1));
        checkPanel.add(chinButton);
        checkPanel.add(glassesButton);
        checkPanel.add(hairButton);
        checkPanel.add(teethButton);

        setLayout(new BorderLayout());
        add(checkPanel, BorderLayout.WEST);
        add(pictureLabel, BorderLayout.CENTER);
        setBorder(BorderFactory.createEmptyBorder(20,20,20,20));
    }


    /** Listens to the check boxes. */
    class CheckBoxListener implements ItemListener {
        public void itemStateChanged(ItemEvent e) {
            int index = 0;
            char c = '-';
            Object source = e.getItemSelectable();

            if (source == chinButton) {
                index = 0;
                c = 'c';
            } else if (source == glassesButton) {
                index = 1;
                c = 'g';
            } else if (source == hairButton) {
                index = 2;
                c = 'h';
            } else if (source == teethButton) {
                index = 3;
                c = 't';
            }

            if (e.getStateChange() == ItemEvent.DESELECTED)
                c = '-';

            choices.setCharAt(index, c);
            pictureLabel.setIcon(new ImageIcon(
                                  "images/geek/geek-"
                                  + choices.toString()
                                  + ".gif"));
            pictureLabel.setToolTipText(choices.toString());
        }
    }

    public static void main(String s[]) {
         JFrame frame = new JFrame("CheckBoxDemo");
         frame.addWindowListener(new WindowAdapter() {
             public void windowClosing(WindowEvent e) {
                 System.exit(0);
             }
         });

         frame.setContentPane(new CheckBoxDemo());
         frame.pack();
         frame.setVisible(true);
    }

}
```

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

public class RadioButtonDemo extends JPanel {
    static JFrame frame;

    static String birdString = "Bird";
    static String catString = "Cat";
    static String dogString = "Dog";
    static String rabbitString = "Rabbit";
    static String pigString = "Pig";

    JLabel picture;

    public RadioButtonDemo() {
        // Create the radio buttons.
        JRadioButton birdButton = new JRadioButton(birdString);
        birdButton.setMnemonic(KeyEvent.VK_B);
        birdButton.setActionCommand(birdString);
        birdButton.setSelected(true);

        JRadioButton catButton = new JRadioButton(catString);
        catButton.setMnemonic(KeyEvent.VK_C);
        catButton.setActionCommand(catString);

        JRadioButton dogButton = new JRadioButton(dogString);
        dogButton.setMnemonic(KeyEvent.VK_D);
        dogButton.setActionCommand(dogString);

        JRadioButton rabbitButton = new JRadioButton(rabbitString);
        rabbitButton.setMnemonic(KeyEvent.VK_R);
        rabbitButton.setActionCommand(rabbitString);

        JRadioButton pigButton = new JRadioButton(pigString);
        pigButton.setMnemonic(KeyEvent.VK_P);
        pigButton.setActionCommand(pigString);

        // Group the radio buttons.
        ButtonGroup group = new ButtonGroup();
        group.add(birdButton);
        group.add(catButton);
        group.add(dogButton);
        group.add(rabbitButton);
        group.add(pigButton);

        // Register a listener for the radio buttons.
        RadioListener myListener = new RadioListener();
        birdButton.addActionListener(myListener);
        catButton.addActionListener(myListener);
        dogButton.addActionListener(myListener);
        rabbitButton.addActionListener(myListener);
        pigButton.addActionListener(myListener);

        // Set up the picture label
        picture = new JLabel(new ImageIcon("images/"
                                           + birdString
                                           + ".gif"));

        // The preferred size is hard-coded to be the width of the
        // widest image and the height of the tallest image.
        // A real program would compute this.
        picture.setPreferredSize(new Dimension(177, 122));
        // Put the radio buttons in a column in a panel
        JPanel radioPanel = new JPanel();
        radioPanel.setLayout(new GridLayout(0, 1));
        radioPanel.add(birdButton);
        radioPanel.add(catButton);
        radioPanel.add(dogButton);
        radioPanel.add(rabbitButton);
        radioPanel.add(pigButton);

        setLayout(new BorderLayout());
        add(radioPanel, BorderLayout.WEST);
        add(picture, BorderLayout.CENTER);
        setBorder(BorderFactory.createEmptyBorder(20,20,20,20));
    }

    /** Listens to the radio buttons. */
    class RadioListener implements ActionListener {
        public void actionPerformed(ActionEvent e) {
            picture.setIcon(new ImageIcon("images/"
                                          + e.getActionCommand()
                                          + ".gif"));
        }
    }

    public static void main(String s[]) {
         frame = new JFrame("RadioButtonDemo");
         frame.addWindowListener(new WindowAdapter() {
             public void windowClosing(WindowEvent e) {System.exit(0);}
         });

         frame.getContentPane().add(new RadioButtonDemo(), BorderLayout.CENTER);
         frame.pack();
         frame.setVisible(true);
    }
}
```

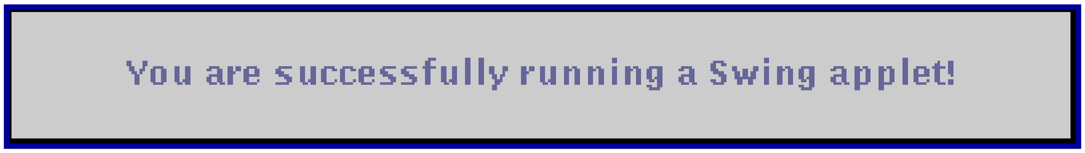
Trail: Creating a GUI with JFC/Swing
Lesson: Getting Started with Swing

Running Swing Applets

This section describes how to run applets that use Swing components. For information on *writing* Swing applets, see How to Make Applets◆.

You can run Swing applets in any browser that has the appropriate version of Java Plug-in ◆ installed. Another option is to use a 1.2-compliant browser. Currently, the only 1.2-compliant browser available is the Applet Viewer utility provided with the Java 2 SDK.

To test whether your browser can run applets, go to `HelloSwingApplet.html`. You should see a box that looks like the following:

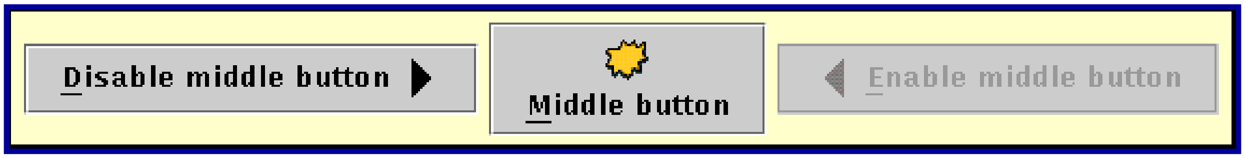


You are successfully running a Swing applet!

This is a picture of the applet's GUI. To run the applet, click the picture. The applet will appear in a new browser window.

You can find the applet's source code in `HelloSwingApplet.java`◆, and the HTML code for including the applet by viewing the HTML source for `HelloSwingApplet.html`. The bad news is that the HTML code for including the applet is rather convoluted. The good news is that you can generate the HTML code automatically from a simple `<APPLET>` tag. See the Java Plug-in documentation◆ for details on downloading a free HTML converter.

Here is a more complex applet, which uses multiple class and image files.



This is a picture of the applet's GUI. To run the applet, click the picture. The applet will appear in a new browser window.

The applet's source code is in AppletDemo.java. It uses the files images/right.gif, images/middle.gif, and images/left.gif as well.

The rest of this section gives step-by-step instructions for running the preceding applets. For information on writing applets, see How to Make Applets.

Step by Step: Running a Swing-Based Applet

1. Find a 1.1 or 1.2 browser or download Java Plug-in into a supported browser. Make sure you have the latest version of the browser and plug-in. If nothing else, you can always use Applet Viewer (`appletviewer`), which is distributed in the JDK . Java Plug-in supports certain versions of Netscape Navigator and Internet Explorer. See the Java Plug-in documentation for details.

2. If you're using a 1.1 browser without Java Plug-in, determine how to load the Swing JAR file into your browser. See Setting the Browser's Class Path for an example of putting the Swing JAR file into the Applet Viewer class path. See Make Your Browser Swing in *The Swing Connection* for examples of doing the same for Internet Navigator and Netscape Navigator.

3. Point the browser at this page. If you can see the first applet but not the second (or the second without any images), please send mail to tutorial@java.sun.com describing what you see in the applet area and in the Java Console.

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Trail: Creating a GUI with JFC/Swing
Lesson: Using Other Swing Features

How to Use Actions

If you have two or more components that perform the same function, consider using an `Action` object to implement the function. An `Action` object is an `ActionListener` that provides not only action-event handling, but also centralized handling of the text, icon, and enabled state of tool bar buttons or menu items. By adding an `Action` to a `JToolBar`, `JMenu`, or `JPopupMenu`, you get the following features:

- A new `JButton` (for `JToolBar`) or `JMenuItem` (for `JMenu` and `JPopupMenu`) that is automatically added to the tool bar or menu. The button or menu item automatically uses the icon and text specified by the `Action`.
- A registered action listener (the `Action` object) for the button or menu item.
- Centralized handling of the button or menu item's enabled state.

Here's an example of using an `Action` to create a tool-bar button and menu item that perform the same function:

```
Action leftAction = new <a class that implements Action>(...);
JButton button = toolBar.add(leftAction);
JMenuItem menuItem = mainMenu.add(leftAction);
```

1.3 Note: A new `AbstractButton` method, `setAction`, lets you associate an action with any button or menu item. For more information, see the 1.3 API documentation for `AbstractButton`.
[PENDING: Write a 1.3 version of this example that uses setAction.]

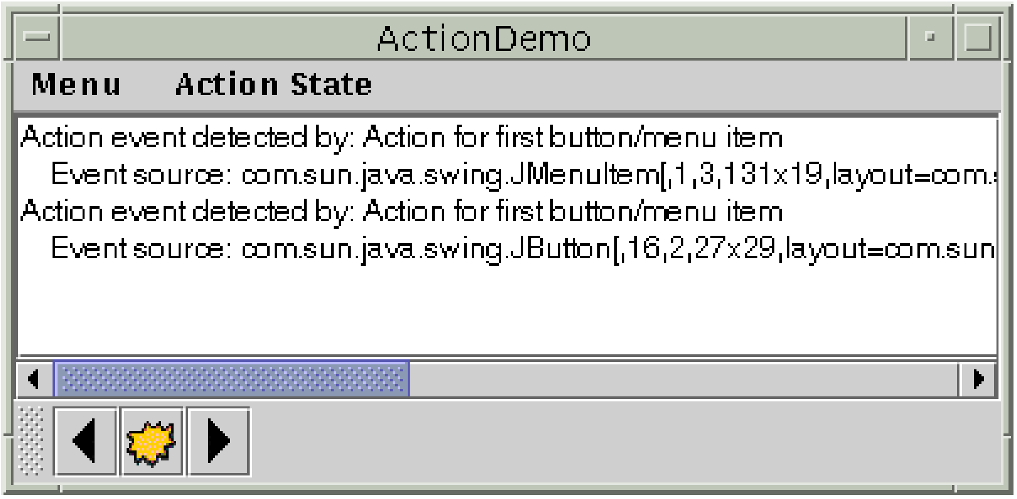
In releases prior to v 1.3, the only way for a button or menu item to get the full benefit of using an `Action` is to create the component using the `add(Action)` method of `JToolBar`, `JMenu`, or `JPopupMenu`. This is because the pre-1.3 releases have no API except `addActionListener(ActionListener)` to connect an `Action` to an already existing component. Although you can use `addActionListener` to add an `Action` object as an action listener to any button, for example, the button won't be notified when the action is disabled.

To create an `Action` object, you generally create a subclass of `AbstractAction` and then instantiate it. In your subclass, you must implement the `actionPerformed` method to react appropriately when the action event occurs. Here's an example of creating and instantiating an

`AbstractAction` subclass:

```
leftAction = new AbstractAction("Go left",
                                new ImageIcon("images/left.gif")) {
    public void actionPerformed(ActionEvent e) {
        displayResult("Action for first button/menu item", e);
    }
};
```

Here's a picture of a demo application that uses actions to implement three features.

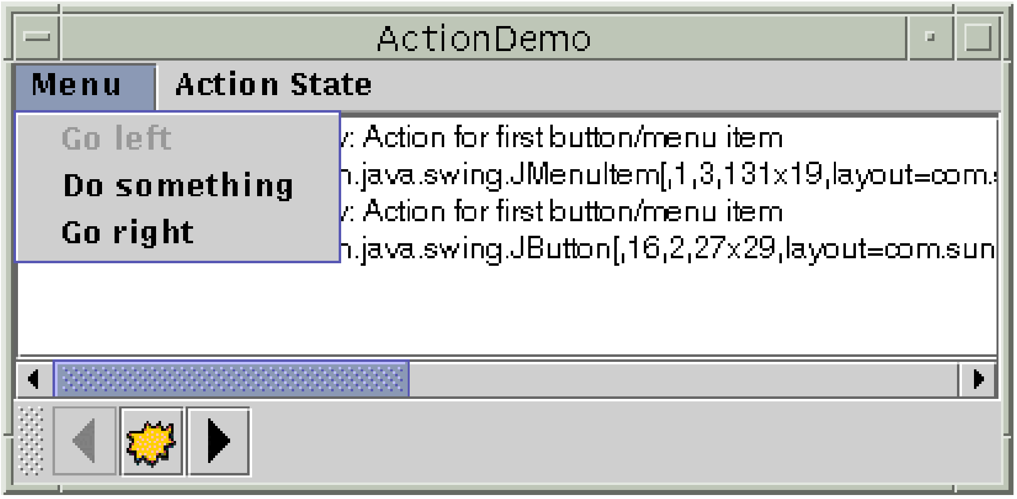


```
Action event detected by: Action for first button/menu item
   Event source: com.sun.java.swing.JMenuItem[,1,3,131x19,layout=com.
Action event detected by: Action for first button/menu item
   Event source: com.sun.java.swing.JButton[,16,2,27x29,layout=com.sun
```

Try this:

1. Compile and run the application. The source file is `ActionDemo.java`.
   You will also need three image files.
   See Getting Started with Swing if you need help compiling or running this application.
2. Choose the top item from the left menu (**Menu** > **Go left**).
   The text area displays some text identifying both the event source and the action listener that received the event.
3. Click the leftmost button in the tool bar.
   The text area again displays information about the event. Note that although the source of the events is different, both events were detected by the same action listener: the `Action` object with which the components were created.
4. Choose the top item from the **Action State** menu.
   This disables the "Go left" `Action` object, which in turn disables its associated menu item and button.

Here is what the user sees when the "Go left" action is disabled:



```
: Action for first button/menu item
.java.swing.JMenuItem[,1,3,131x19,layout=com.
: Action for first button/menu item
.java.swing.JButton[,16,2,27x29,layout=com.sun
```

Here's the code that disables the "Go left" action:

```
boolean selected = ...//true if the action should be enabled;
                      //false, otherwise
leftAction.setEnabled(selected);
```

After you create components using an `Action`, you might well need to customize them. For example, you might want to set the tool-tip text for a button. Or you might want to customize the appearance of one of the components by adding or deleting the icon or text. For example, `ActionDemo.java` has no icons in its menus, no text in its buttons, and tool tips for its buttons. Here's the code that accomplishes this:

```
button = toolBar.add(leftAction);
button.setText(""); //an icon-only button
button.setToolTipText("This is the left button");
menuItem = mainMenu.add(leftAction);
menuItem.setIcon(null); //arbitrarily chose not to use icon in menu
```

The Action API

The following tables list the commonly used `Action` constructors and methods. The API for using `Action` objects falls into two categories:

- Creating and Using an Action
- Creating an Action-Controlled Component

Creating and Using an Action

Constructor or Method	Purpose

`AbstractAction()`
`AbstractAction(String)`
`AbstractAction(String, Icon)`
	Create an `Action` object. Through arguments, you can specify the text and icon to be used in the components that the action controls.

`void setEnabled(boolean)`
`boolean isEnabled()`
	Set or get whether the components the action controls are enabled. Invoking `setEnabled(false)` disables all the components that the action controls. Similarly, invoking `setEnabled(true) enables the action's components.`

Creating an Action-Controlled Component

Method	**Purpose**

`JMenuItem add(Action)`
`JMenuItem insert(Action, int)`
(in `JMenu` and `JPopupMenu`)
	Create a `JMenuItem` object and put it in the menu or popup menu. See the discussion in this section and in How to Use Menus for details.

`JButton add(Action)` *(in `JToolBar`)*	Create a `JButton` object and put it in the tool bar. See the discussion in this section and in How to Use Tool Bars for details.

Examples that Use Actions

The following examples use `Action` objects.

Example	**Where Described**	**Notes**
`ActionDemo`	This section	Uses actions to bind buttons and menu items to the same function.
`TextComponentDemo`	General Rules for Using Text Components◆	Uses text actions to create menu items for text editing commands, such as cut, copy, and paste, and to bind key strokes to caret movement. Also implements custom `AbstractAction` subclasses to implement undo and redo. The text action discussion begins in Concepts: About Editor Kits.

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Trail: Creating a GUI with JFC/Swing
Lesson: Writing Event Listeners

Listeners Supported by Swing Components

You can tell what kinds of events a component can fire by looking at the kinds of event listeners you can register on it. For example, the `Component` class defines these listener registration methods:

- `addComponentListener`
- `addFocusListener`
- `addKeyListener`
- `addMouseListener`
- `addMouseMotionListener`

Thus, every component supports component, focus, key, mouse, and mouse-motion listeners. However, a component fires only those events for which listeners have registered on it. For example, if a mouse listener is registered on a particular component, but the component has no other listeners, then the component will fire only mouse events--no component, focus, key, or mouse-motion events.

Listeners supported by Swing components fall into two categories:

- Listeners that All Swing Components Support
- Other Listeners that Swing Components Support

Listeners that All Swing Components Support

Because all Swing components descend from the AWT `Component` class, you can register the following listeners on any Swing component:

component listener
Listens for changes in the component's size, position, or visibility.

focus listener
Listens for whether the component gained or lost the ability to receive keyboard input.

key listener

Listens for key presses; key events are fired only by the component that has the current keyboard focus.

mouse events

Listens for mouse clicks and mouse movement into or out of the component's drawing area.

mouse-motion events

Listens for changes in the cursor's position over the component.

All Swing components descend from the AWT `Container` class, but many of them aren't used as containers. So, technically speaking, any Swing component can fire container events, which notify listeners that a component has been added to or removed from the container. Realistically speaking, however, only containers (such as panels and frames) and compound components (such as combo boxes) fire container events.

`JComponent` provides support for three more listener types. You can register an ancestor listener◆ to be notified when a component's containment ancestors are added to or removed from a container, hidden, made visible, or moved. This listener type is an implementation detail and can generally be ignored. Swing components are JavaBeans-compliant. Among other things, this means that Swing Components support bound and constrained properties and notify listeners of changes to the properties. Property change listeners◆ listen for changes to bound properties and vetoable change listeners◆ listen for changes to constrained properties. These listeners are used primarily by Beans-aware builder tools. For more information about Beans Properties refer to Properties◆.

Other Listeners that Swing Components Support

The following table lists Swing components and the listeners that they support. In many cases, the events are fired directly from the component. In other cases, the events are fired from the component's data or selection model. To find out the details for the particular component and listener you're interested in, go first to the component how-to section, and then if necessary to the listener how-to section.

Component	**Listener**							
	action	caret	change	document, undoable edit	item	list selection	window	other
button	X		X		X			
check box	X		X		X			
color chooser			X					

combo box	X				X			
dialog							X	
editor pane		X		X				hyperlink◆
file chooser	X							
frame							X	
internal frame								internal frame
list						X		list data
menu								menu◆
menu item	X		X		X			menu key◆ menu drag mouse◆
option pane								
password field	X	X		X				
popup menu								popup menu◆
progress bar			X					
radio button	X		X		X			
slider			X					
tabbed pane			X					
table						X		table model table column model◆ cell editor◆
text area		X		X				
text field	X	X		X				
text pane		X		X				hyperlink◆
toggle button	X		X		X			
tree								tree expansion tree will expand tree model tree selection

viewport (used by scrollpane)			X					

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Trail: Creating a GUI with JFC/Swing
Lesson: Writing Event Listeners

Implementing Listeners for Commonly Handled Events

The following sections give details about implementing specific kinds of event listeners. We don't have a how-to section for every single kind of event listener that you can write. Rather, we cover the listeners we think you're most likely to need. If you're interested in other listeners, you can find some information in the Summary of Listener API section.

- How to Write an Action Listener
- How to Write a Caret Listener
- How to Write a Change Listener
- How to Write a Component Listener
- How to Write a Container Listener
- How to Write a Document Listener
- How to Write a Focus Listener
- How to Write an Internal Frame Listener
- How to Write an Item Listener
- How to Write a Key Listener
- How to Write a List Data Listener
- How to Write a List Selection Listener
- How to Write a Mouse Listener
- How to Write a Mouse-Motion Listener
- How to Write a Table Model Listener
- How to Write a Tree Expansion Listener
- How to Write a Tree Model Listener
- How to Write a Tree Selection Listener
- How to Write a Tree-Will-Expand Listener
- How to Write an Undoable Edit Listener
- How to Write a Window Listener

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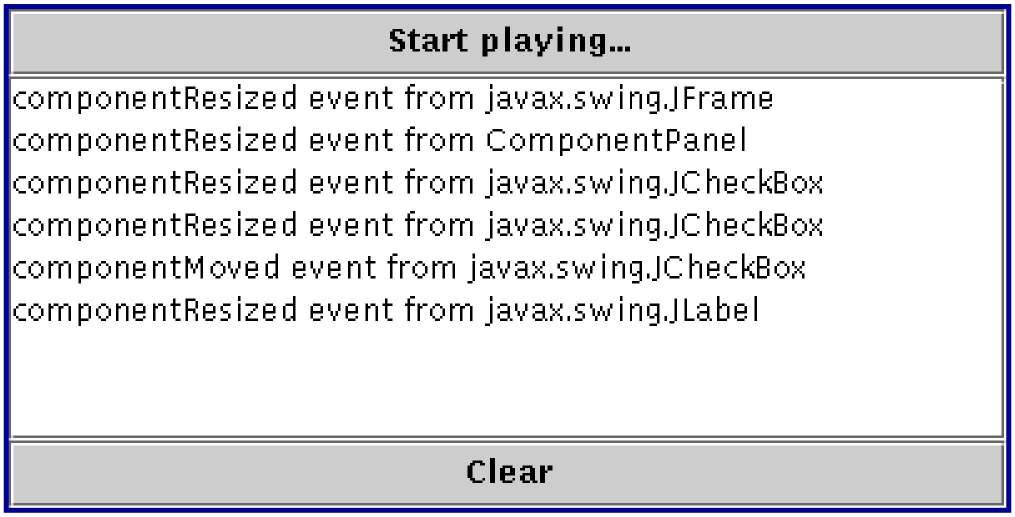
Trail: Creating a GUI with JFC/Swing
Lesson: Writing Event Listeners

How to Write a Component Listener

One or more component events are fired by a `Component` object just after the component is hidden, made visible, moved, or resized. An example of a component listener might be in a GUI builder tool that's displaying information about the size of the currently selected component, and that needs to know when the component's size changes. You shouldn't need to use component events to manage basic layout and rendering.

The component-hidden and component-shown events occur only as the result of calls to a `Component`'s `setVisible` method (or its deprecated equivalents, `show` and `hide`). For example, a window might be miniaturized into an icon (iconified) without a component-hidden event being fired.

The following applet demonstrates component events. The applet contains a button that brings up a window (`JFrame`). The window contains a panel that has a label and a checkbox. The checkbox controls whether the label is visible. When you leave the applet's page, the window disappears; it reappears when you return to the applet's page. A text area displays a message every time the window, panel, label, or checkbox fires a component event.



```
componentResized event from javax.swing.JFrame
componentResized event from ComponentPanel
componentResized event from javax.swing.JCheckBox
componentResized event from javax.swing.JCheckBox
componentMoved event from javax.swing.JCheckBox
componentResized event from javax.swing.JLabel
```

This is a picture of the applet's GUI. To run the applet, click the picture. The applet will appear in a new browser window.

Try this:

1. Click the button labeled "Start playing...".

The window comes up, generating one or more component-shown and component-moved events.

2. Click the checkbox to hide the label.
   The label fires a component-hidden event.
3. Click the checkbox again to show the label.
   The label fires a component-shown event.
4. Iconify and then deiconify the window that contains the label.
   You do *not* get component-hidden or -shown events. If you want to be notified of iconification events, you should use a window listener.
5. Resize the window that contains the label.
   You'll see component-resized (and possibly component-moved) events from all four components -- label, checkbox, panel, and window. If the window and panel's layout manager didn't make every component as wide as possible, the panel, label, and checkbox wouldn't have been resized.

You can find the applet's code in ComponentEventDemo.java. Here is just the code related to handling component events:

```
public class ComponentEventDemo ... implements ComponentListener {
    ...
    //where initialization occurs:
        aFrame = new JFrame("A Frame");
        ComponentPanel p = new ComponentPanel(this);
        aFrame.addComponentListener(this);
        p.addComponentListener(this);
    ...

    public void componentHidden(ComponentEvent e) {
        displayMessage("componentHidden event from "
                       + e.getComponent().getClass().getName());
    }

    public void componentMoved(ComponentEvent e) {
        displayMessage("componentMoved event from "
                       + e.getComponent().getClass().getName());
    }

    public void componentResized(ComponentEvent e) {
        displayMessage("componentResized event from "
                       + e.getComponent().getClass().getName());
    }

    public void componentShown(ComponentEvent e) {
        displayMessage("componentShown event from "
                       + e.getComponent().getClass().getName());
    }
}


class ComponentPanel extends JPanel ... {
    ...
    ComponentPanel(ComponentEventDemo listener) {
        ...//after creating the label and checkbox:
        label.addComponentListener(listener);
        checkbox.addComponentListener(listener);
    }
    ...
}
```

The Component Event API

The `ComponentListener` interface and its corresponding adapter class, `ComponentAdapter`, contain four methods:

`void componentHidden(ComponentEvent)`
Called after the listened-to component is hidden as the result of the `setVisible` method being called.

`void componentMoved(ComponentEvent)`
Called after the listened-to component moves, relative to its container. For example, if a window is moved, the window fires a component-moved event, but the components it contains do not.

`void componentResized(ComponentEvent)`
Called after the listened-to component's size (rectangular bounds) changes.

`void componentShown(ComponentEvent)`
Called after the listened-to component becomes visible as the result of the `setVisible` method being called.

Each component event method has a single parameter: a `ComponentEvent` object. The `ComponentEvent` class defines the following useful method:

`Component getComponent()`
Returns the component that fired the event. You can use this instead of the `getSource` method.

Examples that Use Component Listeners

The following table lists the examples that use component listeners.

Example	Where Described	Notes
`ComponentEventDemo`	This section	Reports all component events that occur on several components to demonstrate the circumstances under which component events are fired.

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Trail: Creating a GUI with JFC/Swing
Lesson: Writing Event Listeners

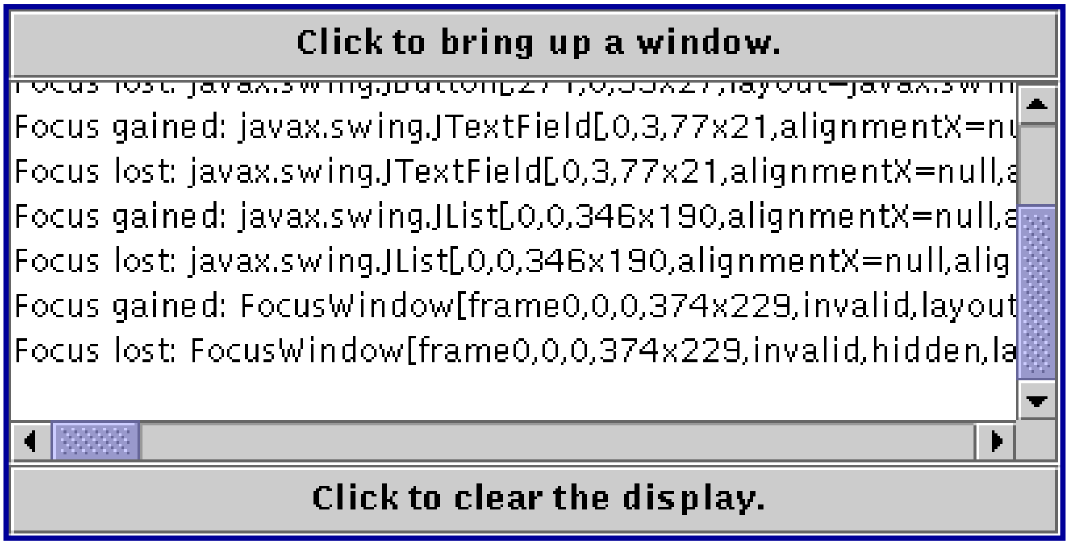
How to Write a Focus Listener

Many components--even those primarily operated with the mouse, such as buttons--can be operated with the keyboard. For a keypress to affect a component, the component must have the keyboard focus.

From the user's point of view, the component with the keyboard focus is generally prominent--with a thicker boarder than usual, for example-- and the window containing the component is also more prominent than other windows on-screen. These visual cues let the user know to which component any typing will go. At most one component in the window system can have the keyboard focus.

Focus events are fired whenever a component gains or loses the *keyboard focus*. Exactly how components gain the focus depends on the window system. Typically, the user sets the focus by clicking a window or component, by tabbing between components, or by otherwise interacting with a component. Once the focus is in a window (the window is *activated*), a program can use the `Component` `requestFocus` method to request that a specific component get the focus.

The following applet demonstrates focus events. By clicking the top button in the applet, you can bring up a window that contains a variety of components. A focus listener listens for focus events on each component in the window, including the window itself (which is an instance of a `JFrame` subclass called `FocusWindow`).

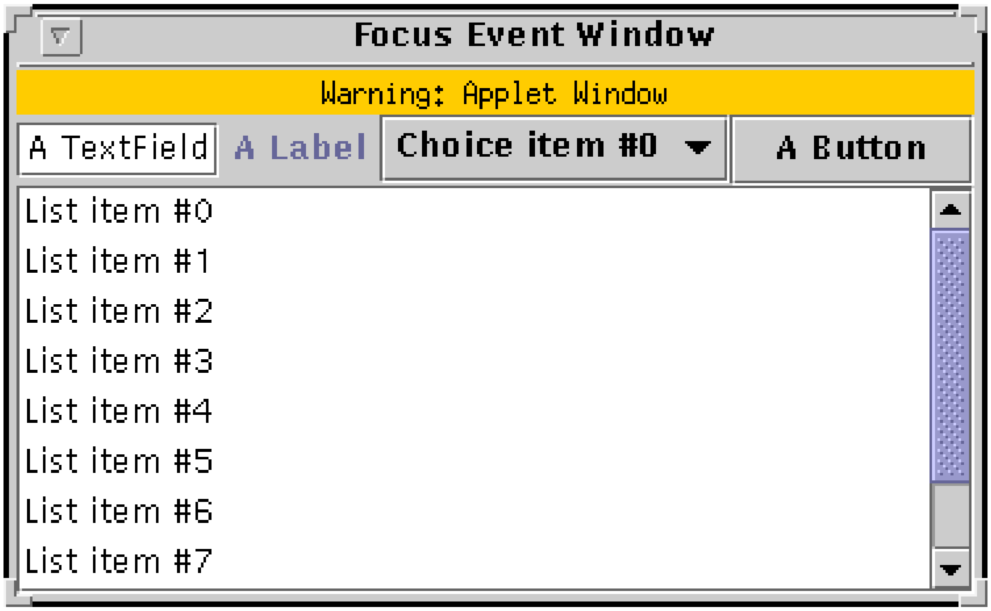


```
Focus lost: javax.swing.JButton[271,0,53x27,layout=javax.swin
Focus gained: javax.swing.JTextField[,0,3,77x21,alignmentX=nu
Focus lost: javax.swing.JTextField[,0,3,77x21,alignmentX=null,a
Focus gained: javax.swing.JList[,0,0,346x190,alignmentX=null,a
Focus lost: javax.swing.JList[,0,0,346x190,alignmentX=null,alig
Focus gained: FocusWindow[frame0,0,0,374x229,invalid,layout
Focus lost: FocusWindow[frame0,0,0,374x229,invalid,hidden,la
```

This is a picture of the applet's GUI. To run the applet, click the picture. The applet will appear in a new browser window.

Try this:

1. Bring up the Focus Event Window by clicking the top button in the applet.



If necessary, click the Focus Event Window so that its contents can gain the keyboard focus. You'll see a "Focus gained" message in the applet's display area. The way in which its window gets the focus and which components get the focus are system dependent by default. You can detect when the window gets or loses the focus by implementing a window listener and listening for window activation or deactivation events.

2. Click the button at the right of the Focus Event Window, and then click in another component, such as the text field.
   Notice that when the focus changes from one component to another, the first component fires a focus-lost event before the second component fires a focus-gained event.
3. Select an item from the combo box.
   The combo box does not a fire focus-gained event even though it appears to have the focus. Now select another component in the Focus Event Window. The combo box does not fire a focus-lost event either.
4. Try changing the focus by pressing Tab or Shift-Tab.
   Most systems let you use the Tab key to cycle through components that are able to get the focus.
5. Iconify the Focus Event Window.
   You should see a "Focus lost" message for the component that last had the focus.

You can find the applet's code in FocusEventDemo.java. Here is the applet's focus event handling code:

```
public class FocusEventDemo ... implements FocusListener ... {
        ...//where initialization occurs
        window = new FocusWindow(this);
    ...
    public void focusGained(FocusEvent e) {
        displayMessage("Focus gained", e);
    }

    public void focusLost(FocusEvent e) {
        displayMessage("Focus lost", e);
    }

    void displayMessage(String prefix, FocusEvent e) {
        display.append(prefix
                       + ": "
                       + e.getComponent()
                       + newline);
    }
    ...
}

class FocusWindow extends JFrame {
    ...
    public FocusWindow(FocusListener listener) {
        super("Focus Demo Window");
        this.addFocusListener(listener);
        ...
        JLabel label = new JLabel("A Label");
        label.addFocusListener(listener);
        ...
        JComboBox choice = new JComboBox(/* list of items */);
        ...
        choice.addFocusListener(listener);
        ...
        JButton button = new JButton("A Button");
        button.addFocusListener(listener);
        ...
        JList list = new JList(/* list of items */);
        ...
        list.addFocusListener(listener);
    }
}
```

The Focus Event API

The `FocusListener` interface and its corresponding adapter class, `FocusAdapter`, contain two methods:

`void focusGained(FocusEvent)`
Called just after the listened-to component gets the focus.

`void focusLost(FocusEvent)`
Called just after the listened-to component loses the focus.

Each focus event method has a single parameter: a `FocusEvent` object. The `FocusEvent` class defines the following method:

`boolean isTemporary()`
Returns true if a focus-lost event is temporary. You'll need to use this method if you're implementing a component that can indicate that it will get the focus if its window regains the focus.

The `getComponent` method, which `FocusEvent` inherits from `ComponentEvent`, returns the component that fired the focus event.

Examples that Use Focus Listeners

The following table lists the examples that use focus listeners.

Example	Where Described	Notes
`FocusEventDemo`	This section	Reports all focus events that occur on several components to demonstrate the circumstances under which focus events are fired.

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Trail: Creating a GUI with JFC/Swing
Lesson: Writing Event Listeners

How to Write a Key Listener

Key events tell you when the user is typing at the keyboard. Specifically, key events are fired by the component with the keyboard focus when the user presses or releases keyboard keys. (For information about focus, see the focus discussion in How to Write a Focus Listener.)

You can be notified about two basic kinds of key events: the typing of a Unicode character, and the pressing or releasing of a key on the keyboard. The first kind of event is called a *key-typed* event. The second kind are *key-pressed* and *key-released* events.

In general, you should try to handle only key-typed events unless you need to know when the user presses keys that don't correspond to characters. For example, if you want to know when the user types some Unicode character -- whether as the result of pressing one key such as 'a' or from pressing several keys in sequence -- you should handle key-typed events. On the other hand, if you want to know when the user presses the F1 key, you need to handle key-pressed events.

Note: Due to bug # 4186905, text components don't forward key-typed events in JDK 1.2 for Win32.

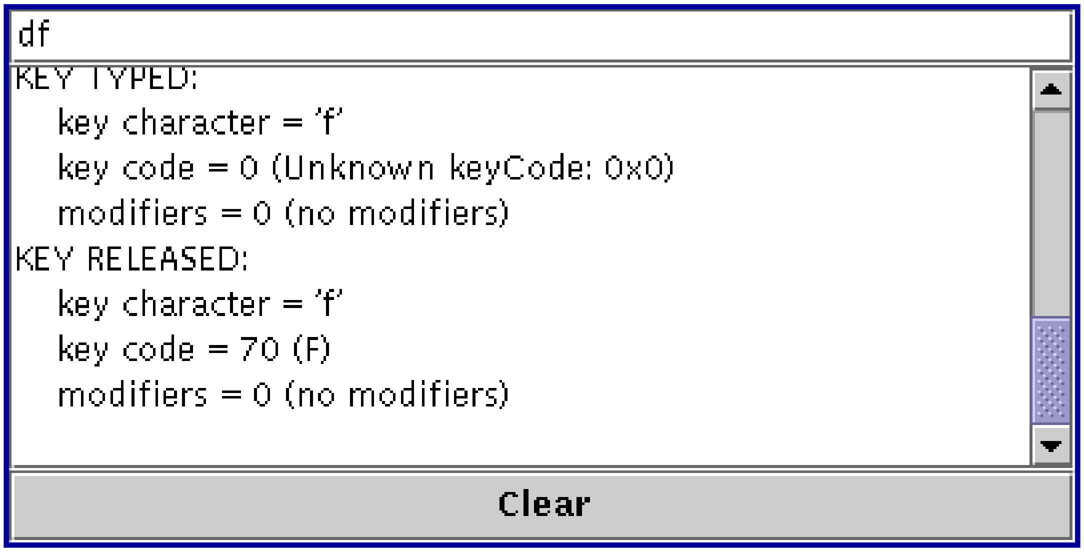
Note: To fire keyboard events, a component *must* have the keyboard focus.

To make a component get the keyboard focus, follow these steps:

1. Make sure the component's `isFocusTraversable` method returns `true`. This lets the user tab to your component. For example, you can enable keyboard focus for a custom `JLabel` subclass by overriding the `isFocusTraversable` method to return `true`.
2. Make sure that the component requests the focus when appropriate. For custom

components, you'll probably need to implement a mouse listener that calls the `requestFocus` method when the component is clicked.

The following applet demonstrates key events. It consists of a text field that you can type into, followed by a text area that displays a message every time the text field fires a key event. A button at the bottom of the applet lets you clear both the text field and text area.



```
df
KEY TYPED:
   key character = 'f'
   key code = 0 (Unknown keyCode: 0x0)
   modifiers = 0 (no modifiers)
KEY RELEASED:
   key character = 'f'
   key code = 70 (F)
   modifiers = 0 (no modifiers)
```

This is a picture of the applet's GUI. To run the applet, click the picture. The applet will appear in a new browser window.

Try this:

1. Click in the applet's text field so that it gets the keyboard focus.
2. Type a lowercase 'a' by pressing and releasing the A key on the keyboard.
   The text field fires three events: a key-pressed event, a key-typed event, and a key-released event. Note that the key-typed event doesn't have key code information; key-typed events also don't have modifier information.
3. Press the Clear button.
   You might want to do this after each of the following steps.
4. Press and release the Shift key.
   The text field fires two events: a key pressed and a key released. The text field doesn't fire a key-typed event because Shift, by itself, doesn't correspond to any character.
5. Type an uppercase 'A' by pressing the Shift and A keys.
   You'll see the following events, although perhaps not in this order: key pressed (Shift), key pressed (A), key typed ('A'), key released (A), key released (Shift).
6. Type an uppercase 'A' by pressing and releasing the Caps Lock key,

   and then pressing the A key.
   You should see the following events: key pressed (Caps Lock), key pressed (A), key typed ('A'), key released (A). Notice that the Caps Lock key doesn't fire a key-released event until you press and release it again. The same is true of other state keys, such as Scroll Lock and Num Lock.
7. Press and hold the A key.
   Does it automatically repeat? If so, you'll see the same events that you would have seen if you pressed and released the A key repeatedly.

You can find the applet's code in KeyEventDemo.java. Here is the applet's key event handling code:

```
public class KeyEventDemo ...  implements KeyListener ... {
    ...//where initialization occurs:
        typingArea = new JTextField(20);
        typingArea.addKeyListener(this);
    ...
    /** Handle the key typed event from the text field. */
    public void keyTyped(KeyEvent e) {
        displayInfo(e, "KEY TYPED: ");
    }

    /** Handle the key pressed event from the text field. */
    public void keyPressed(KeyEvent e) {
        displayInfo(e, "KEY PRESSED: ");
    }

    /** Handle the key released event from the text field. */
    public void keyReleased(KeyEvent e) {
        displayInfo(e, "KEY RELEASED: ");
    }
    ...
    protected void displayInfo(KeyEvent e, String s){
        ...
        char c = e.getKeyChar();
        int keyCode = e.getKeyCode();
        int modifiers = e.getModifiers();
        ...
        tmpString = KeyEvent.getKeyModifiersText(modifiers);
```

```
            ...//display information about the KeyEvent...
        }
    }
```

The Key Event API

The `KeyListener` interface and its corresponding adapter class, `KeyAdapter`, contain three methods:

`void keyTyped(KeyEvent)`
: Called just after the user types a Unicode character into the listened-to component.

`void keyPressed(KeyEvent)`
: Called just after the user presses a key while the listened-to component has the focus.

`void keyReleased(KeyEvent)`
: Called just after the user releases a key while the listened-to component has the focus.

Each key event method has a single parameter: a `KeyEvent` object. The `KeyEvent` class defines the following useful methods:

`int getKeyChar()`
`void setKeyChar(char)`
: Get or set the Unicode character associated with this event.

`int getKeyCode()`
`void setKeyCode(int)`
: Get or set the key code associated with this event. The key code identifies the particular key on the keyboard that the user pressed or released. The `KeyEvent` class defines many key code constants for commonly seen keys. For example, VK_A specifies the key labeled **A**, and VK_ESCAPE specifies the ESCAPE key.

`void setModifiers(int)`
: Sets the state of the modifier keys for this event. You can get the state of the modifier keys using `InputEvent getModifiers` method.

`String getKeyText()`
`String getKeyModifiersText()`
: Return text descriptions of the event's key code and modifier keys, respectively.

The `KeyEvent` class inherits many useful methods from `InputEvent` and `ComponentEvent`. The following methods are described in The MouseEvent Class:

- `Component getComponent()`
- `void consume()`
- `int getWhen()`
- `boolean isAltDown()`
- `boolean isControlDown()`
- `boolean isMetaDown()`
- `boolean isShiftDown()`
- `int getModifiers()`

Examples that Use Key Listeners

The following table lists the examples that use key listeners.

Example	Where Described	Notes
`KeyEventDemo`	This section	Reports all key events that occur on a text field to demonstrate the circumstances under which key events are fired.

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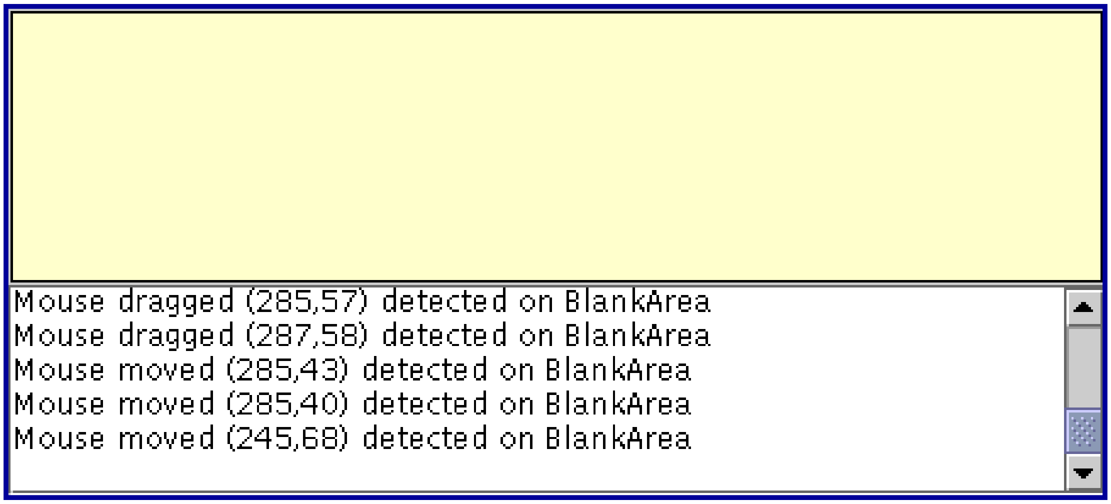
Trail: Creating a GUI with JFC/Swing
Lesson: Writing Event Listeners

How to Write a Mouse-Motion Listener

Mouse-motion events tell you when the user uses the mouse (or a similar input device) to move the onscreen cursor. For information on listening for other kinds of mouse events, such as clicks, see How to Write a Mouse Listener. If your program needs to detect both mouse events and mouse-motion events, you can use Swing's convenient `MouseInputAdapter` class, which implements both `MouseListener` and `MouseMotionListener`.

The following applet contains a mouse-motion listener. It's exactly like the applet in How to Write a Mouse Listener, except for substituting `MouseMotionListener` for `MouseListener`, implementing the `mouseDragged` and `mouseMoved` methods instead of the mouse listener methods, and displaying coordinates instead of numbers of clicks. You can find the applet's code in `MouseMotionEventDemo.java`◆ and `BlankArea.java`◆.



```
Mouse dragged (285,57) detected on BlankArea
Mouse dragged (287,58) detected on BlankArea
Mouse moved (285,43) detected on BlankArea
Mouse moved (285,40) detected on BlankArea
Mouse moved (245,68) detected on BlankArea
```

This is a picture of the applet's GUI. To run the applet, click the picture. The applet will appear in a new browser window.

Try this:

1. Move the cursor into the yellow rectangle at the top of the applet.
   You'll see one or more mouse-moved events.
2. Press and hold the mouse button, and then move the mouse so that the cursor is outside the yellow rectangle.
   You'll see mouse-dragged events.

Here is the code that implements the mouse-motion event handling:

```
public class MouseMotionEventDemo extends JApplet
                                  implements MouseMotionListener {
    //...in initialization code:
        //Register for mouse events on blankArea and applet (panel).
        blankArea.addMouseMotionListener(this);
        addMouseMotionListener(this);
        ...
    }

    public void mouseMoved(MouseEvent e) {
       saySomething("Mouse moved", e);
    }

    public void mouseDragged(MouseEvent e) {
       saySomething("Mouse dragged", e);
    }

    void saySomething(String eventDescription, MouseEvent e) {
        textArea.append(eventDescription
                        + " (" + e.getX() + "," + e.getY() + ")"
                        + " detected on "
                        + e.getComponent().getClass().getName()
                        + newline);
    }
}
```

A more interesting example is `SelectionDemo`, which is discussed in Arguments to the repaint Method◆. The program draws a rectangle illustrating the user's current dragging. To do this, it must implement an event handler for three kinds of mouse events: mouse presses, mouse drags, and mouse releases. To be informed of all these events, the handler must implement both the `MouseListener` and `MouseMotionListener` interfaces, and be registered as both a mouse listener and a mouse-motion listener. To avoid having to define empty methods, the handler doesn't implement either listener interface directly. Instead, it extends `MouseInputAdapter`, as the following code snippet shows.

```
...//where initialization occurs:
    MyListener myListener = new MyListener();
    addMouseListener(myListener);
    addMouseMotionListener(myListener);
...
class MyListener extends MouseInputAdapter {
    public void mousePressed(MouseEvent e) {
        int x = e.getX();
        int y = e.getY();
        currentRect = new Rectangle(x, y, 0, 0);
        updateDrawableRect(getWidth(), getHeight());
        repaint();
    }

    public void mouseDragged(MouseEvent e) {
        updateSize(e);
    }

    public void mouseReleased(MouseEvent e) {
        updateSize(e);
    }

    void updateSize(MouseEvent e) {
        int x = e.getX();
        int y = e.getY();
        ...
        repaint(...);
    }
}
```

The Mouse-Motion Event API

The `MouseMotionListener` interface and its corresponding adapter class, `MouseMotionAdapter`, contain these methods:

`void mouseDragged(MouseEvent)`
Called in response to the user moving the mouse while holding a mouse button down. This event is fired by the component that fired the most recent mouse-pressed event, even if the cursor is no longer over that component.

`void mouseMoved(MouseEvent)`
Called in response to the user moving the mouse with no mouse buttons pressed. This event is fired by the component that's currently under the cursor.

Each mouse-motion event method has a single parameter -- and it's *not* called `MouseMotionEvent`! Instead, each mouse-motion event method has a `MouseEvent` argument. See The Mouse Event API for information about using `MouseEvent` objects.

Examples that Use Mouse-Motion Listeners

The following table lists the examples that use mouse-motion listeners.

Example	Where Described	Notes

`MouseMotionEventDemo`	This section	Reports all mouse motion events that occur within a blank panel to demonstrate the circumstances under which mouse motion events are fired.
`LayeredPaneDemo` and `LayeredPaneDemo2`	How to Use Layered Panes◆	Moves an image of Duke around within a layered pane in response to mouse motion events.
`SelectionDemo`	Arguments to the repaint Method◆	An applet that lets the user drag a rectangle to select a portion of an image. Uses a subclass of `MouseInputAdapter` to listen to both mouse events and mouse-motion events.
`GlassPaneDemo`	How to Use Root Panes◆	Uses a subclass of `MouseInputAdapter` to listen to mouse events and mouse-motion events on the root pane's glass pane. Redispatches the events to underlying components.

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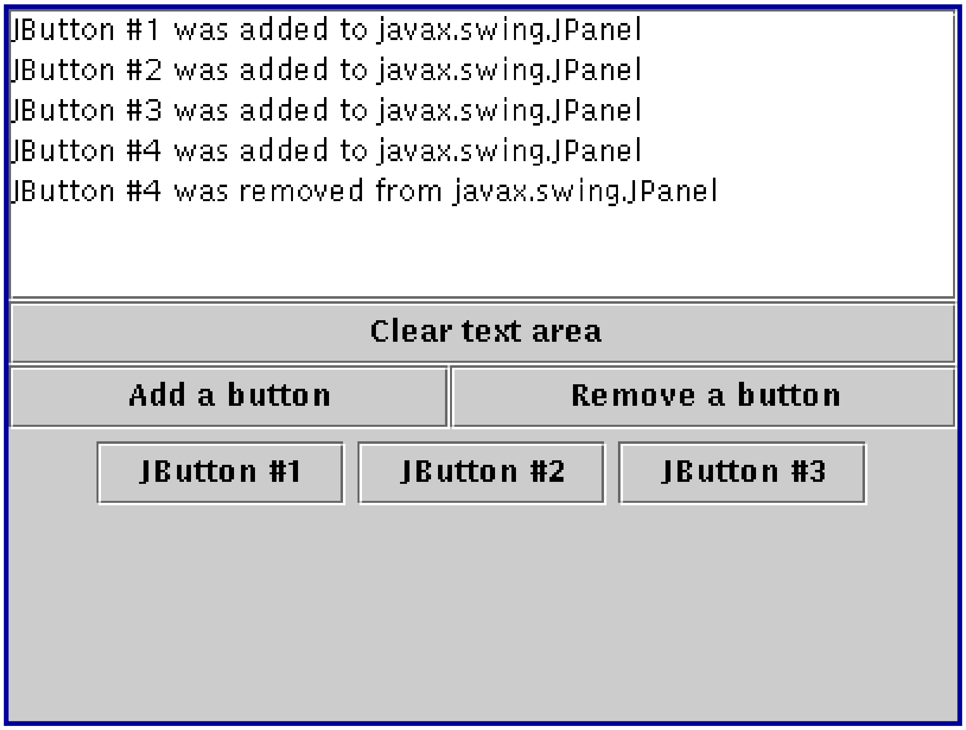
Trail: Creating a GUI with JFC/Swing
Lesson: Writing Event Listeners

How to Write a Container Listener

Container events are fired by a `Container` just after a component is added to or removed from the container. These events are for notification only -- no container listener need be present for components to be successfully added or removed.

The following applet demonstrates container events. By clicking **Add a button** or **Remove a button**, you can add components to or remove them from a panel at the bottom of the applet. Each time a component is added to or removed from the panel, the panel fires a container event, and the panel's container listener is notified. The listener displays descriptive messages in the text area at the top of the applet.



```
JButton #1 was added to javax.swing.JPanel
JButton #2 was added to javax.swing.JPanel
JButton #3 was added to javax.swing.JPanel
JButton #4 was added to javax.swing.JPanel
JButton #4 was removed from javax.swing.JPanel
```

This is a picture of the applet's GUI. To run the applet, click the picture. The applet will appear in a new browser window.

Try this:

1. Click the button labeled **Add a button**.
   You'll see a button appear near the bottom of the applet. The container listener (in this example, an instance of `ContainerEventDemo`) reacts to the resulting component-added event by displaying "JButton #1 was added to

javax.swing.JPanel" at the top of the applet.

2. Click the button labeled **Remove a button**.
   This removes the most recently added button from the panel, causing the container listener to receive a component-removed event.

You can find the applet's code in `ContainerEventDemo.java`. Here is the applet's container event handling code:

```
public class ContainerEventDemo ... implements ContainerListener ... {
    ...//where initialization occurs:
        buttonPanel = new JPanel();
        buttonPanel.addContainerListener(this);
    ...
    public void componentAdded(ContainerEvent e) {
        displayMessage(" added to ", e);
    }

    public void componentRemoved(ContainerEvent e) {
        displayMessage(" removed from ", e);
    }

    void displayMessage(String action, ContainerEvent e) {
        display.append(((JButton)e.getChild()).getText()
                       + " was"
                       + action
                       + e.getContainer().getClass().getName()
                       + newline);
    }
    ...
}
```

The Container Event API

The `ContainerListener` interface and its corresponding adapter class, `ContainerAdapter`, contain two methods:

`void componentAdded(ContainerEvent)`
Called just after a component is added to the listened-to container.

`void componentRemoved(ContainerEvent)`
Called just after a component is removed from the listened-to container.

Each container event method has a single parameter: a `ContainerEvent` object. The `ContainerEvent` class defines two useful methods:

`Component getChild()`

Returns the component whose addition or removal triggered this event.

`Container getContainer()`

Returns the container that fired this event. You can use this instead of the `getSource` method.

Examples that Use Container Listeners

The following table lists the examples that use container listeners.

Example	Where Described	Notes
`ContainerEventDemo`	This section	Reports all container events that occur on a single panel to demonstrate the circumstances under which container events are fired.

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Trail: Creating a GUI with JFC/Swing
Lesson: Writing Event Listeners

How to Write a Caret Listener

Caret events occur when the caret in a text component moves or when the selection in a text component changes. You can attach a caret listener to an instance of any `JTextComponent` subclass with the `addCaretListener` method.

If your program has a custom caret, you might find it more convenient to attach a listener to the caret object rather than to the text component for which it is a caret. A caret fires change events rather than caret events, so you would need to write a change listener rather than a caret listener.

Here is the caret event handling code from an application called `TextComponentDemo`.

```
...
//where initialization occurs
CaretListenerLabel caretListenerLabel =
    new CaretListenerLabel("Caret Status");
...
textPane.addActionListener(caretListenerLabel);
...
protected class CaretListenerLabel extends JLabel
                                   implements CaretListener
{
    ...
    public void caretUpdate(CaretEvent e) {
        //Get the location in the text
        int dot = e.getDot();
        int mark = e.getMark();
        ...
    }
}
```

You can find the full source code for the program and instructions for compiling and running it in General Rules for Using Text Components◆. For a discussion about the caret listener aspect of the program see Listening for Caret and Selection Changes◆.

The Caret Event API

The `CaretListener` interface has just one method, so it has no corresponding adapter class. Here's the method:

`void caretUpdate(CaretEvent)`
Called when the caret in the listened-to component moves or when the selection in the listened-to component changes.

The `caretUpdate` method has a single parameter: a `CaretEvent` object. To get the text component that fired the event, use the `getSource` method which `CaretEvent` inherits from `EventObject`.

The `CaretEvent` class defines two useful methods:

`int getDot()`
Returns the current location of the caret. If text is selected, the caret marks one end of the selection.

`int getMark()`
Returns the other end of the selection. If nothing is selected, the value returned by this method is equal to the value returned by `getDot`. Note that the dot is not guaranteed to be less than the mark.

Examples that Use Caret Listeners

The following table lists the examples that use caret listeners.

Example	Where Described	Notes
`TextComponentDemo`	Listening for Caret and Selection Changes	Uses a "listener label" to display caret and selection status.

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Trail: Creating a GUI with JFC/Swing
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How to Write a Change Listener

Change events occur whenever a component changes state. For example, a button fires a change event every time the button is pressed. The look-and-feel implementation of the button listens for change events so that it can react appropriately to the state change (repainting itself, for example). Although nothing's stopping you from registering for change events on a button, most programs don't need to do so.

Two Swing components rely on change events for basic functionality -- sliders and color choosers. To learn when the value in a slider◆ changes, you need to register a change listener. Similarly, you need to register a change listener on a color chooser◆ to be informed when the user chooses a new color.

Here is an example of change event handling code for a slider:

```
//...where initialization occurs:
framesPerSecond.addChangeListener(new SliderListener());
...
class SliderListener implements ChangeListener {
    public void stateChanged(ChangeEvent e) {
        JSlider source = (JSlider)e.getSource();
        if (!source.getValueIsAdjusting()) {
            int fps = (int)source.getValue();
            ...
        }
    }
}
```

This snippet is from a program named `SliderDemo`. You can find the source and image files for the program, along with instructions for compiling and running it, in How to Use Sliders◆.

The Change Event API

The `ChangeListener` interface has just one method, so it has no corresponding adapter class. Here's the method:

`void stateChanged(ChangeEvent)`

Called when the listened-to component changes state.

The `stateChanged` method has a single parameter: a `ChangeEvent` object. To get the component that fired the event, use the `getSource` method which `ChangeEvent` inherits from `EventObject`. The `ChangeEvent` class defines no additional methods.

Examples that Use Change Listeners

The following table lists the examples that use change listeners.

Example	Where Described	Notes
`SliderDemo` and `SliderDemo2`	How to Use Sliders	Registers a change listener on a slider that controls animation speed. The change listener ignores the change events until the user releases the slider.
`ColorChooserDemo` and `ColorChooserDemo2`	How to Use Color Choosers	Uses a change listener on the selection model of a color chooser to learn when the user changes the current color.
`ConverterRangeModel` and its subclass, `FollowerRangeModel`	The Anatomy of a Swing-Based Program	Implement custom models for the sliders used in the `Converter` demo. Both models explicitly fire change events when necessary.

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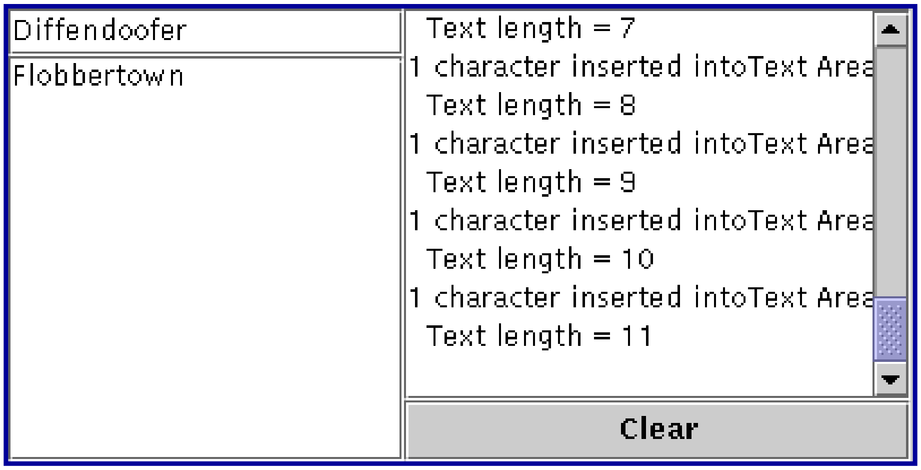
Trail: Creating a GUI with JFC/Swing
Lesson: Writing Event Listeners

How to Write a Document Listener

A Swing text component uses a `Document` to hold and edit its text. Document events occur when the content of a document changes in any way. You attach a document listener to a text component's document, rather than to the text component itself.

The following applet demonstrates document events on two plain text components.



```
Text length = 7
1 character inserted intoText Area
  Text length = 8
1 character inserted intoText Area
  Text length = 9
1 character inserted intoText Area
  Text length = 10
1 character inserted intoText Area
  Text length = 11
```

This is a picture of the applet's GUI. To run the applet, click the picture. The applet will appear in a new browser window.

Try this:

1. Type in the text field at the upper left of the applet or the text area beneath the text field.
   One document event is fired for each character typed.
2. Delete text with the backspace key.
   One document event is fired for each backspace key typed.
3. Select text and then delete it by typing backspace or by using a keyboard command such as `CTRL-X` (cut).
   One document event is fired for the entire deletion.
4. Copy text from one text component into the other using keyboard commands such as `CTRL-C` (copy) and `CTRL-V` (paste).
   One document event is fired for the entire paste operation regardless of the length of the text pasted. If text is selected in the target text component before the paste command is issued, an additional document event is fired because the selected text is deleted first.

You can find the applet's code in `DocumentEventDemo.java`. Here is the applet's document event handling code:

```
public class DocumentEventDemo ... {
    ...//where initialization occurs:
    textField = new JTextField(20);
    textField.addActionListener(new MyTextActionListener());
    textField.getDocument().addDocumentListener(new MyDocumentListener());
    textField.getDocument().putProperty("name", "Text Field");

    textArea = new JTextArea();
    textArea.getDocument().addDocumentListener(new MyDocumentListener());
    textArea.getDocument().putProperty("name", "Text Area");
    ...

class MyDocumentListener implements DocumentListener {
    String newline = "\n";

    public void insertUpdate(DocumentEvent e) {
        updateLog(e, "inserted into");
    }
    public void removeUpdate(DocumentEvent e) {
        updateLog(e, "removed from");
    }
    public void changedUpdate(DocumentEvent e) {
        //Plain text components don't fire these events
    }

    public void updateLog(DocumentEvent e, String action) {
        Document doc = (Document)e.getDocument();
        int changeLength = e.getLength();
        displayArea.append(
            changeLength + " character" +
            ((changeLength == 1) ? " " : "s ") +
            action + doc.getProperty("name") + "." + newline +
            "  Text length = " + doc.getLength() + newline);
    }
}
```

Document listeners shouldn't modify the contents of the document; The change is already complete by the time the listener is notified of the change. Instead, write a custom document that overrides the `insertString` or `remove` methods, or both. See Listening for Changes on a Document◆ for details.

The Document Event API

The `DocumentListener` interface contains these three methods:

`void changedUpdate(DocumentEvent)`

Called when the style of some of the text in the listened-to document changes. This sort of event is fired only from a `StyledDocument` -- a `PlainDocument` does not fire these events.

`void insertUpdate(DocumentEvent)`

Called when text is inserted into the listened-to document.

`void removeUpdate(DocumentEvent)`
Called when text is removed from the listened-to document.

Each document event method has a single parameter: an instance of a class that implements the `DocumentEvent` interface. Typically, the object passed into this method will be an instance of `DefaultDocumentEvent` which is defined in `AbstractDocument`.

To get the document that fired the event, you can use `DocumentEvent`'s `getDocument` method. Note that as an interface, `DocumentEvent` does not inherit from `EventObject`. Thus, it does not inherit the `getSource` method.

In addition to `getDocument`, the `DocumentEvent` interface requires these methods:

`int getLength()`
Returns the length of the change.

`int getOffset()`
Returns the location within the document of the first character changed.

`ElementChange getChange(Element)`
Returns details about what elements in the document have changed and how. `ElementChange` is an interface defined within the `DocumentEvent` interface.

`EventType getType()`
Returns the type of change that occurred. `EventType` is a class defined within the `DocumentEvent` interface that enumerates the possible changes that can occur on a document: insert text, remove text, and change text style.

Examples that Use Document Listeners

The following table lists the examples that use document listeners.

Example	Where Described	Notes
`DocumentEventDemo`	This section	Reports all document events that occur on the documents for both a text field and a text area. One listener listens to both text components and uses a client property on the document to determine which component fired the event.
`TextComponentDemo`	Listening for Changes on a Document	Updates a change log every time text in the listened-to document changes. The document in this example supports styled text, so `changedUpdate` gets called in this example. Requires this additional source file: `LimitedStyledDocument`
`TextFieldDemo`	Listening for Changes on a Document	Registers one document listener on three text fields. The listener computes a numeric value based on numeric values entered into the three text fields by the user.

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Trail: Creating a GUI with JFC/Swing
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How to Write an Undoable Edit Listener

Undoable edit events occur when an operation that can be undone occurs on a component. Currently, only text components fire undoable edit events, and then only indirectly. The text component's document fires the events. For text components, undoable operations include inserting characters, deleting characters, and modifying the style of text. Programs typically listen to undoable edit events to assist in the implementation of undo and redo commands.

Here is the undoable edit event handling code from an application called `TextComponentDemo`.

```
...
//where initialization occurs
document.addUndoableEditListener(new MyUndoableEditListener());
...
protected class MyUndoableEditListener implements UndoableEditListener {
    public void undoableEditHappened(UndoableEditEvent e) {
        //Remember the edit and update the menus
        undo.addEdit(e.getEdit());
        undoAction.updateUndoState();
        redoAction.updateRedoState();
    }
}
```

You can find the full source code for the program and instructions for compiling and running it in General Rules for Using Text Components◆. For a discussion about the undoable edit listener aspect of the program see Implementing Undo and Redo◆

The Undoable Edit Event API

The `UndoableEditListener` interface has just one method, so it has no corresponding adapter class. Here's the method:

`void undoableEditHappened(UndoableEditEvent)`
Called when an undoable event occurs on the listened-to component.

The `undoableEditHappened` method has a single parameter: a `UndoableEditEvent`◆ object. To get the document that fired the event, use the `getSource` method which `UndoableEditEvent` inherits from `EventObject`.

The `UndoableEditEvent` class defines one method which returns an object that contains detailed information about the edit that occurred.

`UndoableEdit getEdit()`

Returns an `UndoableEdit`◆ object that represents the edit that occurred and contains information about and commands for undoing or redoing the edit.

Examples that Use Undoable Edit Listeners

The following table lists the examples that use undoable edit listeners.

Example	Where Described	Notes
`TextComponentDemo`	Implementing Undo and Redo◆	Implements undo and redo on a text pane with help from an undoable edit listener.

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Trail: Creating a GUI with JFC/Swing
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How to Write a List Selection Listener

List selection events occur when the selection in a list◆ or table◆ is either changing or has just changed. List selection events are fired from an object that implements the `ListSelectionModel`◆ interface. To get a list or table's list selection model object, use the `getSelectionModel` method.

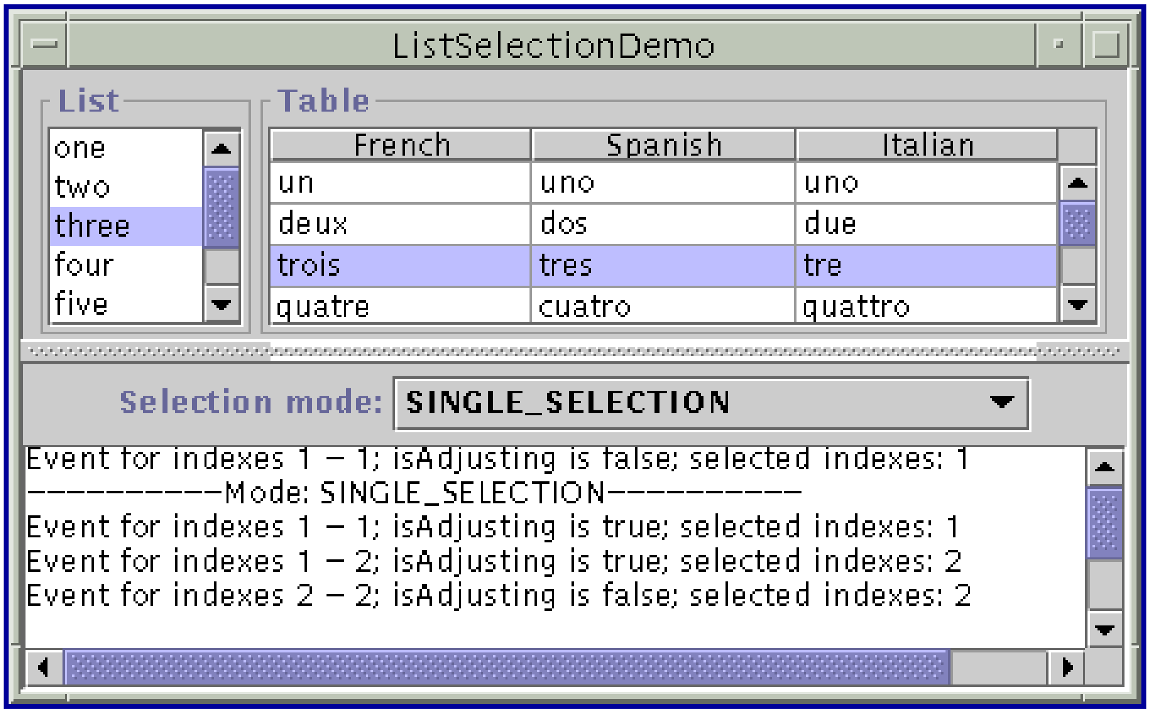
To detect list selection events, you register a listener on the appropriate list selection model object. The `JList` class also gives you the option of registering a listener on the list itself, rather than directly on the list selection model.

This section looks at an example that shows how to listen to list selection events on a selection model. Examples that Use List Selection Listeners lists examples that listen on the list directly.

The selection model is shared by a list and a table. You can dynamically change the selection mode to any of the three supported modes:

- single selection mode
- single interval selection mode
- multiple interval selection mode

Here's a picture of the example running:



French	Spanish	Italian
un	uno	uno
deux	dos	due
trois	tres	tre
quatre	cuatro	quattro

```
Event for indexes 1 - 1; isAdjusting is false; selected indexes: 1
----------Mode: SINGLE_SELECTION----------
Event for indexes 1 - 1; isAdjusting is true; selected indexes: 1
Event for indexes 1 - 2; isAdjusting is true; selected indexes: 2
Event for indexes 2 - 2; isAdjusting is false; selected indexes: 2
```

This figure has been reduced to fit on the page.
Click the image to view it at its natural size.

Try this:

1. Compile and run the application. The main source file is `ListSelectionDemo`.
   See Getting Started with Swing if you need help compiling or running this application.
2. Select and deselect items in the list and table. The mouse and keyboard commands required to select items depends on the look and feel. For the Java Look & Feel, click the left mouse button to begin a selection, use the shift key to extend a selection contiguously, and use the control key to extend a selection discontiguously. Dragging the mouse moves or extends the selection, depending on the list selection mode.

Here's the code from `ListSelectionDemo` that sets up the selection model and adds a listener to it:

```
...//where the member variables are defined
JList list;
JTable table;
    ...//in the init method:
    listSelectionModel = list.getSelectionModel();
    listSelectionModel.addListSelectionListener(
                            new SharedListSelectionHandler());
```

```
        ...
        table.setSelectionModel(listSelectionModel);
```

And here's the code for the listener, which works for all the possible selection modes:

```
    class SharedListSelectionHandler implements ListSelectionListener {
        public void valueChanged(ListSelectionEvent e) {
            ListSelectionModel lsm = (ListSelectionModel)e.getSource();

            int firstIndex = e.getFirstIndex();
            int lastIndex = e.getLastIndex();
            boolean isAdjusting = e.getValueIsAdjusting();
            output.append("Event for indexes "
                          + firstIndex + " - " + lastIndex
                          + "; isAdjusting is " + isAdjusting
                          + "; selected indexes:");

            if (lsm.isSelectionEmpty()) {
                output.append(" <none>");
            } else {
                // Find out which indexes are selected.
                int minIndex = lsm.getMinSelectionIndex();
                int maxIndex = lsm.getMaxSelectionIndex();
                for (int i = minIndex; i <= maxIndex; i++) {
                    if (lsm.isSelectedIndex(i)) {
                        output.append(" " + i);
                    }
                }
            }
            output.append(newline);
        }
    }
```

This `valueChanged` method displays the first and last indices reported by the event, the value of the event's `isAdjusting` flag, and the indices currently selected.

Note that the first and last indices reported by the event indicate the inclusive range of items for which the selection has changed. If the selection mode is multiple interval selection some items within the range might not have changed. The `isAdjusting` flag is `true` if the user is still manipulating the selection, and `false` if the user has finished changing the selection.

The `ListSelectionEvent` object passed into `valueChanged` indicates only that the selection has changed. The event contains no information about the current selection. So, this method queries the selection model to figure out the current selection.

> **Note:** The output from this program depends on the version of Swing you are using. Swing 1.0.x contains several bugs and the operation of lists and tables were inconsistent. Later versions of Swing fix these problems.

The List Selection Event API

The `ListSelectionListener` interface has just one method, so it has no corresponding adapter class. Here's the method:

`void valueChanged(ListSelectionEvent)`

Called when the selection in the listened-to component is changing, as well as just after the selection has changed.

Each list selection event method has a single parameter: a `ListSelectionEvent` object. The event object tells the listener that the selection changed. One list selection event can indicate a change in selection on multiple, discontiguous items in the list.

To get the source of a `ListSelectionEvent`, use the `getSource` method, which `ListSelectionEvent` inherits from `EventObject`. If you register a list selection listener on a list directly, then the source for each event is the list. Otherwise, the source is the selection model.

The `ListSelectionEvent` class defines the following handy methods:

`int getFirstIndex()`

Returns the index of the first item whose selection value has changed. Note that for multiple interval selection, the first and last items are guaranteed to have changed but items between them might not have.

`int getLastIndex()`

Returns the index of the last item whose selection value has changed. Note that for multiple interval selection, the first and last items are guaranteed to have changed but items between them might not have.

`int getValueIsAdjusting()`

Returns `true` if the selection is still changing. Many list selection listeners are interested only in the final state of the selection and can ignore list selection events when this method returns `true`.

Examples that Use List Selection Listeners

The following table lists the examples that use list selection listeners.

Example	Where Described	Notes

ListSelectionDemo	This section	Reports all list selection events that occur on a list and on a table. The table and the list share a list selection model, so only one listener is required. Let's the user dynamically change the selection mode.
SplitPaneDemo	How to Use Lists◆	Listens to events on a single-selection list (not on the list's selection model).
SimpleTableSelectionDemo	How to Use Tables◆	Uses two different list selection listeners on one table. One listener listens to list selection events on table columns, the other listens to list selection events on table rows.

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How to Write a Window Listener

Window events are fired by a window (such as a frame◆ or dialog◆) just after the window is opened, closed, iconified, deiconified, activated, or deactivated. *Opening* a window means showing it for the first time; *closing* it means removing the window from the screen. *Iconifying* it means substituting a small icon on the desktop for the window; *deiconifying* means the opposite. A window is *activated* if it or a component it contains has the keyboard focus; *deactivation* occurs when the window and all of its contents lose the keyboard focus. If you want to be notified when a window is made visible or hidden, then you should register a component listener on the window.

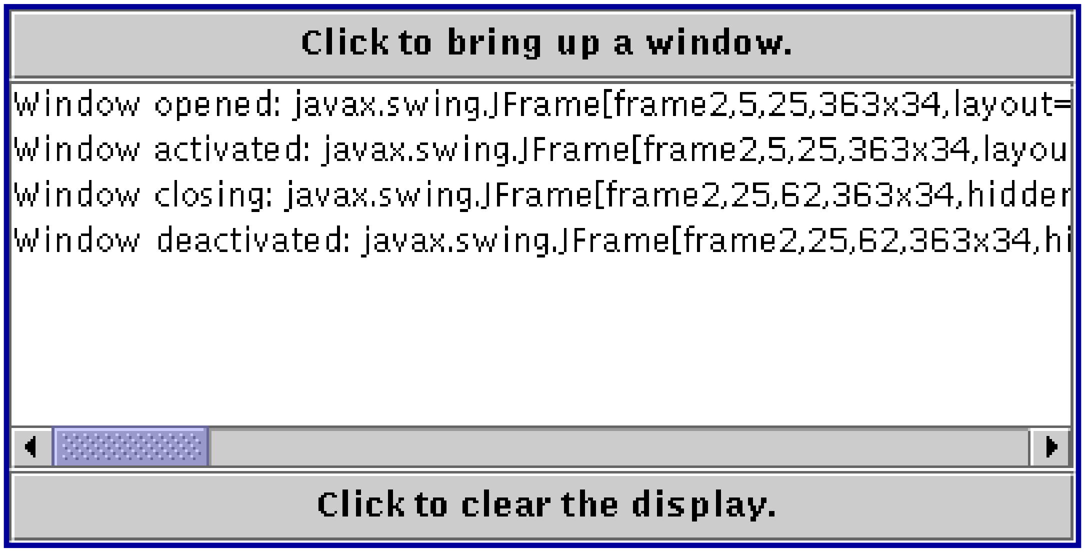
The most common use of window listeners is implementing custom window-closing behavior. For example, you might use a window listener to save data before closing the window, or to exit the program when the last window closes.

You don't necessarily need to implement a window listener to specify what a window should do when the user closes it. By default, when the user closes a window the window becomes invisible. You can specify different behavior -- disposing of the window, for example -- using the `JFrame` or `JDialog` `setDefaultCloseOperation` method. If you decide to implement a window-closing handler, then you might want to use `setDefaultCloseOperation(WindowConstants.DO_NOTHING_ON_CLOSE)` to specify that your window listener takes care of all window-closing duties.

See How to Make Frames (Main Windows)◆ for an example of a handler for window-closing events. Within that section, Responding to Window-Closing Events◆ has details on how to use `setDefaultCloseOperation`.

Another common use of window listeners is to stop threads and release resources when a window is iconified, and to start up again when the window is deiconified. This way, you can avoid unnecessarily using the processor or other resources. For example, when a window that contains animation is iconified, it should stop its animation thread and free any large buffers. When the window is deiconified, it can start the thread again and recreate the buffers.

The following applet demonstrates window events. By clicking the top button in the applet, you can bring up a small window. The controlling class listens for window events from the window, displaying a message whenever it detects a window event. You can find the applet's code in `WindowEventDemo.java`◆.



```
Window opened: javax.swing.JFrame[frame2,5,25,363x34,layout=
Window activated: javax.swing.JFrame[frame2,5,25,363x34,layou
Window closing: javax.swing.JFrame[frame2,25,62,363x34,hidden
Window deactivated: javax.swing.JFrame[frame2,25,62,363x34,hi
```

This is a picture of the applet's GUI. To run the applet, click the picture. The applet will appear in a new browser window.

Try this:

1. Bring up the Window Demo Window by clicking the applet's top button.
   The first time you click this button, you'll see a "Window opened" message in the applet's display area.
2. Click the window if it doesn't already have the focus.
   Do you see a "Window activated" message in the applet's display area?
3. Iconify the window, using the window controls.
   You'll see a "Window iconified" message in the applet's display area.
4. Deiconify the window.
   You'll see a "Window deiconified" message in the applet's display area.
5. Close the window, using the window controls.
   You'll see "Window closing" in the applet's display area. Because the window-closing event handler invokes `setVisible(false)` instead of `dispose()`, you won't see "Window closed".

Here is the applet's window event handling code:

```
public class WindowEventDemo ... implements WindowListener {
    ...//where initialization occurs:
        //Create but don't show window.
        window = new JFrame("Window Event Window");
        window.addWindowListener(this);
        window.getContentPane().add(
            new JLabel("The applet listens to this window "
                       + "for window events."),
            BorderLayout.CENTER);
        window.pack();
    }

    public void windowClosing(WindowEvent e) {
        window.setVisible(false);
        displayMessage("Window closing", e);
    }

    public void windowClosed(WindowEvent e) {
        displayMessage("Window closed", e);
    }

    public void windowOpened(WindowEvent e) {
        displayMessage("Window opened", e);
    }

    public void windowIconified(WindowEvent e) {
        displayMessage("Window iconified", e);
    }

    public void windowDeiconified(WindowEvent e) {
        displayMessage("Window deiconified", e);
    }

    public void windowActivated(WindowEvent e) {
        displayMessage("Window activated", e);
    }

    public void windowDeactivated(WindowEvent e) {
        displayMessage("Window deactivated", e);
    }

    void displayMessage(String prefix, WindowEvent e) {
        display.append(prefix
                       + ": "
                       + e.getWindow()
                       + newline);
    }
    ...
}
```

The Window Event API

The `WindowListener` interface and its corresponding adapter class, `WindowAdapter`, contain these methods:

`void windowOpened(WindowEvent)`
Called just after the listened-to window has been shown for the first time.

`void windowClosing(WindowEvent)`
Called in response to a user request that the listened-to window be closed. To actually close the window, the listener should invoke the window's `dispose` or `setVisible(false)` method.

`void windowClosed(WindowEvent)`
Called just after the listened-to window has closed.

`void windowIconified(WindowEvent)`
`void windowDeiconified(WindowEvent)`
Called just after the listened-to window is iconified or deiconified, respectively.

`void windowActivated(WindowEvent)`
`void windowDeactivated(WindowEvent)`
Called just after the listened-to window is activated or deactivated, respectively.

Each window event method has a single parameter: a `WindowEvent` object.

`Window getWindow()`
Returns the window that fired the event. You can use this instead of the `getSource` method.

Examples that Use Window Listeners

The following table lists the examples that use window listeners.

Example	Where Described	Notes
WindowEventDemo	This section	Reports all window events that occur on one window to demonstrate the circumstances under which window events are fired.
FrameDemo	How to Make Frames (Main Windows)◆	One of many examples that listens for window closing events, so that the application can exit when its only window is closed.
ComponentEventDemo	How to Write a Component Listener	Listens for window-closing events on a frame displayed by an applet. This way, the applet knows whether to re-open the window when the user leaves and returns to the applet's page.
FlowWindow	How to Use FlowLayout◆	Disposes a frame displayed by an applet when the user closes the frame.
SliderDemo	How to Use Sliders◆	Listens for window iconify and deiconify events, so that it can stop the animation when the window isn't visible.
InternalFrameEventDemo	How to Write an Internal Frame Listener	Reports all internal frame events that occur on one internal frame to demonstrate the circumstances under which internal frame events are fired. Internal frame events are similar to window events.
TextComponentDemo	General Rules for Using Text Components◆	Contains a text pane that requests the keyboard focus in response to window-activated events.
DialogDemo and CustomDialog.java◆	General Rules for Using Text Components◆	Uses `setDefaultCloseOperation` instead of a window listener to determine what action to take when the user closes the window.

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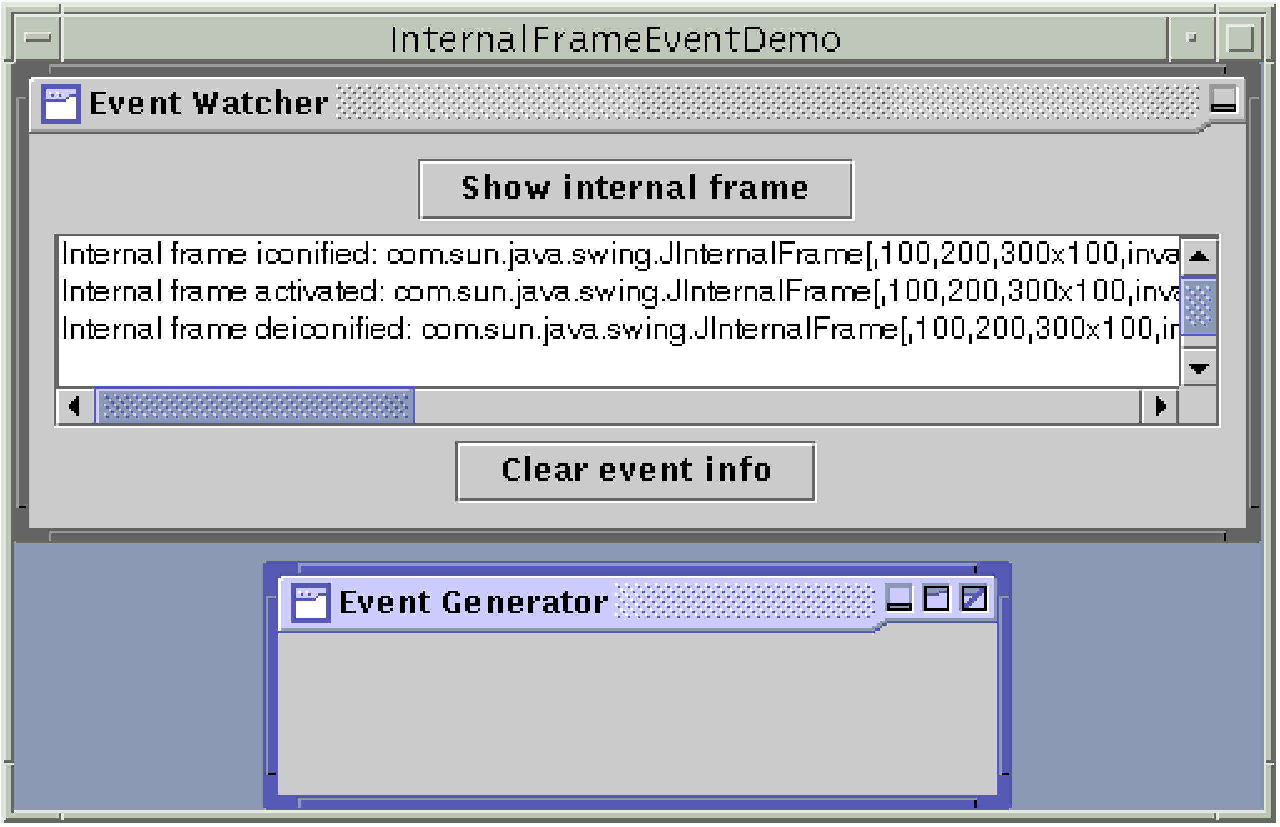
How to Write an Internal Frame Listener

Internal frame events are to `JInternalFrame`◆ what window events are to `JFrame`◆. Like window events, internal frame events notify listeners that the "window" has been shown for the first time, disposed of, iconified, deiconified, activated, or deactivated. Before using internal frame events, please familiarize yourself with How to Write a Window Listener.

The application shown in the following figure demonstrates internal frame events. The application listens for internal frame events from the Event Generator frame, displaying a message that describes each event.



```
Internal frame iconified: com.sun.java.swing.JInternalFrame[,100,200,300x100,inva
Internal frame activated: com.sun.java.swing.JInternalFrame[,100,200,300x100,inva
Internal frame deiconified: com.sun.java.swing.JInternalFrame[,100,200,300x100,in
```

Try this:

1. Compile and run `InternalFrameEventDemo`. The source file is `InternalFrameEventDemo.java`◆.
   See Getting Started with Swing if you need help compiling or running this

application.
2. Bring up the Event Generator internal frame by clicking the applet's top button.
   You should see an "Internal frame opened" message in the display area.
3. Try various operations to see what happens. For example, click the Event Generator so that it gets activated. Click the Event Watcher so that the Event Generator gets deactivated. Click the Event Generator's decorations to iconify, maximize, minimize, and close the window.

Here is the internal frame event handling code:

```
public class InternalFrameEventDemo ...
                     implements InternalFrameListener ... {
    ...
    protected void createListenedToWindow() {
        listenedToWindow = new JInternalFrame("Event Generator",
                                              true,  //resizable
                                              true,  //closable
                                              true,  //maximizable
                                              true); //iconifiable
        listenedToWindow.setDefaultCloseOperation(
                                WindowConstants.DISPOSE_ON_CLOSE);
        ...
    }

    public void internalFrameClosing(InternalFrameEvent e) {
        displayMessage("Internal frame closing", e);
    }

    public void internalFrameClosed(InternalFrameEvent e) {
        displayMessage("Internal frame closed", e);
        listenedToWindow = null;
    }

    public void internalFrameOpened(InternalFrameEvent e) {
        displayMessage("Internal frame opened", e);
    }

    public void internalFrameIconified(InternalFrameEvent e) {
        displayMessage("Internal frame iconified", e);
    }

    public void internalFrameDeiconified(InternalFrameEvent e) {
        displayMessage("Internal frame deiconified", e);
    }
    public void internalFrameActivated(InternalFrameEvent e) {
        displayMessage("Internal frame activated", e);
    }

    public void internalFrameDeactivated(InternalFrameEvent e) {
        displayMessage("Internal frame deactivated", e);
    }

    void displayMessage(String prefix, InternalFrameEvent e) {
        String s = prefix + ": " + e.getSource();
        display.append(s + newline);
    }

    public void actionPerformed(ActionEvent e) {
        if (e.getActionCommand().equals(SHOW)) {
            ...
            if (listenedToWindow == null) {
                createListenedToWindow();
                listenedToWindow.addInternalFrameListener(this);
                ...
            }
        }
        ...
    }
}
```

The Internal Frame Event API

The `InternalFrameListener` interface and its corresponding adapter class, `InternalFrameAdapter`, contain these methods:

`void internalFrameOpened(InternalFrameEvent)`
Called just after the listened-to internal frame has been shown for the first time.

`void internalFrameClosing(InternalFrameEvent)`
Called in response to a user request that the listened-to internal frame be closed. By default, `JInternalFrame` hides the window when the user closes it. You can use the `JInternalFrame` `setDefaultCloseOperation` method to specify another option, which must be either `DISPOSE_ON_CLOSE` or `DO_NOTHING_ON_CLOSE` (both defined in `WindowConstants`, an interface that `JInternalFrame` implements). Or by implementing an `internalFrameClosing` method in the internal frame's listener, you can add custom behavior (such as bringing up dialogs or saving data) to internal frame closing.

`void internalFrameClosed(InternalFrameEvent)`

Called just after the listened-to internal frame has been disposed of.

`void internalFrameIconified(InternalFrameEvent)`
`void internalFrameDeiconified(InternalFrameEvent)`
Called just after the listened-to internal frame is iconified or deiconified, respectively.

`void internalFrameActivated(InternalFrameEvent)`
`void internalFrameDeactivated(InternalFrameEvent)`
Called just after the listened-to internal frame is activated or deactivated, respectively.

Each internal frame event method has a single parameter: a `InternalFrameEvent`◆ object. The `InternalFrameEvent` class defines no generally useful methods. To get the internal frame that fired the event, use the `getSource` method, which `InternalFrameEvent` inherits from `EventObject`.

Examples that Use Internal Frame Listeners

No other source files currently contain internal frame listeners. However, internal frame listeners are very similar to window listeners, and many Swing programs have window listeners:

Example	Where Described	Notes
`InternalFrameEventDemo`	This section	Reports all internal frame events that occur on one internal frame to demonstrate the circumstances under which internal frame events are fired.
`FrameDemo`	How to Make Frames (Main Windows)◆	One of many examples that listens for window closing events, so that the application can exit when its only window is closed.
`SliderDemo`	How to Use Sliders◆	Listens for window iconify and deiconify events, so that it can stop the animation when the window isn't visible.

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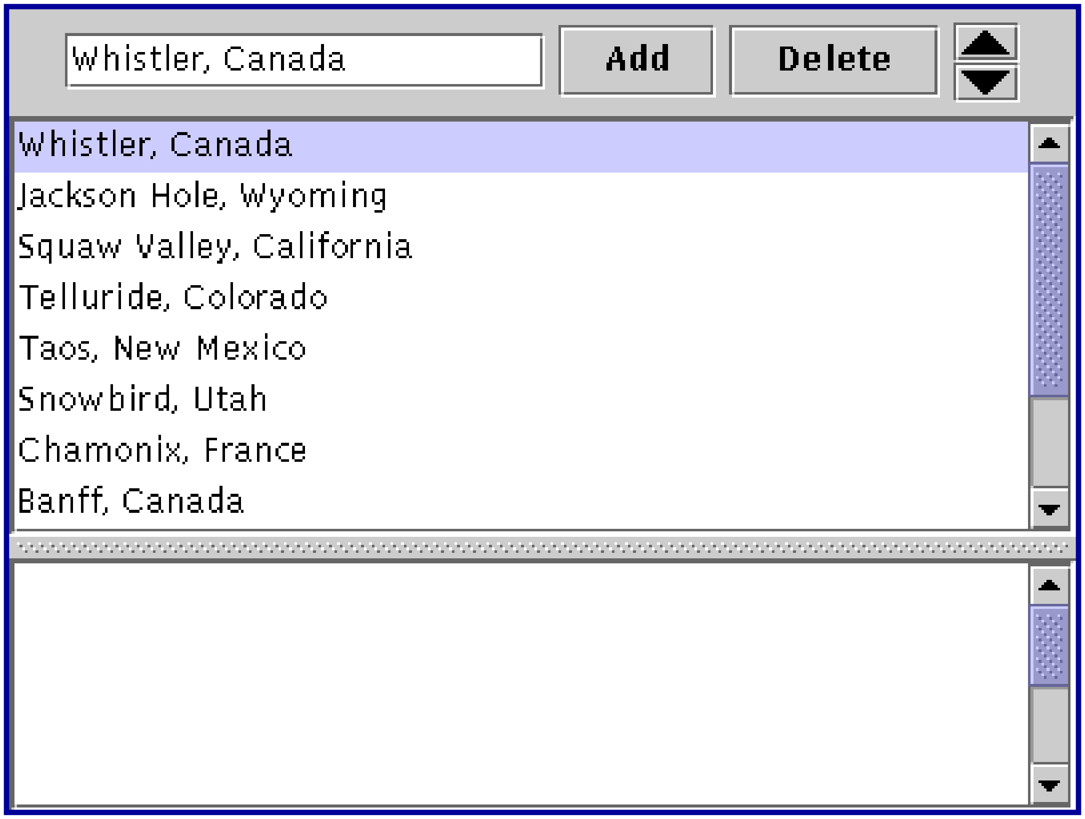
How to Write a List Data Listener

List data events occur when the contents of a mutable list◆ change. The list's model fires these events, the list does not. So you have to register a list data listener with the list model. If you haven't explicitly created a list with a mutable list model, then your list is immutable, and its model will not fire these events.

The following applet demonstrates list data events on a mutable list:



Whistler, Canada

Whistler, Canada
Jackson Hole, Wyoming
Squaw Valley, California
Telluride, Colorado
Taos, New Mexico
Snowbird, Utah
Chamonix, France
Banff, Canada

This is a picture of the applet's GUI. To run the applet, click the picture. The applet will appear in a new browser window.

Try this:

1. Type in the name of your favorite ski resort and click the **Add** button.
2. Select a few continguous items in the list and click the **Delete** button.

3. Select one item and move it up or down in the list with the arrow buttons.

You can find the applet's code in `ListDataEventDemo.java`. You will also need two image files.

Here's the code from the applet that registers a list data listener on the list model and implements the listener:

```
//...where member variables are declared...
private DefaultListModel listModel;
...
//Create and populate the list model
listModel = new DefaultListModel();
...
listModel.addListDataListener(new MyListDataListener());

class MyListDataListener implements ListDataListener {
    public void contentsChanged(ListDataEvent e) {
        log.append("contentsChanged: " + e.getIndex0() +
                   ", " + e.getIndex1() + newline);
    }
    public void intervalAdded(ListDataEvent e) {
        log.append("intervalAdded: " + e.getIndex0() +
                   ", " + e.getIndex1() + newline);
    }
    public void intervalRemoved(ListDataEvent e) {
        log.append("intervalRemoved: " + e.getIndex0() +
                   ", " + e.getIndex1() + newline);
    }
}
```

The List Data Event API

The `ListDataListener` interface contains these three methods:

`void intervalAdded(ListDataEvent)`
Called when one or more items have been added to the list.

`void intervalRemoved(ListDataEvent)`
Called when one or more items have been removed from the list.

`void contentsChanged(ListDataEvent)`
Called when the contents of one or more items in the list have changed.

Each list selection event method has a single parameter: a `ListDataEvent` object. To get the source of a `ListDataEvent`, use the `getSource` method, which `ListDataEvent` inherits from `EventObject`.

The `ListDataEvent` class defines the following handy methods:

`int getIndex0()`
Returns the index of the first item whose value has changed.

`int getIndex1()`
Returns the index of the last item whose value has changed.

Examples that Use List Data Listeners

The following table lists the examples that use list data listeners.

Example	Where Described	Notes
`ListDataEventDemo`	This section	Reports all list data events that occur on a list.

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How to Write a Table Model Listener

Each `JTable`◆ object has a table model that holds its data. When a table model listener is registered on the table model, the listener is notified every time the table model's data changes. The `JTable` itself automatically uses a table model listener to make its GUI reflect the current state of the table model. You register a table model listener using the `TableModel` `addTableModelListener` method.

The Table Model Event API

The `TableModelListener`◆ interface contains a single method, and thus has no corresponding adapter class. Here is the lone `TableModelListener` method:

`void tableChanged(TableModelEvent)`
Called when the structure of or data in the table has changed.

The `tableChanged` method's argument is a `TableModelEvent`◆ object that specifies which cells changed, and how in general they changed. You can query the `TableModelEvent` using the following methods:

`int getFirstRow()`
Returns the index of the first row that changed. `TableModelEvent.HEADER_ROW` specifies the table header.

`int getLastRow()`
The last row that changed. Again, `HEADER_ROW` is a possible value.

`int getColumn()`
Returns the index of the column that changed. The constant `TableModelEvent.ALL_COLUMNS` specifies that all the columns might have changed.

`int getType()`
Specifies what happened to the changed cells. The returned value is one of the following: `TableModelEvent.INSERT`, `TableModelEvent.DELETE`, or `TableModelEvent.UPDATE`.

Also useful is the `getSource` method, which `TableModelEvent` inherits from `EventObject`.

Examples that Use Table Model Listeners

The following table lists the examples that use table model listeners.

Example	Where Described	Notes
`TableMap`	Sorting and Otherwise Manipulating Data	A superclass for data-manipulating table models. It implements a table model that sits between a table data model and a `JTable`. The `TableMap` listens for table model events from the data model, and then simply forwards them to its table model listeners (such as the `JTable`).
`TableSorter`	Sorting and Otherwise Manipulating Data	A sorting table model implemented as a subclass of `TableMap`. In addition to forwarding table model events, the `tableChanged` method keeps track of the number of rows.
`SharedModelDemo`	--	Does *not* implement a table model listener. Instead, it implements a combined list and table model.

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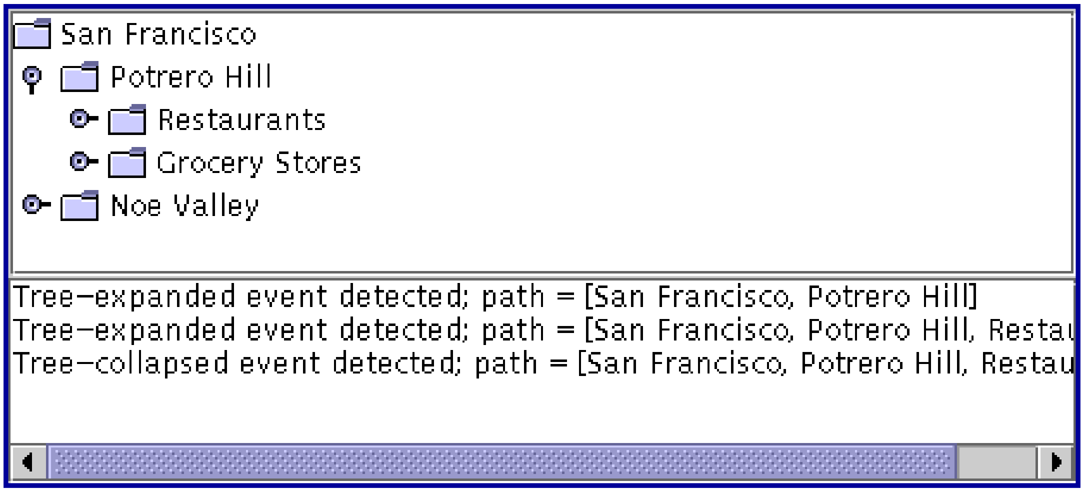
How to Write a Tree Expansion Listener

Sometimes when using a tree◆, you might need to react when a branch becomes expanded or collapsed. For example, you might need to load or save data. Or you might need to prevent the user from expanding a particular node.

Two kinds of listeners report expansion and collapse occurrences: tree expansion listeners and tree-will-expand listeners. This page discusses the former. A tree expansion listener detects when an expansion or collapse has happened. In general, you should implement a tree expansion listener unless you might need to prevent an expansion or collapse from happening.

Tree-will-expand listeners are discussed in How to Write a Tree-Will-Expand Listener. A tree-will-expand listener detects when an expansion or collapse is about to happen.

The following applet demonstrates a simple tree expansion listener. The text area at the bottom of the applet displays a message every time a tree expansion event occurs. It's a straightforward, boring applet. To see a more interesting version that can veto expansions, go to How to Write a Tree-Will-Expand Listener.



```
Tree-expanded event detected; path = [San Francisco, Potrero Hill]
Tree-expanded event detected; path = [San Francisco, Potrero Hill, Restau
Tree-collapsed event detected; path = [San Francisco, Potrero Hill, Restau
```

This is a picture of the applet's GUI. To run the applet, click the picture. The applet will appear in a new browser window.

The following code shows how the program handles expansion events. You can find all the applet's source code in `TreeExpandEventDemo.java`◆.

```
public class TreeExpandEventDemo ... {
    ...
    void saySomething(String eventDescription, TreeExpansionEvent e) {
        textArea.append(eventDescription + "; "
                        + "path = " + e.getPath()
                        + newline);
    }

    class DemoArea ... implements TreeExpansionListener {
        ...
        public DemoArea() {
            ...
            tree.addTreeExpansionListener(this);
            ...
        }
        ...
        // Required by TreeExpansionListener interface.
        public void treeExpanded(TreeExpansionEvent e) {
            saySomething("Tree-expanded event detected", e);
        }

        // Required by TreeExpansionListener interface.
        public void treeCollapsed(TreeExpansionEvent e) {
            saySomething("Tree-collapsed event detected", e);
        }
    }
}
```

The Tree Expansion Event API

The `TreeExpansionListener` interface contains two methods:

`void treeCollapsed(TreeExpansionEvent)`
: Called just after a tree node collapses.

`void treeExpanded(TreeExpansionEvent)`
: Called just after a tree node expands.

Both methods have a single parameter: a `TreeExpansionEvent` object. The `TreeExpansionEvent` class defines the following method:

`TreePath getPath()`
: Returns a `TreePath` object that identifies each node from the root of the tree to the collapsed/expanded node, inclusive.

Another useful method is `getSource`, which `TreeExpansionEvent` inherits from `EventObject`.

Examples that Use Tree Expansion Listeners

The following table lists the examples that use tree expansion listeners.

Example	Where Described	Notes
`TreeExpandEventDemo`	This section	Displays a message whenever a tree expansion event occurs.
`TreeExpandEventDemo2`	How to Write a Tree-Will-Expand Listener	Adds a tree-will-expand listener to `TreeExpandEventDemo`.

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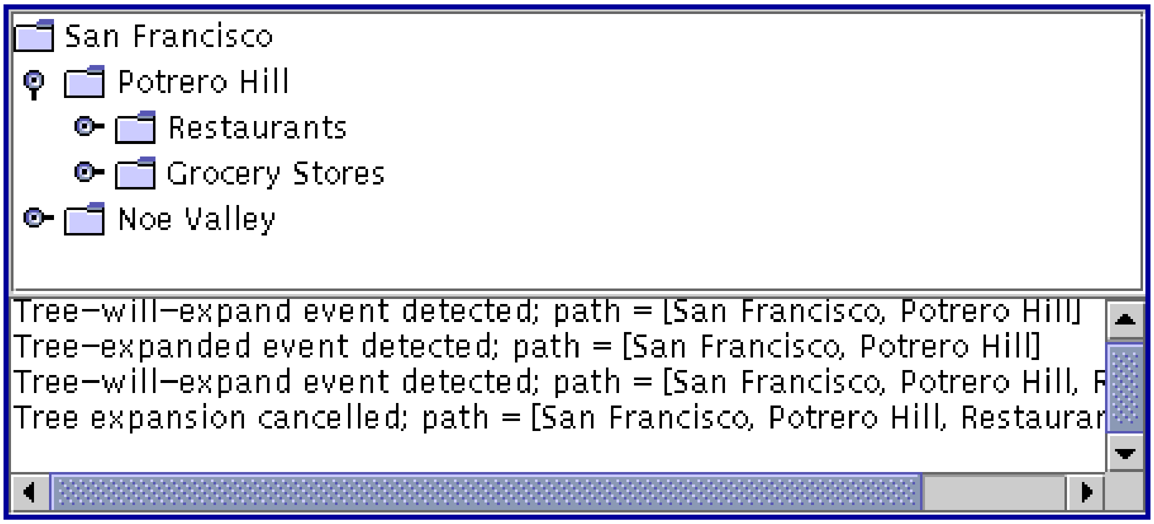
How to Write a Tree-Will-Expand Listener

As explained in How to Write a Tree Expansion Listener, you can use a tree-will-expand listener to prevent a tree◆ node from expanding or collapsing. To be notified just *after* an expansion or collapse occurs, you should use a tree expansion listener instead.

The following applet adds a tree-will-expand listener to the `TreeExpandEventDemo` example discussed in How to Write a Tree Expansion Listener. The new code demonstrates the ability of tree-will-expand listeners to veto node expansions and collapses: it asks for confirmation each time you try to expand a node.



```
Tree-will-expand event detected; path = [San Francisco, Potrero Hill]
Tree-expanded event detected; path = [San Francisco, Potrero Hill]
Tree-will-expand event detected; path = [San Francisco, Potrero Hill, R
Tree expansion cancelled; path = [San Francisco, Potrero Hill, Restaurar
```

This is a picture of the applet's GUI. To run the applet, click the picture. The applet will appear in a new browser window.

Try this:

1. Click the graphic to the left of the **Potrero Hill** node. This tells the tree that you want to expand the node.
   A dialog will appear asking you whether you really want to expand the node.
2. Click "Expand" or dismiss the dialog.
   Messages in the text area tell you that both a tree-will-expand event and a tree expanded event have occurred. At the end of each message is the path to the expanded node.

3. Try to expand another node, but this time press the "Cancel Expansion" button in the dialog.
   The node does not expand. Messages in the text area tell you that a tree-will-expand event occurred, and that you cancelled a tree expansion.
4. Collapse the **Potrero Hill** node.
   The node collapses without a dialog appearing, because the event handler's `treeWillCollapse` method lets the collapse occur, uncontested.

The following snippet shows the code that this program adds to `TreeExpandEventDemo`. The bold line prevents the tree expansion from happening. You can find all the applet's source code in `TreeExpandEventDemo.2java`.

```
public class TreeExpandEventDemo2 ... {
    ...
    class DemoArea ... implements ... TreeWillExpandListener {
        ...
        public DemoArea() {
            ...
            tree.addTreeWillExpandListener(this);
            ...
        }
        ...
        // Required by TreeWillExpandListener interface.
        public void treeWillExpand(TreeExpansionEvent e)
                    throws ExpandVetoException {
            saySomething("Tree-will-expand event detected", e);
            //...show a dialog...
            if (/* user said to cancel the expansion */) {
                //Cancel expansion.
                saySomething("Tree expansion cancelled", e);
                throw new ExpandVetoException(e);
            }
        }

        // Required by TreeWillExpandListener interface.
        public void treeWillCollapse(TreeExpansionEvent e) {
            saySomething("Tree-will-collapse event detected", e);
        }
        ...
    }
}
```

The Tree-Will-Expand Event API

The `TreeWillExpandListener` interface contains two methods:

`void treeWillCollapse(TreeExpansionEvent)`
Called just before a tree node collapses. To prevent the collapse from occurring, your implementation of this method should throw a `ExpandVetoException` event.

`void treeWillExpand(TreeExpansionEvent)`
Called just before a tree node expands. To prevent the expansion from occurring, your implementation of this method should throw a `ExpandVetoException` event.

See The Tree Expansion Event API for information about the `TreeExpansionEvent` argument for the preceding methods.

Examples that Use Tree-Will-Expand Listeners

`TreeExpandEventDemo2`, featured in this section, is our only example that uses a tree-will-expand listener.

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Trail: Creating a GUI with JFC/Swing
Lesson: Writing Event Listeners

How to Write a Tree Model Listener

By implementing a tree model listener, you can detect when the data displayed by a tree◆ changes. You might use a tree model listener to detect when the user edits tree nodes. To see an example and discussion of doing so, read Dynamically Changing a Tree◆.

The Tree Model Event API

The `TreeModelListener`◆ interface contains four methods:

`void treeNodesChanged(TreeModelEvent)`
Called when one or more sibling nodes have changed in some way.

`void treeNodesInserted(TreeModelEvent)`
Called after nodes have been inserted into the tree.

`void treeNodesRemoved(TreeModelEvent)`
Called after nodes have been removed from the tree.

`void treeNodesStructureChanged(TreeModelEvent)`
Called after the tree's structure has drastically changed.

Each tree model event method has a single parameter: a `TreeModelEvent`◆ object. The `TreeModelEvent` class defines the following useful method:

`int[] getChildIndices()`
For `treeNodesChanged`, `treeNodesInserted`, and `treeNodesRemoved`, returns the indices of the changed, inserted, or deleted nodes, respectively. Returns nothing useful for `treeStructureChanged`.

`Object[] getChildren()`
Returns the objects corresponding to the child indices.

`Object[] getPath()`
Returns the path to the parent of the changed, inserted, or deleted nodes. For `treeStructureChanged`, returns the path to the node beneath which the structure has changed.

`TreePath getTreePath()`
Returns the same thing as `getPath`, but as a `TreePath`◆ object.

Also useful is the `getSource` method, which `TreeModelEvent` inherits from `EventObject`◆.

Examples that Use Tree Model Listeners

The `DynamicTree` example implements a tree model listener to detect when the user has edited a node's data. You can find the listener's code in `DynamicTree`◆. The example also relies on `DynamicTreeDemo`◆. The code is discussed in Dynamically Changing a Tree◆.

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Trail: Creating a GUI with JFC/Swing
Lesson: Writing Event Listeners

How to Write a Tree Selection Listener

To detect when the user selects a node in a tree◆, you need to register a tree selection listener. Here is an example, taken from the TreeDemo example discussed in Responding to Node Selection◆, of detecting node selection in a tree that can have at most one node selected at a time:

```
tree.addTreeSelectionListener(new TreeSelectionListener() {
    public void valueChanged(TreeSelectionEvent e) {
        DefaultMutableTreeNode node = (DefaultMutableTreeNode)
                           tree.getLastSelectedPathComponent();

        if (node == null) return;

        Object nodeInfo = node.getUserObject();
        ...
        /* React to the node selection. */
        ...
    }
});
```

To specify that the tree should support single selection, the program uses this code:

```
tree.getSelectionModel().setSelectionMode
        (TreeSelectionModel.SINGLE_TREE_SELECTION);
```

The `TreeSelectionModel` interface defines three values for the selection mode:

`DISCONTIGUOUS_TREE_SELECTION`
This is the default mode for the default tree selection model. With this mode, any combination of nodes can be selected.

`SINGLE_TREE_SELECTION`
This is the mode used by the preceding example. At most one node can be selected at a time.

`CONTIGUOUS_TREE_SELECTION`
With this mode, only nodes in adjoining rows can be selected.

The Tree Selection Event API

The `TreeSelectionListener` interface contains a single method, and thus has no corresponding adapter class. Here is the lone `TreeSelectionListener` method:

`void valueChanged(TreeSelectionEvent)`
Called whenever the selection changes.

The `valueChanged` method has a single parameter: an `TreeSelectionEvent` object. The `TreeSelectionEvent` class defines several methods for returning the path or paths of the selection. As the preceding code example shows, you can also use `JTree` methods such as `getLastSelectedPathComponent` to get the current selection.

If you need to find the object that fired the tree selection event, you can use the `getSource` method, which `TableSelectionEvent` inherits from `EventObject`.

Examples that Use Tree Selection Listeners

The `TreeDemo` example, as well as examples such as `TreeIconDemo` that add to it, uses a tree selection listener. The listener responds to node clicks by showing the appropriate HTML document. You can find the source code for `TreeDemo` in `TreeDemo`, and a full discussion of the program in How to Use Trees.

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Summary of Listener API

In the table that follows, the first column gives the name of the listener interface, with either a link to the tutorial page that discusses the listener or, if the tutorial doesn't discuss the listener, a link to the API docs. The second column names the corresponding adapter class, if any. (For a discussion of using adapters, see Using Adapters and Inner Classes to Handle Events.) The third column lists the methods that the listener interface contains and shows the type of the event object passed into the method. Typically, the listener, the adapter, and the event type have the same name prefix, but this is not always the case.

To see which Swing components can fire which kinds of events, see Listeners Supported by Swing Components.

Listener Interface	Adapter Class	Listener Methods
`ActionListener`	*none*	`actionPerformed(ActionEvent)`

`AncestorListener`◆	*none*	`ancestorAdded(AncestorEvent)`
		`ancestorMoved(AncestorEvent)`
		`ancestorRemoved(AncestorEvent)`

`CaretListener`	*none*	`caretUpdate(CaretEvent)`

`CellEditorListener`◆	*none*	`editingStopped(ChangeEvent)`
		`editingCanceled(ChangeEvent)`

`ChangeListener`	*none*	`stateChanged(ChangeEvent)`

`ComponentListener`	`ComponentAdapter`	`componentHidden(ComponentEvent)`
		`componentMoved(ComponentEvent)`
		`componentResized(ComponentEvent)`
		`componentShown(ComponentEvent)`

`ContainerListener`	`ContainerAdapter`	`componentAdded(ContainerEvent)`
		`componentRemoved(ContainerEvent)`

`DocumentListener`	*none*	`changedUpdate(DocumentEvent)`
		`insertUpdate(DocumentEvent)`
		`removeUpdate(DocumentEvent)`

`FocusListener`	`FocusAdapter`	`focusGained(FocusEvent)`
		`focusLost(FocusEvent)`

`HyperlinkListener`◆	*none*	`hyperlinkUpdate(HyperlinkEvent)`

`InternalFrameListener`	`InternalFrameAdapter`	`internalFrameActivated(InternalFrameEvent)`
		`internalFrameClosed(InternalFrameEvent)`
		`internalFrameClosing(InternalFrameEvent)`
		`internalFrameDeactivated(InternalFrameEvent)`
		`internalFrameDeiconified(InternalFrameEvent)`
		`internalFrameIconified(InternalFrameEvent)`
		`internalFrameOpened(InternalFrameEvent)`

`ItemListener`	*none*	`itemStateChanged(ItemEvent)`

`KeyListener`	`KeyAdapter`	`keyPressed(KeyEvent)`
		`keyReleased(KeyEvent)`
		`keyTyped(KeyEvent)`

`ListDataListener`	*none*	`contentsChanged(ListDataEvent)`
		`intervalAdded(ListDataEvent)`
		`intervalRemoved(ListDataEvent)`

ListSelectionListener	*none*	valueChanged(ListSelectionEvent)

MenuDragMouseListener◆	*none*	menuDragMouseDragged(MenuDragMouseEvent)
		menuDragMouseEntered(MenuDragMouseEvent)
		menuDragMouseExited(MenuDragMouseEvent)
		menuDragMouseReleased(MenuDragMouseEvent)

MenuKeyListener◆	*none*	menuKeyPressed(MenuKeyEvent)
		menuKeyReleased(MenuKeyEvent)
		menuKeyTyped(MenuKeyEvent)

MenuListener◆	*none*	menuCanceled(MenuEvent)
		menuDeselected(MenuEvent)
		menuSelected(MenuEvent)

MouseInputListener◆	MouseInputAdapter	mouseClicked(MouseEvent)
		mouseEntered(MouseEvent)
		mouseExited(MouseEvent)
		mousePressed(MouseEvent)
		mouseReleased(MouseEvent)
		mouseDragged(MouseEvent)
		mouseMoved(MouseEvent)

MouseListener	MouseAdapter	mouseClicked(MouseEvent)
		mouseEntered(MouseEvent)
		mouseExited(MouseEvent)
		mousePressed(MouseEvent)
		mouseReleased(MouseEvent)

MouseMotionListener	MouseMotionAdapter	mouseDragged(MouseEvent)
		mouseMoved(MouseEvent)

PopupMenuListener◆	*none*	popupMenuCanceled(PopupMenuEvent)
		popupMenuWillBecomeInvisible(PopupMenuEvent)
		popupMenuWillBecomeVisible(PopupMenuEvent)

TableColumnModelListener◆	*none*	columnAdded(TableColumnModelEvent)
		columnMoved(TableColumnModelEvent)
		columnRemoved(TableColumnModelEvent)
		columnMarginChanged(ChangeEvent)
		columnSelectionChanged(ListSelectionEvent)

TableModelListener	*none*	tableChanged(TableModelEvent)

TreeExpansionListener	*none*	treeCollapsed(TreeExpansionEvent)
		treeExpanded(TreeExpansionEvent)

TreeModelListener	*none*	treeNodesChanged(TreeModelEvent)
		treeNodesInserted(TreeModelEvent)
		treeNodesRemoved(TreeModelEvent)
		treeStructureChanged(TreeModelEvent)

TreeSelectionListener	*none*	valueChanged(TreeSelectionEvent)

TreeWillExpandListener	*none*	treeWillCollapse(TreeExpansionEvent)
		treeWillExpand(TreeExpansionEvent)

UndoableEditListener	*none*	undoableEditHappened(UndoableEditEvent)

WindowListener	WindowAdapter	windowActivated(WindowEvent)
		windowClosed(WindowEvent)
		windowClosing(WindowEvent)
		windowDeactivated(WindowEvent)
		windowDeiconified(WindowEvent)
		windowIconified(WindowEvent)
		windowOpened(WindowEvent)

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Trail: Creating a GUI with JFC/Swing
Lesson: Writing Event Listeners

Solving Common Event-Handling Problems

This section discusses problems that you might encounter while handling events.

Problem: I'm trying to handle certain events from a component, but the component isn't generating the events it should.

- First, make sure you registered the right kind of listener to detect the events. See whether another kind of listener might detect the kind of events you need.
- Make sure you registered the listener on the right object.
- Did you implement the event handler correctly? For example, if you extended an adapter class, then make sure you used the right method signautre. Make sure each event-handling method is `public void`, that the name spelled right and that the argument is of the right type.
- If you still think that the component isn't generating the events it should, check the Java Developer Connection to see whether this is a known bug.

Problem: My combo box isn't generating low-level events such as focus events.

- Combo boxes are compound components -- components implemented using multiple components. For this reason, combo boxes don't fire the low-level events that simple components fire. For more information, see Handling Events on a Combo Box.

Problem: The document for an editor pane (or text pane) isn't firing document events.

- The document instance for an editor pane or text pane might change when loading text from a URL. Thus, your listeners might be listening for events on an unused document. For example, if you load an editor pane or text pane with HTML that was previously loaded with plain text, the document will change to an `HTMLDocument` instance. If your program dynamically loads text into an editor pane or text pane, make sure the code adjusts for possible changes to the document (re-register document listeners on the new document, and so on).

If you don't see your problem in this list, see Solving Common Component Problems◆.

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Lesson: Using Swing Components

Solving Common Component Problems

This section discusses problems that you might encounter while using components. If you don't find your problem in this section, consult the following sections:

- Solving Common Problems Using Other Swing Features◆
- Solving Common Layout Problems◆
- Solving Common Event-Handling Problems◆
- Solving Common Graphics Problems◆
- Solving Common Conversion Problems◆

Problem: I can't make HTML tags work in my labels or buttons or... (See How to Use JButton Features for an example.)

- Make sure your program is running in a release that supports HTML text in the desired component. The following table shows which releases support HTML in which components.

API Version	Corresponding JFC 1.1 Release	Corresponding Java 2 Release	Status of HTML support
Swing 1.1	JFC 1.1 (with Swing 1.1)	Java 2 v 1.2, Java 2 v 1.2.1	HTML supported in styled text components only.
Swing 1.1.1 Beta 1	JFC 1.1 (with Swing 1.1.1 Beta 1)	*none*	HTML support added for `JButton` and `JLabel`. Because table cells and tree nodes use labels to render strings, tables and trees automatically support HTML, as well.

Swing 1.1.1 Beta 2	JFC 1.1 (with Swing 1.1.1 Beta 2)	*none*	HTML support added for `JMenuItem`, `JMenu`, `JCheckBoxMenuItem`, `JRadioButtonMenuItem`, `JTabbedPane`, and `JToolTip`.
Swing 1.1.1 *(expected)*	JFC 1.1 (with Swing 1.1.1) *(expected)*	Java 2 v 1.2.2 *(expected)*	Same as Swing 1.1.1 Beta 2.

- `JCheckBox` and `JRadioButton` don't support HTML yet. We don't know yet when that support will be added.
- If you can't guarantee that your program will be executed only with a release that supports HTML text in the desired component, *don't use that feature!*

Problem: Certain areas of the content pane look weird when they're repainted.

- If you set the content pane, make sure it's opaque. `JPanel` and `JDesktopPane` make good content panes because they're opaque by default. See Adding Components to the Content Pane for details.
- If one or more of your components performs custom painting, make sure you implemented it correctly. See Solving Common Graphics Problems◆ for help.
- You might have a thread safety problem. See the next entry.

Problem: My program is exhibiting weird symptoms that sometimes seem to be related to timing.

- Make sure your code is thread-safe. See Threads and Swing◆ for details.

Problem: The scroll bar policies don't seem to be working as advertised.

- Some Swing releases contain bugs in the implementations for the `VERTICAL_SCROLLBAR_AS_NEEDED` and the `HORIZONTAL_SCROLLBAR_AS_NEEDED` policies. If feasible for your project, use the most recent release of Swing.
- If the scroll pane's client can change size dynamically, the program should set the client's preferred size and then call `revalidate` on the client.
- Make sure you specified the policy you intended for the orientation you intended.

Problem: My scroll pane has no scroll bars.

- If you want a scroll bar to appear all the time, specify either `VERTICAL_SCROLLBAR_ALWAYS` or `HORIZONTAL_SCROLLBAR_ALWAYS` for the scroll bar policy as appropriate.
- If you want the scroll bars to appear as needed, and you want to force the scroll bars to be needed when the scroll pane is created, you have two choices: either set the preferred size of scroll pane or its container, or implement a scroll-savvy class and return a value smaller than the component's standard preferred size from the `getPreferredScrollableViewportSize` method. Refer to Sizing a Scroll Pane for information.

Problem: The divider in my split pane won't move!

- You need to set the minimum size of at least one of the components in the split pane. Refer to Positioning and Restricting the Divider for information.

Problem: The `setDividerLocation` method doesn't work.

- In some releases of Swing, there is a bug whereby a call to `setDividerLocation` doesn't work unless the split pane is already on screen. For information and possible workarounds, see bug #4101306 and bug #4182558 in the Bug Parade at the Java Developer's Connection.

Problem: The borders on nested split panes look too wide.

- If you nest split panes, the borders accumulate--the border of the inner split panes display next to the border of the outer split pane causing borders that look extra wide. The problem is particularly noticeable when nesting many split panes. The workaround is to set the border to null on any split pane that is placed within another split pane. For information, see bug #4131528 in the Bug Parade at the Java Developer's Connection.

Problem: The buttons in my tool bar are too big.

- Try reducing the margin for the buttons. For example:

```
    button.setMargin(new Insets(0,0,0,0));
```

Problem: The components in my layered pane aren't layered correctly. In fact, the layers seem to be inversed--the lower the depth the higher the component.

- This can happen if you use an `int` instead of an `Integer` when adding components to a layered pane. To see what happens, make the following change to `LayeredPaneDemo`:

Change this...	**to this...**
`layeredPane.add(label, new Integer(i));`	`layeredPane.add(label, **i**);`

Problem: The method call *`colorChooser`*`.setPreviewPanel(null)` does not remove the color chooser's preview panel as expected.

- A `null` argument specifies the default preview panel. To remove the preview panel, specify a standard panel with no size, like this: *`colorChooser`*`.setPreviewPanel(new JPanel());`

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```
<APPLET CODE="Beeper.class"
        ARCHIVE="example-swing/intro.jar"
        WIDTH="250" HEIGHT="100"
        ALT="Your browser understands the applet tag but isn't displaying any applet.">

Since you can't run the applet,
here's a picture of it:

#usemacro UI_FIGURE (
    NAME Beeper.gif
    W 250
    H 100
    ALT A snapshot of Beeper, which illustrates the use of action listeners.
)

</APPLET>
```

```
/*
 * Swing version
 */

import javax.swing.*;

import java.awt.Dimension;
import java.awt.BorderLayout;
import java.awt.event.*;

public class ComponentEventDemo extends JApplet
                                implements ComponentListener,
                                           ActionListener {
    JTextArea display;
    JFrame aFrame;
    public boolean showIt = false;
    final static String SHOW = "show";
    final static String CLEAR = "clear";
    String newline = "\n";

    public void init() {
        display = new JTextArea();
        display.setEditable(false);
        JScrollPane scrollPane = new JScrollPane(display);
        scrollPane.setPreferredSize(new Dimension(200, 75));
        getContentPane().add(scrollPane, BorderLayout.CENTER);

        JButton b1 = new JButton("Start playing...");
        b1.setActionCommand(SHOW);
        b1.addActionListener(this);
        getContentPane().add(b1, BorderLayout.NORTH);

        JButton b2 = new JButton("Clear");
        b2.setActionCommand(CLEAR);
        b2.addActionListener(this);
        getContentPane().add(b2, BorderLayout.SOUTH);

        aFrame = new JFrame("A Frame");
        ComponentPanel p = new ComponentPanel(this);
        aFrame.addComponentListener(this);
        p.addComponentListener(this);
        aFrame.getContentPane().add(p, BorderLayout.CENTER);
        aFrame.pack();

        aFrame.addWindowListener(new WindowAdapter() {
            // This event handler is executed before the
            // default close operation (hide) is applied.
            public void windowClosing(WindowEvent e) {
                showIt = false;
            }
        });
    }

    public void actionPerformed(ActionEvent e) {
        if (e.getActionCommand() == SHOW) {
            showIt = true;
            aFrame.setVisible(true);
        } else { //CLEAR
            display.setText("");
        }
    }
    public void stop() {
        SwingUtilities.invokeLater(new Runnable() {
            public void run() {
                aFrame.setVisible(false);
            }
        });
    }

    public void start() {
        SwingUtilities.invokeLater(new Runnable() {
            public void run() {
                if (showIt) {
                    aFrame.setVisible(true);
                }
            }
        });
    }

    protected void displayMessage(String message) {
        display.append(message + newline);
    }

    public void componentHidden(ComponentEvent e) {
        displayMessage("componentHidden event from "
                       + e.getComponent().getClass().getName());
    }

    public void componentMoved(ComponentEvent e) {
        displayMessage("componentMoved event from "
                       + e.getComponent().getClass().getName());
    }

    public void componentResized(ComponentEvent e) {
        displayMessage("componentResized event from "
                       + e.getComponent().getClass().getName());
    }

    public void componentShown(ComponentEvent e) {
        displayMessage("componentShown event from "
                       + e.getComponent().getClass().getName());
    }
}

class ComponentPanel extends JPanel
                     implements ItemListener {
    JLabel label;
    JCheckBox checkbox;

    ComponentPanel(ComponentEventDemo listener) {
        super(new BorderLayout());

        label = new JLabel("This is a Label", JLabel.CENTER);
        add(label, BorderLayout.CENTER);

        checkbox = new JCheckBox("Label visible", true);
        checkbox.addItemListener(this);
        add(checkbox, BorderLayout.SOUTH);

        label.addComponentListener(listener);
        checkbox.addComponentListener(listener);
    }

    public void itemStateChanged(ItemEvent e) {
        if (e.getStateChange() == ItemEvent.SELECTED) {
            label.setVisible(true);

            //Need to revalidate and repaint, or else the label
            //will probably be drawn in the wrong place.
            label.revalidate();
            label.repaint();

        } else {
            label.setVisible(false);
        }
    }
}
```

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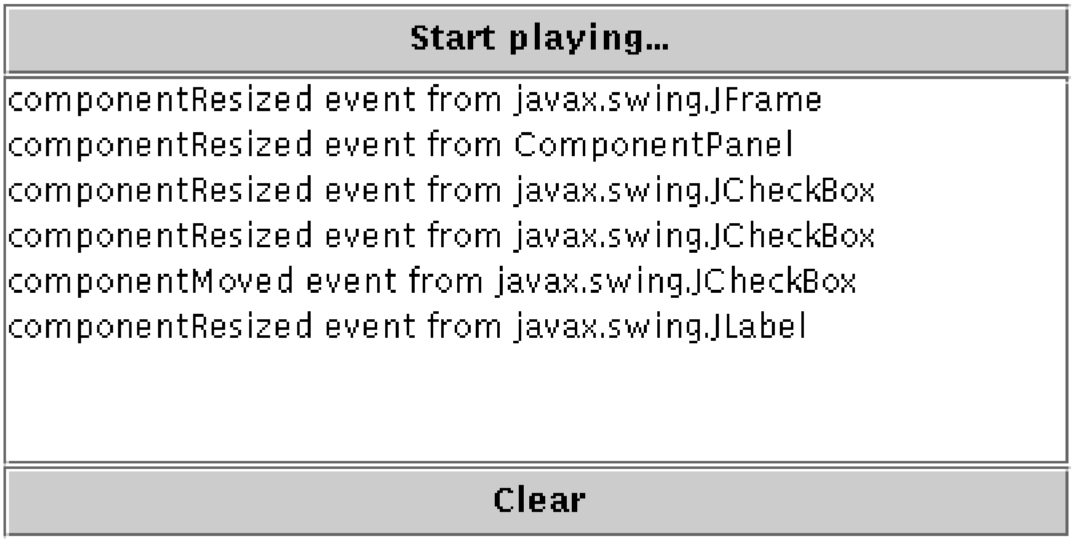
Trail: Creating a GUI with JFC/Swing
Lesson: Writing Event Listeners

Run ComponentEventDemo

Since you can't run the applet, here's a picture of it:



```
componentResized event from javax.swing.JFrame
componentResized event from ComponentPanel
componentResized event from javax.swing.JCheckBox
componentResized event from javax.swing.JCheckBox
componentMoved event from javax.swing.JCheckBox
componentResized event from javax.swing.JLabel
```

Note: Because the preceding applet uses the Swing 1.1 API, it requires Java Plug-in 1.1.2 or Java Plug-in 1.2. It won't work with Java Plug-in 1.1.1 or uncustomized 1.1 browsers. For more information about running applets in the tutorial, refer to About Our Examples. That page includes a section about Downloading Java Plug-in.

```
<APPLET CODE="ComponentEventDemo.class"
        ARCHIVE="example-swing/component.jar"
        WIDTH="400" HEIGHT="200"
        ALT="Your browser understands the applet tag but isn't displaying any applet.">

Since you can't run the applet,
here's a picture of it:

#usemacro UI_FIGURE (
    NAME ComponentEventDemo.gif
    W 400
    H 200
    ALT A snapshot of ComponentEventDemo, which demonstrates the events that are fired when a
component is hidden, resized, and so on.
)

</APPLET>
```

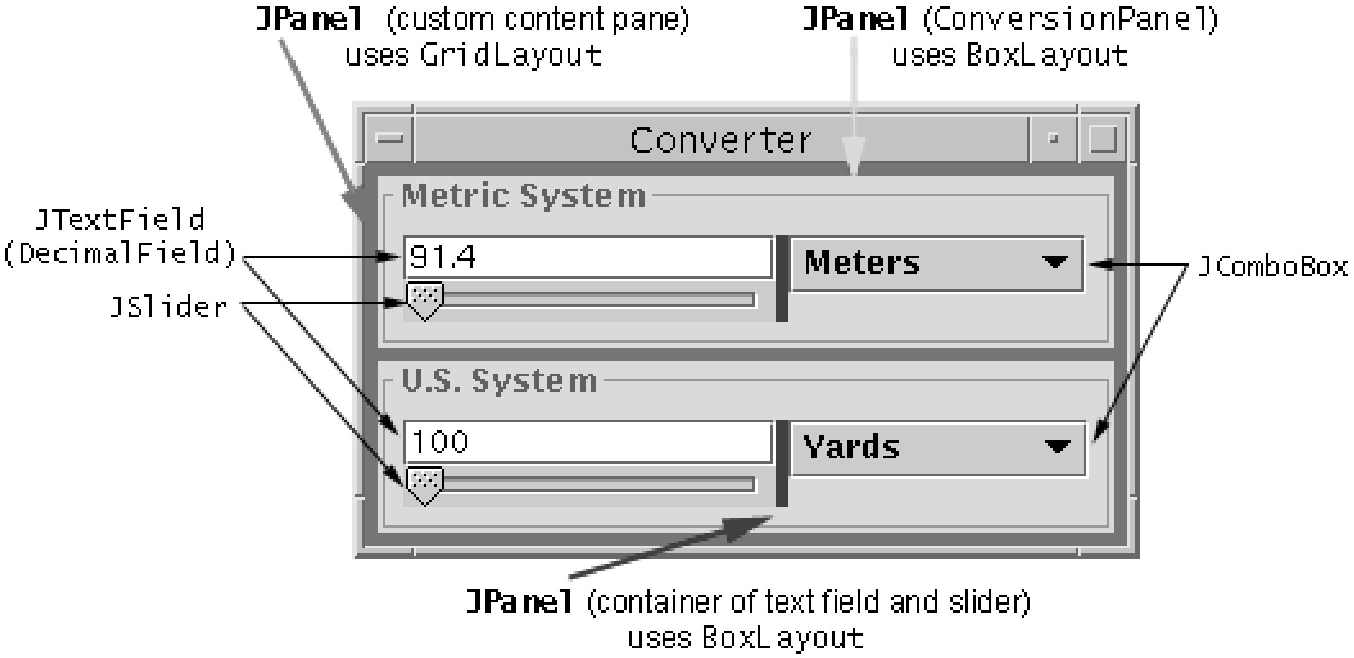
Trail: Creating a GUI with JFC/Swing
Lesson: Swing Features and Concepts

The Anatomy of a Swing-Based Program

This section picks apart a Swing program, called `Converter`, that has a GUI. You can see how this program is implemented by looking at its source code, which is mainly in `Converter.java` and `ConversionPanel.java`. However, this section doesn't talk about individual lines of code. Instead, it concentrates on how the `Converter` program uses the GUI features provided by the Java platform. If you get lost while looking at the `Converter` source code, you might want to refresh your memory by going to A Quick Tour of a Swing Application's Code.

`Converter` is an application that converts distance measurements between metric and U.S. units. To run it, compile the seven source files listed in the Examples Index. Once you've compiled the program, run it by invoking the interpreter on the `Converter` class. If you need help compiling or running `Converter`, see Compiling and Running Swing Programs.

Here is an annotated snapshot of `Converter`'s GUI:


JPanel (custom content pane) uses GridLayout
JPanel (ConversionPanel) uses BoxLayout
Converter
Metric System
JTextField (DecimalField)
91.4
Meters
JComboBox
JSlider
U.S. System
100
Yards
JPanel (container of text field and slider) uses BoxLayout

This section discusses the following features of `Converter`:

- Swing components
- The containment hierarchy
- Layout management and borders
- Separate models
- Look and feel
- Event Handling

Swing Components

As the preceding figure shows, `Converter` has the following visible components:

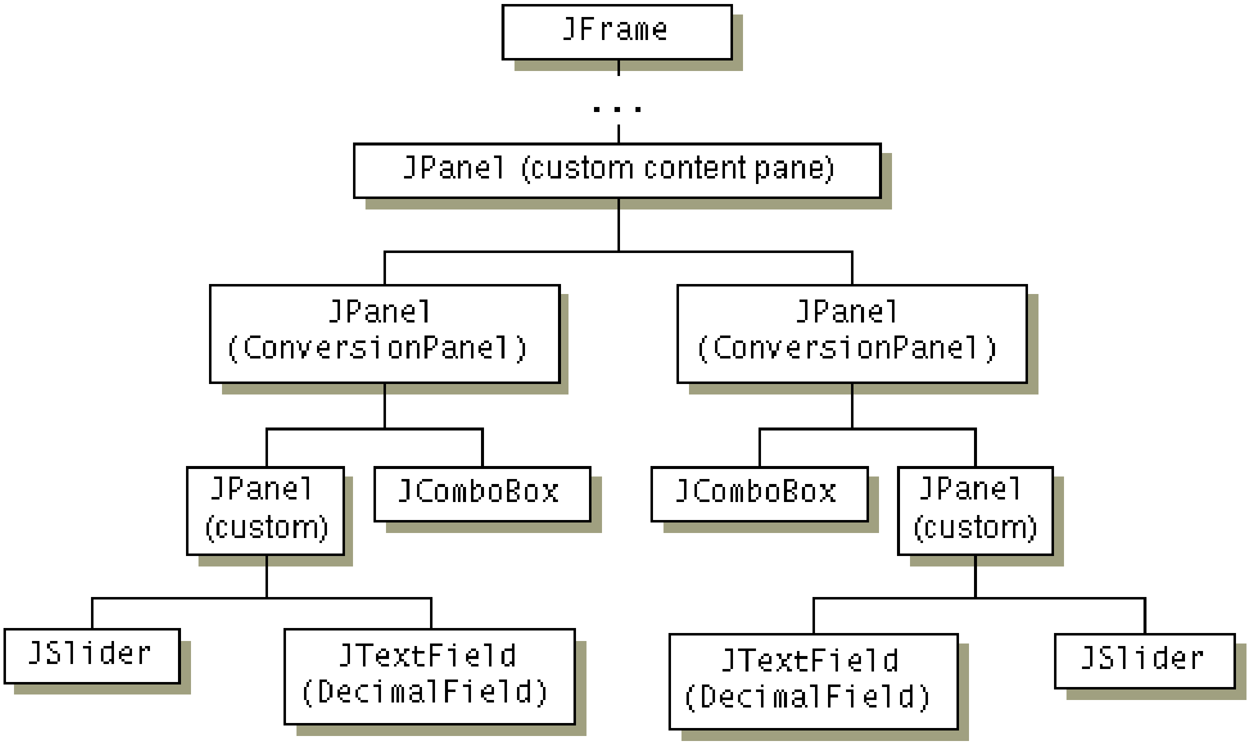
- One `JFrame`
- Two custom `JPanel`s
- Two custom `JTextField`s
- Two `JSlider`s
- Two `JComboBox`es

The `JFrame` is the top-level container; it provides the only window in the application. All the other components in the application are contained by the `JFrame`.

Except for the top-level container, all the visible components in `Converter` inherit from `JComponent`. The `JComponent` class provides many features, such as support for borders and accessibility. The two custom `JPanel`s shown in the snapshot use the border support to provide titles (for example, "Metric System") and to paint boxes around themselves.

The Containment Hierarchy

The following figure shows the containment hierarchy for the `JFrame`:



This diagram shows three components not labeled in the preceding snapshot because they don't paint anything noticeable on-screen:

- One `JPanel` that serves as the content pane
- Two custom `JPanel`s that each hold a text field and slider

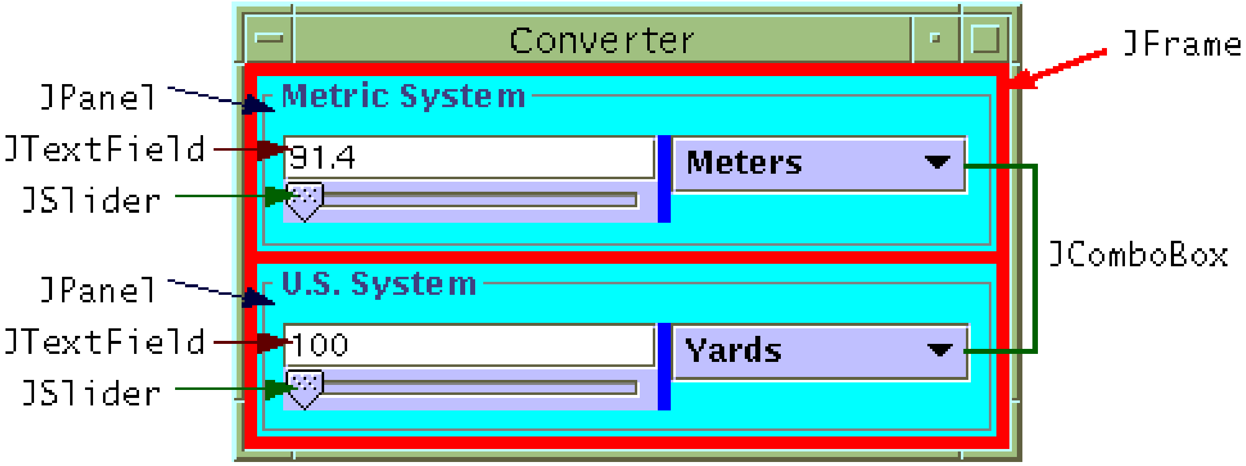
These three components exist to affect layout. They do this either by simplifying layout or by adding "empty" borders that add space to the layout. Grouping components -- whether in visible or invisible containers -- also provides hints to assistive technologies. For example, grouping a text field and slider in their own container gives assistive technologies the information that the text field and slider might be closely related.

Under the content pane are two `ConversionPanel`s. One of the `ConversionPanel`s holds the components related to metric distances; the other one does the same for U.S. distances.

Each `ConversionPanel` contains three visible components: a text field, a slider, and a combo box. The text field and slider are grouped together in a `JPanel`, mainly to make layout simpler.

Layout Management and Borders

The following figure shows a colorized version of `Converter`. In this version, each container has a background color, so that you can easily see the parts of the containers that aren't covered by other components. Note that all the containers are opaque; otherwise, the background color would not automatically be painted on the container.



`Converter` creates five layout manager objects -- one instance of `GridLayout` and four of `BoxLayout`.

The first `JPanel` (the custom content pane) uses `GridLayout` to make the `ConversionPanel`s exactly equal in size. The code sets up the `GridLayout` so that it puts the `ConversionPanel`s in a single column (two rows), with five pixels between components. The `JPanel` is initialized to have an empty border that adds five pixels between the panel and the sides of the frame.

Each `ConversionPanel` has a compound border. On the outside is a titled border, and on the inside is an empty border. The titled border paints a look-and-feel-specific box around the `ConversionPanel` and places the panel's title in the box. The empty border puts some more space between the `ConversionPanel` and its contents.

Each `ConversionPanel` uses a `BoxLayout` manager to place its contents, a `JPanel` and a `JComboBox`, in a row. By setting the Y alignment of both the panel and combo box, the program aligns the top of the panel with the top of the combo box.

The `JPanel` that groups the text field and slider is implemented with an unnamed subclass of `JPanel`. This subclass overrides the `getMinimumSize`, `getPreferredSize`, and `getMaximumSize` methods so that they all return the same value: 150 pixels wide and the preferred height. This is how we ensure that both text-slider groups have the same width, even though they're controlled by different layout managers. We need to create a subclass of `JPanel`, instead of just calling the `set`*`Xxxx`*`Size` methods, because the preferred height of components is determined at run time, by the layout manager.

The `JPanel` that groups the text field and slider uses a top-to-bottom `BoxLayout` manager so that the text field is placed on top of the slider. This panel also has an empty border that adds a bit of space to its right, between it and the combo box.

Separate Models

This program uses three custom models. The first is a data model for the text fields. Text data models are known as *document models*. The document model parses the value that the user enters into the text field. It also formats the number so that it looks nice. We borrowed this document model, without changing it, from the example presented in Creating a Validated Text Field.

The other two custom models are slider data models. They ensure that the data displayed by the application is kept in only one place -- in the model for the top slider. The top slider's model is an instance of a custom class called `ConverterRangeModel`. The bottom slider uses a second custom class, `FollowerRangeModel`, which forwards all requests to get and set data to the top slider's model.

All slider data models must implement the `BoundedRangeModel` interface. We learned this by looking at the API section of How to Use Sliders. The `BoundedRangeModel` API documentation tells us that the interface has an implementing class named `DefaultBoundedRangeModel`. The API documentation for `DefaultBoundedRangeModel` shows that it's a general-purpose implementation of `BoundedRangeModel`.

We didn't use `DefaultBoundedRangeModel` directly because it stores data as integers, and we need to store floating-point data. Thus, we implemented `ConverterRangeModel` as a subclass of `Object`, checking it against the `DefaultBoundedRangeModel` source code (distributed with the JFC 1.1 and JDK 1.2 releases), to make sure we implemented the model correctly. We then implemented `FollowerRangeModel` as a subclass of `ConverterRangeModel`.

Look and Feel

The `Converter` program sets itself up to use the Java Look & Feel. By changing the value of its `LOOKANDFEEL` variable, you can make it use a different look and feel. Three of its incarnations are pictured in What Are the JFC and Swing?.

Event Handling

The `Converter` program creates several event handlers:

Action listeners

Each combo box has an action listener. Whenever the user selects a new unit of measure, the action listener notifies the relevant slider's model and resets the maximum values of both sliders.

Each text field has an action listener that's notified when the user presses Return to indicate that typing has ended. This action listener updates the corresponding slider's model to reflect the text field's value.

Change listeners

Each slider model has a custom change listener. Whenever a slider's value changes, the custom change listener updates the appropriate text field. We didn't have to register the sliders as listeners on their own models, since Swing automatically does so. In other words, whenever a program sets a value in a slider's model, that slider is automatically updated to reflect the model's new state.

The model for the bottom slider adds a change listener to the top slider's model. This change listener fires a change event to the bottom slider model's change listeners, which are the bottom slider and the custom change listener described in the previous paragraph. The effect is that when the top slider's value changes, the value displayed in the bottom slider and text field is updated. It isn't necessary to notify the top slider of changes in the bottom slider, since the bottom slider's model forwards all data-setting requests to the top slider's model.

Window listener

A window listener on the frame causes the application to exit when the window is closed.

Most of the `Converter` program's listeners are implemented in anonymous inner classes. Although inner classes might seem hard to read, at first, they actually make code easier to understand, once you're used to them. By keeping an event handler implementation close to where the event handler is registered, inner classes help you, and those who follow you, to easily find the entire implementation of the event handler. See Using Adapters and Inner Classes to Handle Events◆ for more information.

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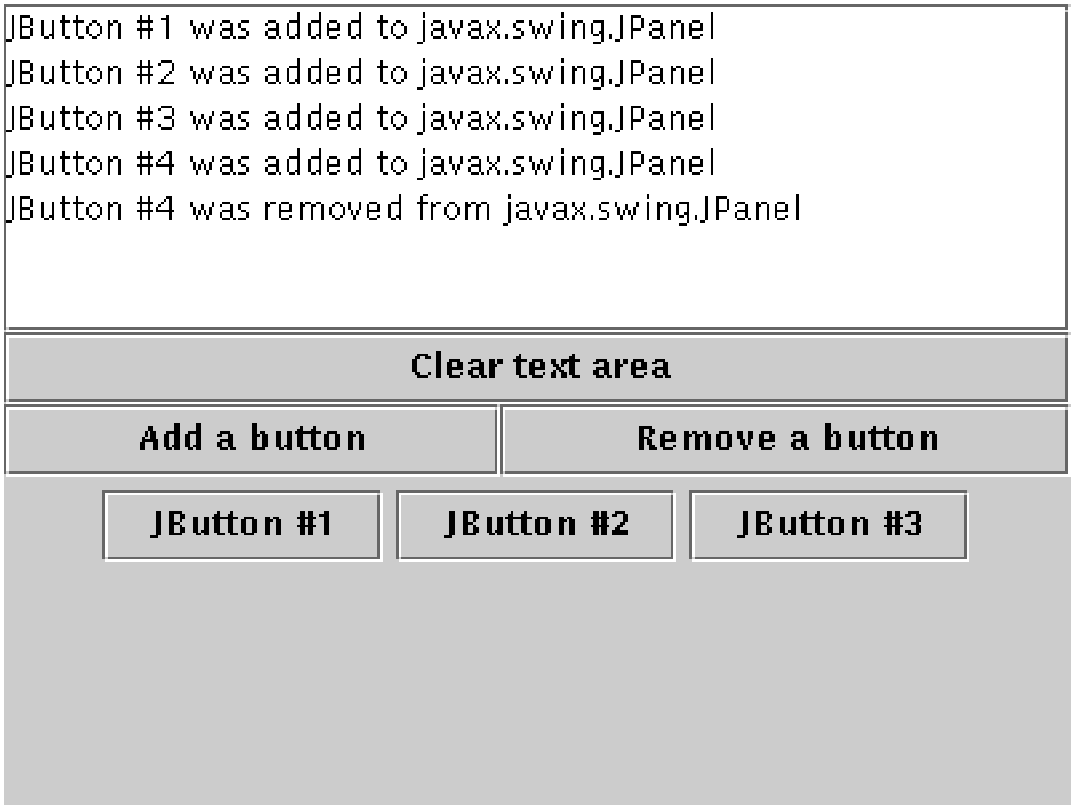
The Java^{TM} Tutorial

Trail: Creating a GUI with JFC/Swing
Lesson: Writing Event Listeners

Run ContainerEventDemo

Since you can't run the applet, here's a picture of it:



```
JButton #1 was added to javax.swing.JPanel
JButton #2 was added to javax.swing.JPanel
JButton #3 was added to javax.swing.JPanel
JButton #4 was added to javax.swing.JPanel
JButton #4 was removed from javax.swing.JPanel
```

Note: Because the preceding applet uses the Swing 1.1 API, it requires Java Plug-in 1.1.2 or Java Plug-in 1.2. It won't work with Java Plug-in 1.1.1 or uncustomized 1.1 browsers. For more information about running applets in the tutorial, refer to About Our Examples. That page includes a section about Downloading Java Plug-in.

```
/*
 * Swing version
 */

import javax.swing.*;

import java.awt.Dimension;
import java.awt.GridBagLayout;
import java.awt.GridBagConstraints;

import java.awt.event.ContainerEvent;
import java.awt.event.ContainerListener;
import java.awt.event.ActionEvent;
import java.awt.event.ActionListener;

import java.util.Vector;

public class ContainerEventDemo extends JApplet
                                implements ContainerListener,
                                           ActionListener {
    JTextArea display;
    JPanel buttonPanel;
    JButton addButton, removeButton, clearButton;
    Vector buttonList;
    static final String ADD = "add";
    static final String REMOVE = "remove";
    static final String CLEAR = "clear";
    static final String newline = "\n";

    public void init() {
        //Initialize an empty list of buttons.
        buttonList = new Vector(10, 10);

        //Create all the components.
        addButton = new JButton("Add a button");
        addButton.setActionCommand(ADD);
        addButton.addActionListener(this);

        removeButton = new JButton("Remove a button");
        removeButton.setActionCommand(REMOVE);
        removeButton.addActionListener(this);

        buttonPanel = new JPanel();
        buttonPanel.setPreferredSize(new Dimension(200, 75));
        buttonPanel.addContainerListener(this);

        display = new JTextArea();
        display.setEditable(false);
        JScrollPane scrollPane = new JScrollPane(display);
        scrollPane.setPreferredSize(new Dimension(200, 75));

        clearButton = new JButton("Clear text area");
        clearButton.setActionCommand(CLEAR);
        clearButton.addActionListener(this);

        //Lay out the components.
        GridBagLayout gridbag = new GridBagLayout();
        GridBagConstraints c = new GridBagConstraints();
        JPanel contentPane = new JPanel();
        contentPane.setLayout(gridbag);
        c.fill = GridBagConstraints.BOTH; //Fill entire cell.

        c.weighty = 1.0;  //Button area and message area have equal height.
        c.gridwidth = GridBagConstraints.REMAINDER; //end of row
        gridbag.setConstraints(scrollPane, c);
        contentPane.add(scrollPane);

        c.weighty = 0.0;
        gridbag.setConstraints(clearButton, c);
        contentPane.add(clearButton);

        c.weightx = 1.0;  //Add/remove buttons have equal width.
        c.gridwidth = 1;  //NOT end of row
        gridbag.setConstraints(addButton, c);
        contentPane.add(addButton);

        c.gridwidth = GridBagConstraints.REMAINDER; //end of row
        gridbag.setConstraints(removeButton, c);
        contentPane.add(removeButton);

        c.weighty = 1.0;  //Button area and message area have equal height.
        gridbag.setConstraints(buttonPanel, c);
        contentPane.add(buttonPanel);

        setContentPane(contentPane);
    }

    public void componentAdded(ContainerEvent e) {
        displayMessage(" added to ", e);
    }

    public void componentRemoved(ContainerEvent e) {
        displayMessage(" removed from ", e);
    }

    void displayMessage(String action, ContainerEvent e) {
        display.append(((JButton)e.getChild()).getText()
                       + " was"
                       + action
                       + e.getContainer().getClass().getName()
                       + newline);
    }

    /*
     * This could have been implemented as two or three
     * classes or objects, for clarity.
     */
    public void actionPerformed(ActionEvent e) {
        String command = e.getActionCommand();

        if (command == ADD) {
            JButton newButton = new JButton("JButton #"
                                      + (buttonList.size() + 1));
            buttonList.addElement(newButton);
            buttonPanel.add(newButton);
            buttonPanel.revalidate(); //Make the button show up.

        } else if (command == REMOVE) {
            int lastIndex = buttonList.size() - 1;
            try {
                JButton nixedButton = (JButton)buttonList.elementAt(lastIndex);
                buttonPanel.remove(nixedButton);
                buttonList.removeElementAt(lastIndex);
                buttonPanel.revalidate(); //Make the button disappear.
                buttonPanel.repaint(); //Make the button disappear.
            } catch (ArrayIndexOutOfBoundsException exc) {}
        } else if (command == CLEAR) {
            display.setText("");
        }
    }
}
```

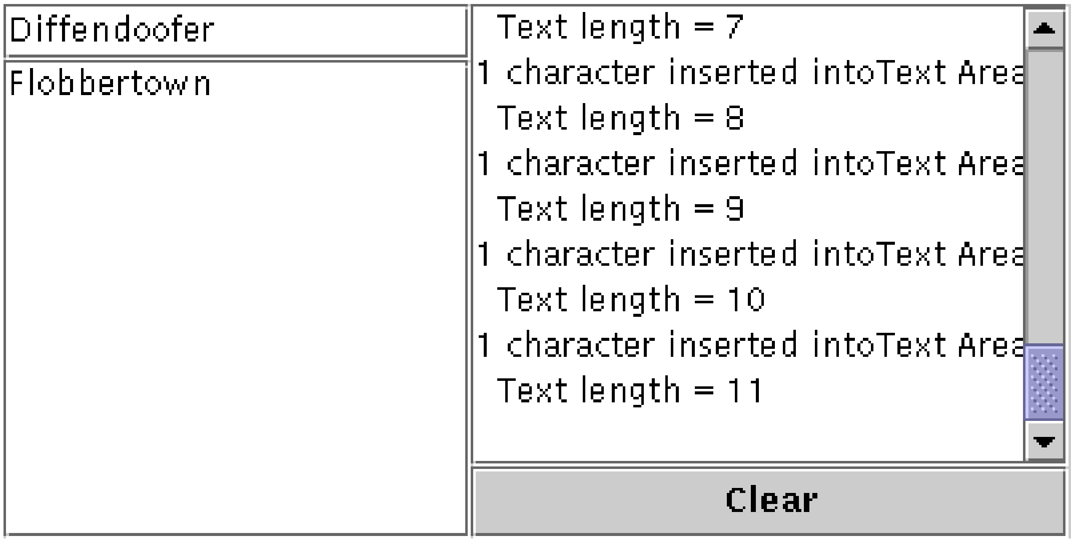
```
<APPLET CODE="ContainerEventDemo.class"
        ARCHIVE="example-swing/container.jar"
        WIDTH="400" HEIGHT="300"
        ALT="Your browser understands the applet tag but isn't displaying any applet.">

Since you can't run the applet,
here's a picture of it:

#usemacro UI_FIGURE (
    NAME ContainerEventDemo.gif
    W 400
    H 300
    ALT A snapshot of ContainerEventDemo, which demonstrates the events that are fired when the
containment hierarchy changes.

)

</APPLET>
```

The Java^{TM} Tutorial

Trail: Creating a GUI with JFC/Swing
Lesson: Writing Event Listeners

Run DocumentEventDemo

Since you can't run the applet, here's a picture of it:



Diffendoofer

Flobbertown

```
 Text length = 7
1 character inserted intoText Area
 Text length = 8
1 character inserted intoText Area
 Text length = 9
1 character inserted intoText Area
 Text length = 10
1 character inserted intoText Area
 Text length = 11
```

Note: Because the preceding applet uses the Swing 1.1 API, it requires Java Plug-in 1.1.2 or Java Plug-in 1.2. It won't work with Java Plug-in 1.1.1 or uncustomized 1.1 browsers. For more information about running applets in the tutorial, refer to About Our Examples. That page includes a section about Downloading Java Plug-in.

```
/*
 * Swing version
 */

import javax.swing.*;
import javax.swing.text.*;
import javax.swing.event.*;

import java.awt.Dimension;
import java.awt.BorderLayout;
import java.awt.GridBagLayout;
import java.awt.GridBagConstraints;

import java.awt.event.*;

public class DocumentEventDemo extends JApplet
                               implements ActionListener {
    JTextField textField;
    JTextArea textArea;
    JTextArea displayArea;

    public void init() {
        JButton button = new JButton("Clear");
        button.addActionListener(this);

        textField = new JTextField(20);
        textField.addActionListener(new MyTextActionListener());
        textField.getDocument().addDocumentListener(new MyDocumentListener());
        textField.getDocument().putProperty("name", "Text Field");

        textArea = new JTextArea();
        textArea.getDocument().addDocumentListener(new MyDocumentListener());
        textArea.getDocument().putProperty("name", "Text Area");

        JScrollPane scrollPane = new JScrollPane(textArea);
        scrollPane.setPreferredSize(new Dimension(200, 75));

        displayArea = new JTextArea();
        displayArea.setEditable(false);
        JScrollPane displayScrollPane = new JScrollPane(displayArea);
        displayScrollPane.setPreferredSize(new Dimension(200, 75));

        JPanel contentPane = new JPanel();
        GridBagLayout gridbag = new GridBagLayout();
        GridBagConstraints c = new GridBagConstraints();
        contentPane.setLayout(gridbag);

        c.gridx = 0;
        c.gridy = 0;
        c.weightx = 1.0;
        c.fill = GridBagConstraints.HORIZONTAL;
        gridbag.setConstraints(textField, c);
        contentPane.add(textField);

        c.gridx = 0;
        c.gridy = 1;
        c.weightx = 0.0;
        c.gridheight = 2;
        c.fill = GridBagConstraints.BOTH;
        gridbag.setConstraints(scrollPane, c);
        contentPane.add(scrollPane);

        c.gridx = 1;
        c.gridy = 0;
        c.weightx = 1.0;
        c.weighty = 1.0;
        gridbag.setConstraints(displayScrollPane, c);
        contentPane.add(displayScrollPane);

        c.gridx = 1;
        c.gridy = 2;
        c.weightx = 0.0;
        c.gridheight = 1;
        c.weighty = 0.0;
        c.fill = GridBagConstraints.HORIZONTAL;
        gridbag.setConstraints(button, c);
        contentPane.add(button);

        setContentPane(contentPane);
    }

    class MyDocumentListener implements DocumentListener {
        final String newline = "\n";

        public void insertUpdate(DocumentEvent e) {
            updateLog(e, "inserted into");
        }
        public void removeUpdate(DocumentEvent e) {
            updateLog(e, "removed from");
        }
        public void changedUpdate(DocumentEvent e) {
            //Plain text components don't fire these events.
        }

        public void updateLog(DocumentEvent e, String action) {
            Document doc = (Document)e.getDocument();
            int changeLength = e.getLength();
            displayArea.append(
                changeLength + " character"
              + ((changeLength == 1) ? " " : "s ")
              + action + " " + doc.getProperty("name") + "."
              + newline
              + "  Text length = " + doc.getLength() + newline);
        }
    }

    class MyTextActionListener implements ActionListener {
        /** Handle the text field Return. */
        public void actionPerformed(ActionEvent e) {
            int selStart = textArea.getSelectionStart();
            int selEnd = textArea.getSelectionEnd();

            textArea.replaceRange(textField.getText(),
                                  selStart, selEnd);
            textField.selectAll();
        }
    }

    /** Handle button click. */
    public void actionPerformed(ActionEvent e) {
        displayArea.setText("");
        textField.requestFocus();
    }
}
```

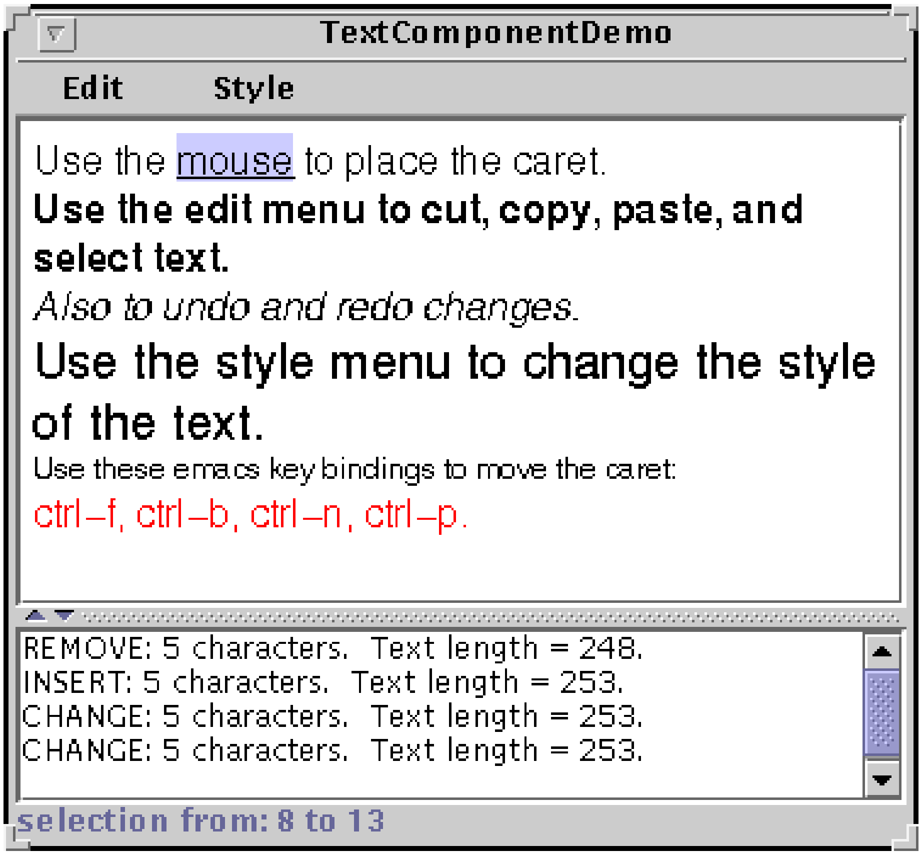
Trail: Creating a GUI with JFC/Swing
Lesson: Using Swing Components

General Rules for Using Text Components

`JTextComponent`◆ is the foundation for Swing's text components, and provides these customizable features for all of its descendants:

- A separate model, known as a *document*, to manage the component's content.
- A separate view, which is in charge of displaying the component on screen.
- A separate controller, known as an *editor kit*, that can read and write text and that implements editing capabilities with actions◆.
- Customizable keymaps and key bindings.
- Support for infinite undo and redo.
- Pluggable caret and support for caret change listeners.

This section uses the application shown below to explore each of these capabilities. Although the demo application contains a customized instance of `JTextPane`, the capabilities discussed in this section are inherited by all of `JTextComponent`'s subclasses.



Use the mouse to place the caret.
Use the edit menu to cut, copy, paste, and select text.
Also to undo and redo changes.
Use the style menu to change the style of the text.
Use these emacs key bindings to move the caret:
ctrl-f, ctrl-b, ctrl-n, ctrl-p.

```
REMOVE: 5 characters.  Text length = 248.
INSERT: 5 characters.  Text length = 253.
CHANGE: 5 characters.  Text length = 253.
CHANGE: 5 characters.  Text length = 253.
```

selection from: 8 to 13

The upper text component is the customized text pane. The lower text component is an instance of `JTextArea`, which serves as a log that reports all changes made to the contents of the text pane. The status line at the bottom of the window reports either the location of the selection or the position of the caret, depending on whether text is selected.

Try this:

1. Compile and run the application. The source is in `TextComponentDemo.java`◆ and `LimitedStyledDocument.java` ◆.
   See Getting Started with Swing if you need help compiling or running this application.
2. Use the mouse to select text and place the cursor in the text pane. Information about the selection and cursor is displayed at the bottom of the window.
3. Enter text by typing at the keyboard. You can move the caret around using four emacs key bindings: `CTRL-B` (backward one character), `CTRL-F` (forward one character), `CTRL-N` (down one line), and `CTRL-P` (up one line).
4. Bring up the **Edit** menu, and use its various menu items to perform editing on the text in the text pane. Make a selection in the text area at the bottom of the window. Because the text area is uneditable, only some of the **Edit** menu's commands, like **copy-to-clipboard**, work. It's important to note, though, that the menu operates on both text components.
5. Use the items in the **Style** menu to apply different styles to the text in the text pane.

Using this example application as a reference point, this section covers these topics:

- Concepts: About Documents
- Customizing a Document
- Listening for Changes on a Document
- Concepts: About Editor Kits
- Associating Text Actions with Menus and Buttons
- Concepts: About Keymaps
- Associating Text Actions with Keystrokes
- Implementing Undo and Redo
- Listening for Caret and Selection Changes

Concepts: About Documents

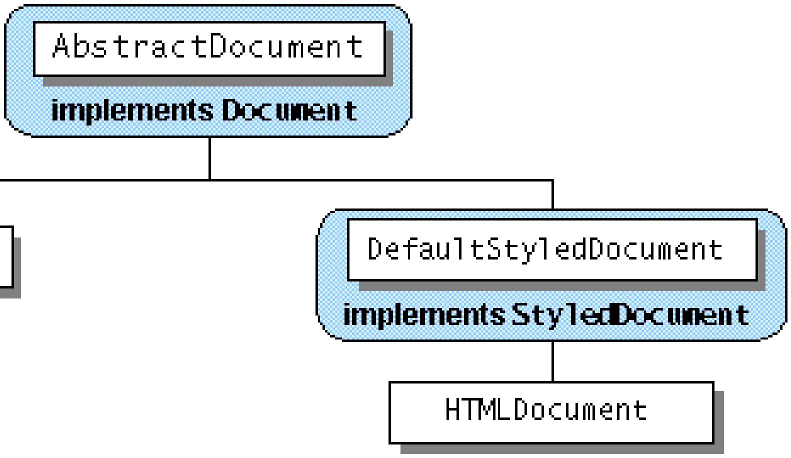
Like other Swing components, a text component separates its data (known as the *model*) from its view of the data. If you are not yet familiar with the model-view split used by Swing components, refer to Separate Data and State Models.

A text component's model is known as a *document* and is an instance of a class that implements the `Document` interface. A document provides these services for a text component:

- Contains the text. A document stores the textual content in `Element` objects, which can represent any logical text structure, such as paragraphs, text runs that share styles, and so on. We do not cover `Element`s. However, The Swing Connection has at least one article on the subject.
- Provides support for editing the text through the `remove` and `insertString` methods.
- Notifies document listeners and undoable edit listeners of changes to the text.
- Manages `Position` objects, which track a particular location within the text even as the text is modified.
- Allows you to get information about the text, such as its length, and segments of the text as a string.

The Swing text package contains a subinterface of `Document`, `StyledDocument`, that adds support for marking up the text with styles. One `JTextComponent` subclass, `JTextPane`, requires that its document be a `StyledDocument` rather than merely a `Document`.

The `javax.swing.text` package provides the following hierarchy of document classes, which implement specialized documents for the various `JTextComponent` subclasses:



A `PlainDocument` is the default document for text fields, password fields, and text areas. `PlainDocument` provides a basic container for text where all the text is displayed in the same font. Even though an editor pane is a styled text component, it uses an instance of `PlainDocument` by default. The default document for a standard `JTextPane` in an instance of `DefaultStyledDocument`--a container for styled text in no particular format. However, the document instance used by any particular editor pane or text pane depends on the type of content bound to it. If you use `setPage` to load text into an editor pane or text pane, the document instance used by the pane might change. Refer to Concepts: Editor Panes and Text Panes for details.

Text components inherit the `setDocument` method, which you can use to dynamically change a component's document. Also most `JTextComponent` subclasses provide constructors that set the document when creating the component. By replacing a text component's document with one of your own, you can implement certain customizations. For example, the text pane in `TextComponentDemo` has a custom document that limits the number of characters it can contain.

Customizing a Document

The `TextComponentDemo` application has a custom document, `LimitedStyledDocument`, that limits the number of characters that the text pane can contain. `LimitedStyledDocument` is a subclass of `DefaultStyledDocument`, the default document for `JTextPane`. The example needs to use a subclass of `DefaultStyledDocument` because `JTextPane` requires its document to be of that type. If you changed the superclass to `PlainDocument`, the document would work for a text field or text area -- any text component except a text pane. No other code changes would be required, although you would probably remove `Styled` from the class name, for clarity.

Here's the code from the example program that creates a `LimitedStyledDocument` and makes it the document for the text pane:

```
...where the member variables are declared...
JTextPane textPane;
static final int MAX_CHARACTERS = 300;
    ...in the constructor for the frame...
    //Create the document for the text area
    LimitedStyledDocument lsd =
        new LimitedStyledDocument(MAX_CHARACTERS);
    ...
    //Create the text pane and configure it
    textPane = new JTextPane(lsd);
    ...
```

To limit the characters allowed in the document, `LimitedStyledDocument` overrides its superclass's `insertString` method, which is called each time text is inserted into the document. Text insertion can be the result of the user typing or pasting text in, or because of a call to `setText`. Here is `LimitedStyledDocument`'s implementation of `insertString`:

```
public void insertString(int offs, String str, AttributeSet a)
    throws BadLocationException
{
    if ((getLength() + str.length()) <= maxCharacters)
        super.insertString(offs, str, a);
    else
        Toolkit.getDefaultToolkit().beep();
}
```

In addition to `insertString`, custom documents commonly override the `remove` method , which is called each time text is removed from the document.

One common use of a custom document is to create a change-validated text field (a field whose value is checked each time its text changes). For two examples of validated text fields, refer to Creating a Validated Text Field.

Listening for Changes on a Document

You can register two different types of listeners on a document: document listeners and undoable edit listeners. This subsection covers document listeners. For information about undoable edit listeners, refer to Implementing Undo and Redo.

A document notifies registered document listeners of changes to the document. Use a document listener to react when text is inserted or removed from a document, or when the style of some of the text changes.

The `TextComponentDemo` program uses a document listener to update the change log whenever a change is made to the text pane. The following line of code registers an instance of `MyDocumentListener` as a listener on the `LimitedStyledDocument` used in the example:

```
lsd.addDocumentListener(new MyDocumentListener());
```

Here's the implementation of `MyDocumentListener`:

```
protected class MyDocumentListener implements DocumentListener {
    public void insertUpdate(DocumentEvent e) {
        displayEditInfo(e);
    }
    public void removeUpdate(DocumentEvent e) {
        displayEditInfo(e);
    }
    public void changedUpdate(DocumentEvent e) {
        displayEditInfo(e);
    }
    private void displayEditInfo(DocumentEvent e) {
            Document doc = (Document)e.getDocument();
            int changeLength = e.getLength();
            changeLog.append(e.getType().toString() + ": "
                + changeLength + " character"
                + ((changeLength == 1) ? ". " : "s. ")
                + " Text length = " + doc.getLength()
                + "." + newline);
    }
}
```

The listener implements three methods for handling three different types of document events: insertion, removal, and style changes. `StyledDocument`s can fire all three types of events. `PlainDocument`s fire events only for insertion and removal. For general information about document listeners and document events, see How to Write a Document Listener.

Remember that the document for this text pane limits the number of characters allowed in the document. If you try to add more text than the document allows, the document blocks the change and the listener's `insertUpdate` method is not called. Document listeners are notified of changes only if the change has already occurred.

Sometimes, you might be tempted to change the document's text from within a document listener. For example, if you have a text field that should contain only integers and the user enters some other type of data, you might want to change the text to `0`. **However, you should never modify the contents of text component from within a document listener.** In fact, if you do, your program will likely deadlock! Instead, provide a custom document and override the `insertString` and `remove` methods as needed.

Concepts: About Editor Kits

All Swing text components supports standard editing commands such as cut, copy, paste, and inserting characters. Each editing command is represented and implemented by an `Action` object. Actions makes it easy for you to associate a command with a GUI component, such as a menu item or button, and therefore build a GUI around a text component.

Under the hood, text components use an `EditorKit` to create and manage actions. Besides managing a set of actions for a text component, an editor kit also knows how to read and write documents of a particular format. Although all text components use editor kits, some components hide theirs. You can't set or get the editor kit used by a text field, password field, or text area. Editor panes and text panes provide the `getEditorKit` method to get the current editor kit and the `setEditorKit` to change it.

For all components, `JTextComponent` provides API for you to indirectly invoke or customize some editor kit capabilities. For example, `JTextComponent` provides `read` and `write` methods, which invoke the editor kit's `read` and `write` methods. `JTextComponent` also provides a method, `getActions`, which returns all of the actions supported by a component.

The Swing text package provides these editor kits:

`DefaultEditorKit`◆

Reads and writes plain text. Provides a basic set of editing commands. All the other editor kits are descendants of this one.

`StyledEditorKit`◆

Reads and writes styled text and provides a minimal set of actions for styled text. This class is a subclass of `DefaultEditorKit` and is the editor kit used by `JTextPane` by default.

`HTMLEditorKit`◆

Reads, writes, and edits HTML. This is a subclass of `StyledEditorKit`.

`RTFEditorKit`

Reads, writes, and edits RTF. This is a subclass of `StyledEditorKit`.

Each of the editor kits above has been registered with the `JEditorPane` class and associated with the text format that the kit reads, writes, and edits. When a file is loaded into an editor pane, the pane checks the format of the file against its registered kits. If a registered kit is found that supports that file format, the pane uses the kit to read the file, display, and edit it. Thus, the editor pane effectively transforms itself into an editor for that text format. You can extend `JEditorPane` to support your own text format by creating an editor kit for it, and then using `JEditorPane`'s `registerEditorKitForContentType` to associate your kit with your text format.

Associating Text Actions with Menus and Buttons

As we mentioned before, you can call the `getActions` method on any text component to get an array containing all of the actions supported by it. Often it's convenient to load the array of actions into a `Hashtable` so your program can retrieve an action by name. Here's the code from `TextComponentDemo` that gets the actions from the text pane and loads them into a `Hashtable`:

```
private void createActionTable(JTextComponent textComponent) {
    actions = new Hashtable();
    Action[] actionsArray = textComponent.getActions();
    for (int i = 0; i < actionsArray.length; i++) {
        Action a = actionsArray[i];
        actions.put(a.getValue(Action.NAME), a);
    }
}
```

And here's a convenient method for retrieving an action by its name from the hashtable:

```
private Action getActionByName(String name) {
    return (Action)(actions.get(name));
}
```

You can use both methods verbatim in your programs.

Now let's look at how the **Cut** menu item is created and associated with the action of removing text from the text component:

```
protected JMenu createEditMenu() {
    JMenu menu = new JMenu("Edit");
    ...
    menu.add(getActionByName(DefaultEditorKit.cutAction));
    ...
```

This code gets the action by name using the handy method shown previously. It then adds the action to the menu. That's all you need to do. The menu and the action take care of everything else. You'll note that the name of the action comes from `DefaultEditorKit`. This kit provides actions for basic text editing and is the superclass for all the editor kits provided by Swing. So its capabilities are available to all text components unless overridden by a customization.

For efficiency, text components share actions. The `Action` object returned by `getActionByName(DefaultEditorKit.cutAction)` is shared by the uneditable `JTextArea` at the bottom of the window. This has two important ramifications:

- Generally speaking, you shouldn't modify `Action` objects you get from editor kits. If you do, the changes affect all text components in your program.
- `Action` objects can operate on other text components in the program, perhaps more than you intended. In this example, even though it's uneditable, the `JTextArea` shares actions with the `JTextPane`. (Select some text in the text area, then choose the `cut-to-clipboard` menu item. You'll hear a beep because the text area is uneditable.) If you don't want to share, consider instantiating the `Action` object yourself. `DefaultEditorKit` defines a number of useful `Action` subclasses.

Here's the code that creates the **Style** menu and puts the **Bold** menu item in it:

```
protected JMenu createStyleMenu() {
    JMenu menu = new JMenu("Style");

    Action action = new StyledEditorKit.BoldAction();
    action.putValue(Action.NAME, "Bold");
    menu.add(action);
    ...
```

The `StyledEditorKit` provides `Action` subclasses to implement editing commands for styled text. You'll note that instead of getting the action from the editor kit, this code creates an instance of the `BoldAction` class. Thus, this action is not shared with any other text component, and changing its name won't affect any other text component.

In addition to associating an action with a GUI component, you can also associate an action with a keystroke. Associating Text Actions with Keystrokes shows you how.

Concepts: About Keymaps

This section assumes that you understand actions and how to get them from the editor kit. If you don't, read Concepts: About Editor Kits and Associating Text Actions with Menus and Buttons.

Every text component has one or more `Keymap` objects. A keymap contains a collection of name-value pairs where the name is a `KeyStroke` and the value is an `Action`. Each pair *binds* the keystroke to the action such that when the user types the keystroke, the action occurs.

By default, a text component has one keymap named `JTextComponent.DEFAULT_KEYMAP`. This keymap contains standard, basic key bindings. For example, the arrow keys are mapped to caret movement, and so on. You can enhance or modify the default keymap in the following ways:

- Add a custom keymap to the text component with `JTextComponent`'s `addKeymap` method.
- Add key bindings to the default keymap with `Keymap`'s `addActionForKeyStroke` method. The default keymap is shared among text components, so use this with caution.
- Remove key bindings from the default keymap with `Keymap`'s `removeKeyStrokeBinding` method. The default keymap is shared among text components, so again, use this with caution.

When resolving a keystroke to its action, the text component checks the keymaps in the order they are added to the text component. Thus, the binding for a specific keystroke in a keymap that you add to a text component overrides any binding for the same keystroke in the default keymap.

Associating Text Actions with Keystrokes

The text pane in the `TextComponentDemo` supports four key bindings not provided by the default keymap.

- `CTRL-B` for moving the caret backward one character
- `CTRL-F` for moving the caret forward one character
- `CTRL-N` for moving the caret down one line
- `CTRL-P` for moving the caret up one line

The following code adds a new keymap to the text pane and adds the `CTRL-B` key binding to it. The code for adding the other three is similar.

```
Keymap keymap = textPane.addKeymap("MyEmacsBindings",
                                   textPane.getKeymap());

Action action = getActionByName(DefaultEditorKit.backwardAction);
KeyStroke key = KeyStroke.getKeyStroke(KeyEvent.VK_B,
                                       Event.CTRL_MASK);
keymap.addActionForKeyStroke(key, action);
```

The code first adds a keymap to the component's hierarchy. The `addKeymap` method creates the keymap for you with the name and parent provided in the method call. In the example, the parent is the text pane's default keymap. Next, the code gets the backward action from the editor kit and gets a `KeyStroke`◆ object representing the `CTRL-B` key sequence. Finally, the code adds the action and keystroke pair to the keymap, thereby binding the key to the action.

Implementing Undo and Redo

Note: The implementation of undo and redo in `TextComponentDemo` was taken from the `NotePad` demo that comes with the JFC 1.1 and JDK 1.2 releases. Many programmers will also be able to copy this implementation of undo/redo without modification.

Implementing undo and redo has two parts:

- Remembering the undoable edits that occur.
- Implementing the undo and redo commands and providing a user interface for them.

Part 1: Remembering Undoable Edits
To support undo and redo, a text component must remember each edit that occurs, the order of edits, and what it takes to undo each edit. The example program uses an instance of the `UndoManager` class to manage its list of undoable edits. The undo manager is created where the member variables are declared:

```
protected UndoManager undo = new UndoManager();
```

Now, let's look at how the program finds out about undoable edits and adds them to the undo manager.

A document notifies interested listeners whenever an undoable edit occurs on its content. An important step in implementing undo and redo is to register an undoable edit listener on the document of the text component. The following code adds an instance of `MyUndoableEditListener` to the text pane's document:

```
lsd.addUndoableEditListener(new MyUndoableEditListener());
```

The undoable edit listener used in our example adds the edit to the undo manager's list:

```
protected class MyUndoableEditListener
          implements UndoableEditListener
{
    public void undoableEditHappened(UndoableEditEvent e) {
        //Remember the edit and update the menus
        undo.addEdit(e.getEdit());
        undoAction.updateUndoState();
        redoAction.updateRedoState();
    }
}
```

Note that this method updates two objects: `undoAction` and `redoAction`. These are the action objects attached to the **Undo** and **Redo** menu items, respectively. The next step shows you how the menu items are created and the implementation of the two actions. For general information about undoable edit listeners and undoable edit events, see How to Write an Undoable Edit Listener.

Part 2: Implementing the Undo and Redo Commands
The first step in this part of implementing undo and redo is to create the actions to put in the **Edit** menu.

```
JMenu menu = new JMenu("Edit");

//Undo and redo are actions of our own creation
undoAction = new UndoAction();
menu.add(undoAction);

redoAction = new RedoAction();
menu.add(redoAction);
...
```

The undo and redo actions are implemented by custom `AbstractAction` subclasses: `UndoAction` and `RedoAction`, respectively. These classes are inner classes of the example's primary class.

When the user invokes the **Undo** command, `UndoAction`'s `actionPerformed` method, shown here, gets called:

```
public void actionPerformed(ActionEvent e) {
    try {
        undo.undo();
    } catch (CannotUndoException ex) {
        System.out.println("Unable to undo: " + ex);
        ex.printStackTrace();
    }
    updateUndoState();
    redoAction.updateRedoState();
}
```

This method calls the undo manager's `undo` method and updates the menu items to reflect the new undo/redo state.

Similarly, when the user invokes the **Redo** command, the `actionPerformed` method in `RedoAction` gets called:

```
public void actionPerformed(ActionEvent e) {
    try {
        undo.redo();
    } catch (CannotRedoException ex) {
        System.out.println("Unable to redo: " + ex);
        ex.printStackTrace();
    }
    updateRedoState();
    undoAction.updateUndoState();
}
```

This method is similar except that it calls the undo manager's `redo` method.

Much of the code in the `UndoAction` and `RedoAction` classes is dedicated to enabling and disabling the actions as appropriate for the current state, and changing the names of the menu items to reflect the edit to be undone or redone.

Listening for Caret and Selection Changes

The `TextComponentDemo` program uses a caret listener to display the current position of the caret or, if text is selected, the extent of the selection.

The caret listener class in this example is a `JLabel` subclass. Here's the code that creates the caret listener label and makes it a caret listener of the text pane:

```
//Create the status area
CaretListenerLabel caretListenerLabel = new CaretListenerLabel(
                                                "Caret Status");
...
textPane.addCaretListener(caretListenerLabel);
```

A caret listener must implement one method, `caretUpdate`, which is called each time the caret moves or the selection changes. Here's the `CaretListenerLabel` implementation of `caretUpdate`:

```
public void caretUpdate(CaretEvent e) {
    //Get the location in the text
    int dot = e.getDot();
    int mark = e.getMark();
    if (dot == mark) {  // no selection
        try {
            Rectangle caretCoords = textPane.modelToView(dot);
            //Convert it to view coordinates
            setText("caret: text position: " + dot +
                    ", view location = [" +
                    caretCoords.x + ", " + caretCoords.y + "]" +
                    newline);
        } catch (BadLocationException ble) {
            setText("caret: text position: " + dot + newline);
        }
     } else if (dot < mark) {
        setText("selection from: " + dot + " to " + mark + newline);
     } else {
        setText("selection from: " + mark + " to " + dot + newline);
     }
}
```

As you can see, this listener updates its text label to reflect the current state of the caret or selection. The listener gets the information to display from the caret event object. For general information about caret listeners and caret events, see How to Write a Caret Listener.

As with document listeners, a caret listener is passive. It reacts to changes in the caret or in the selection but does not change the caret or the selection. If you want to change the caret or selection, then you should use a custom caret instead. To create a custom caret, write a class that implements the `Caret`◆ interface, then provide an instance of your class as an argument to `setCaret` on a text component.

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```
<APPLET CODE="DocumentEventDemo.class"
        ARCHIVE="example-swing/document.jar"
        WIDTH="400" HEIGHT="200"
        ALT="Your browser understands the applet tag but isn't displaying any applet.">

Since you can't run the applet,
here's a picture of it:

#usemacro UI_FIGURE (
    NAME DocumentEventDemo.gif
    W 400
    H 200
    ALT A snapshot of DocumentEventDemo, which demonstrates the events that are fired when text is
modified.

)

</APPLET>
```

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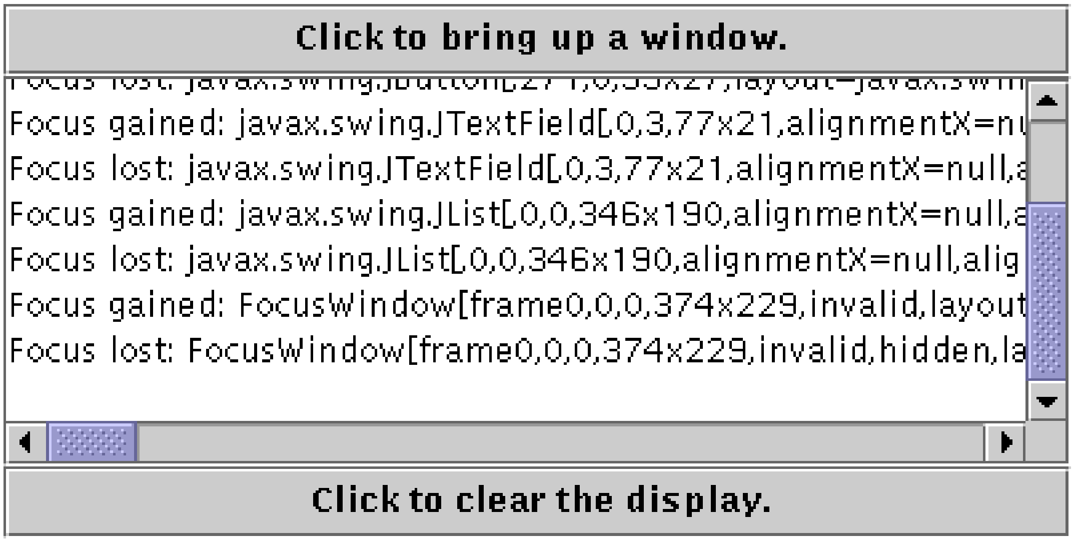
Trail: Creating a GUI with JFC/Swing
Lesson: Writing Event Listeners

Run FocusEventDemo

Since you can't run the applet, here's a picture of it:



```
Focus lost: javax.swing.JButton[,271,0,55x27,layout=javax.swin
Focus gained: javax.swing.JTextField[,0,3,77x21,alignmentX=nu
Focus lost: javax.swing.JTextField[,0,3,77x21,alignmentX=null,a
Focus gained: javax.swing.JList[,0,0,346x190,alignmentX=null,a
Focus lost: javax.swing.JList[,0,0,346x190,alignmentX=null,alig
Focus gained: FocusWindow[frame0,0,0,374x229,invalid,layout
Focus lost: FocusWindow[frame0,0,0,374x229,invalid,hidden,la
```

Note: Because the preceding applet uses the Swing 1.1 API, it requires Java Plug-in 1.1.2 or Java Plug-in 1.2. It won't work with Java Plug-in 1.1.1 or uncustomized 1.1 browsers. For more information about running applets in the tutorial, refer to About Our Examples. That page includes a section about Downloading Java Plug-in.

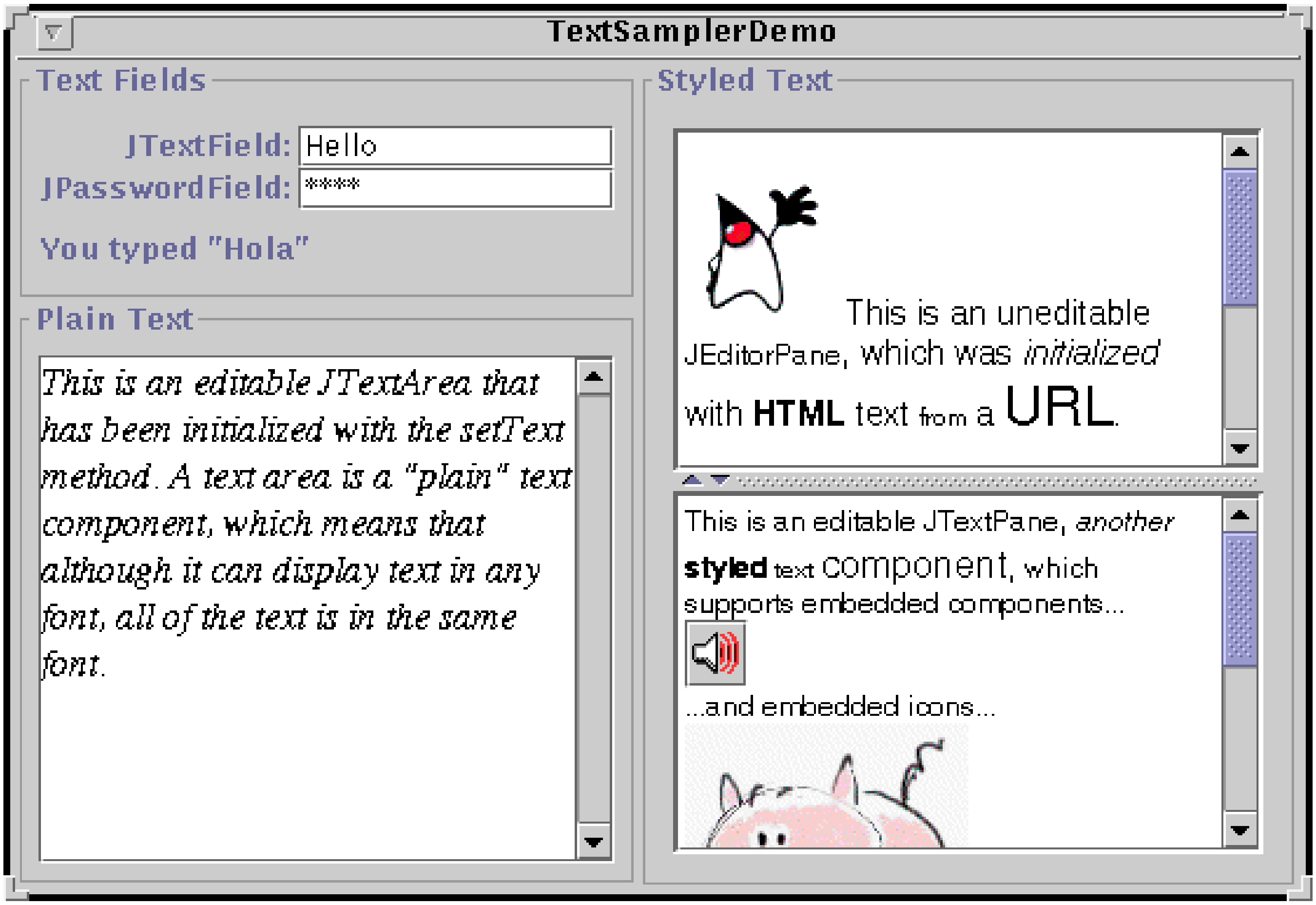
```
/*
 * Swing version
 */

import javax.swing.*;

import java.awt.BorderLayout;
import java.awt.Dimension;
import java.awt.GridBagLayout;
import java.awt.GridBagConstraints;
import java.awt.Insets;

import java.util.Vector;

import java.awt.event.FocusListener;
import java.awt.event.FocusEvent;
import java.awt.event.ActionListener;
import java.awt.event.ActionEvent;
import java.awt.event.WindowEvent;
import java.awt.event.WindowAdapter;

public class FocusEventDemo extends JApplet
                            implements FocusListener,
                                       ActionListener {

    JTextArea display;
    FocusWindow window;
    JButton b1, b2;
    static final String SHOW = "show";
    static final String CLEAR = "clear";
    static final String newline = "\n";

    public void init() {
        b1 = new JButton("Click to bring up a window.");
        b1.setActionCommand(SHOW);
        b1.addActionListener(this);

        b2 = new JButton("Click to clear the display.");
        b2.setActionCommand(CLEAR);
        b2.addActionListener(this);

        display = new JTextArea();
        display.setEditable(false);
        JScrollPane scrollPane = new JScrollPane(display);
        scrollPane.setPreferredSize(new Dimension(375, 125));

        JPanel contentPane = new JPanel();
        contentPane.setLayout(new BorderLayout());
        contentPane.add(b1, BorderLayout.NORTH);
        contentPane.add(scrollPane, BorderLayout.CENTER);
        contentPane.add(b2, BorderLayout.SOUTH);
        setContentPane(contentPane);

        //Create but don't show window.
        window = new FocusWindow(this);
    }

    public void stop() {
        SwingUtilities.invokeLater(new Runnable() {
            public void run() {
                window.setVisible(false);
            }
        });
    }

    public void focusGained(FocusEvent e) {
        displayMessage("Focus gained", e);
    }

    public void focusLost(FocusEvent e) {
        displayMessage("Focus lost", e);
    }

    void displayMessage(String prefix, FocusEvent e) {
        display.append(prefix
                       + ": "
                       + e.getComponent()
                       + newline);
    }

    public void actionPerformed(ActionEvent e) {
        if (e.getActionCommand() == SHOW) {
            window.pack();
            window.setVisible(true);
        } else { //CLEAR
            display.setText("");
        }
    }
}

class FocusWindow extends JFrame {
    public FocusWindow(FocusListener listener) {
        super("Focus Event Window");
        //We'll use the default close operation -- hiding.

        JPanel contentPane = new JPanel();
        this.addFocusListener(listener);

        GridBagLayout gridbag = new GridBagLayout();
        GridBagConstraints c = new GridBagConstraints();
        contentPane.setLayout(gridbag);

        c.fill = GridBagConstraints.HORIZONTAL;
        c.weightx = 1.0;  //Make column as wide as possible.
        JTextField textField = new JTextField("A TextField");
        textField.setMargin(new Insets(0,2,0,2));
        textField.addFocusListener(listener);
        gridbag.setConstraints(textField, c);
        contentPane.add(textField);

        c.weightx = 0.1;  //Widen every other column a bit, when possible.
        c.fill = GridBagConstraints.NONE;
        JLabel label = new JLabel("A Label");
        label.setBorder(BorderFactory.createEmptyBorder(0,5,0,5));
        label.addFocusListener(listener);
        gridbag.setConstraints(label, c);
        contentPane.add(label);

        //We'll add a focus listener to a choice, but since it's
        //typically implemented as a compound component, we aren't
        //likely to get any events.
        String choiceprefix = "Choice item #";
        final int numItems = 10;
        Vector vector = new Vector(numItems);
        for (int i = 0; i < numItems; i++) {
            vector.addElement(choiceprefix + i);
        }
        JComboBox choice = new JComboBox(vector);
        choice.addFocusListener(listener);
        gridbag.setConstraints(choice, c);
        contentPane.add(choice);

        c.gridwidth = GridBagConstraints.REMAINDER;
        JButton button = new JButton("A Button");
        button.addFocusListener(listener);
        gridbag.setConstraints(button, c);
        contentPane.add(button);

        c.weighty = 1.0;   //Make this row as tall as possible.
        c.weightx = 0.0;
        c.fill = GridBagConstraints.BOTH;
        String listprefix = "List item #";
        Vector listVector = new Vector(numItems);
        for (int i = 0; i < numItems; i++) {
            listVector.addElement(listprefix + i);
        }
        JList list = new JList(listVector);
        JScrollPane scrollPane = new JScrollPane(list);
        list.addFocusListener(listener);
        gridbag.setConstraints(scrollPane, c);
        contentPane.add(scrollPane);

        setContentPane(contentPane);
    }
}
```

The Java^{TM} Tutorial

Trail: Creating a GUI with JFC/Swing
Lesson: Using Swing Components

An Example of Using Each Text Component

Here's a picture of an application that shows one of each of Swing's text components.



JTextField: Hello
JPasswordField: *****
You typed "Hola"

This is an editable JTextArea that has been initialized with the setText method. A text area is a "plain" text component, which means that although it can display text in any font, all of the text is in the same font.

This is an uneditable JEditorPane, which was *initialized* with **HTML** text from a URL.

This is an editable JTextPane, *another* **styled** text component, which supports embedded components...

...and embedded icons...

Try this:

1. Compile and run the application. The main source file is `TextSamplerDemo.java`. You will need some additional files to run this program. See the examples index for links to all the files required by this example.
   See Getting Started with Swing if you need help compiling or running this application.
2. Type some text into the text field and press Return. Do the same with the password field.
3. Select and edit text in the text area and the text pane. Use special keyboard keys

to cut, copy, and paste text.

4. Try to edit the text in the editor pane, which has been made uneditable with a call to `setEditable`.
5. Look in the text pane to find an example of an embedded component and an embedded icon.

The `TextSamplerDemo` program is fairly basic in how it uses the text components: It simply creates each one, configures it, and adds it to the frame's content pane. This section looks at the code from `TextSamplerDemo` that creates each text component. With the information in this short section alone, you can quickly learn everything necessary to include the various text components in a program and interact with them on a basic level.

This section has five parts:

- An Example of Using a Text Field
- An Example of Using a Password Field
- Using a Text Area
- Using an Editor Pane to Display Text from a URL
- An Example of Using a Text Pane

An Example of Using a Text Field

`TextSamplerDemo` contains a text field in the upper left corner of the main frame. Here's the code that creates the text field.

```
JTextField textField = new JTextField(10);
textField.setActionCommand(textFieldString);
textField.addActionListener(this);
```

As with buttons, you can set an action command and register an action listener on a text field. Here's the `actionPerformed` method implemented by the text field's action listener, which is shared with the program's password field. The `actionPerformed` method copies the text field's contents to a label.

```
public void actionPerformed(ActionEvent e) {
    String prefix = "You typed \"";
    if (e.getActionCommand().equals(textFieldString)) {
        JTextField source = (JTextField)e.getSource();
        actionLabel.setText(prefix + source.getText() + "\"");
    } else {
        JPasswordField source = (JPasswordField)e.getSource();
        actionLabel.setText(prefix + new String(source.getPassword())
                                   + "\"");
    }
}
```

For descriptions of the constructor and the `getText` method used by this program, refer to How to Use Text Fields. That section also includes information and examples of customized text fields, including how to write a validated field.

An Example of Using a Password Field

`JPasswordField` is a subclass of `JTextField` that, instead of showing the actual character the user types, shows another character such as an asterisk '*'. This type of field is useful for prompting users to enter passwords when logging in or validating identity. Here's the code from `TextSamplerDemo` that creates the password field and registers an action listener on it:

```
JPasswordField passwordField = new JPasswordField(10);
passwordField.setActionCommand(passwordFieldString);
passwordField.addActionListener(this);
```

This code is the similar to that used to create the text field. The password field shares the text field's action listener, which uses these three lines of code to copy the password field's content to a label:

```
String prefix = "You typed \"";
...
JPasswordField source = (JPasswordField)e.getSource();
actionLabel.setText(prefix + new String(source.getPassword())
                    + "\"");
```

Notice that this code uses the `getPassword` method to get the contents of the password field instead of `getText`. Providing a Password Field explains why and provides additional information about password fields. Remember that password fields are text fields, so the information covered in How to Use Text Fields pertains to password fields as well.

Using a Text Area

A text area displays multiple lines of text and allows the user to edit the text with the keyboard and mouse. Here's the `TextSamplerDemo` code that creates its text area:

```
JTextArea textArea = new JTextArea(
    "This is an editable JTextArea " +
    "that has been initialized with the setText method. " +
    "A text area is a \"plain\" text component, " +
    "which means that although it can display text " +
    "in any font, all of the text is in the same font."
);
textArea.setFont(new Font("Serif", Font.ITALIC, 16));
textArea.setLineWrap(true);
textArea.setWrapStyleWord(true);
```

The constructor used in this example initializes the text area with some text. Next the code sets the text area's font.

By default, a text area doesn't wrap lines. Instead it shows all the text on one line, and if the text area is within a scroll pane, allows itself to be scrolled horizontally. This example turns line wrapping on with a call to `setLineWrap` and then calls `setWrapStyleWord` to indicate that the text area should wrap lines at word boundaries rather than at character boundaries.

To provide scrolling capability, the example puts the text area in a scroll pane.

```
JScrollPane areaScrollPane = new JScrollPane(textArea);
areaScrollPane.setVerticalScrollBarPolicy(
                JScrollPane.VERTICAL_SCROLLBAR_ALWAYS);
areaScrollPane.setPreferredSize(new Dimension(250, 250));
areaScrollPane.setBorder(...create border...);
```

A text area is typically managed by a scroll pane. If you put a text area in a scroll pane, be sure to set the scroll pane's preferred size or use a text area constructor that sets the number of rows and columns for the text area.

This section is the only section provided by this tutorial about using text areas because `JTextArea` is a straightforward class to use and is largely backward compatible with the AWT `TextArea` class. If you are interested in customizing a text area, you can apply what you learn in General Rules about Using Text Components. In addition to a slightly customized text pane, the example program described there uses a standard text area as a log. Be sure to check the Summary of Text section for relevant API and other examples that use text areas.

Using an Editor Pane to Display Text from a URL

`JEditorPane` is the foundation for Swing's styled text components and provides the mechanism through which you can add support for custom text formats. `TextSamplerDemo` doesn't begin to exercise `JEditorPane`'s capability. But it does illustrate a very handy, easy-to-use editor pane feature: displaying uneditable help information loaded from a URL. Here's the code that creates the editor pane in `TextSamplerDemo`:

```
JEditorPane editorPane = new JEditorPane();
editorPane.setEditable(false);
...//create a URL object for the TextSamplerDemoHelp.html file...
try {
    editorPane.setPage(url);
} catch (IOException e) {
    System.err.println("Attempted to read a bad URL: " + url);
}
```

The code uses the default constructor to create the editor pane, then calls `setEditable(false)` so the user cannot edit the text. Next, the code creates the `URL` object, and calls the `setPage` method with it. The `setPage` method opens the resource pointed to by the URL and figures out the format of the text (which in the example is HTML). If the text format is known, the editor pane initializes itself with the text found at the URL. A standard editor pane can understand plain text, HTML, and RTF.

The code that creates the URL is missing from the above code sample and is interesting in and of itself. Here it is:

```
String s = null;
try {
    s = "file:"
        + System.getProperty("user.dir")
        + System.getProperty("file.separator")
        + "TextSamplerDemoHelp.html";
    URL helpURL = new URL(s);
    /* ...  use the URL to initialize the editor pane  ... */
} catch (Exception e) {
    System.err.println("Couldn't create help URL: " + s);
}
```

This code uses system properties to compute a `file` URL for the help file. Due to security restrictions, this code won't work in untrusted applets. Instead, use the applet's codebase to compute an `http` URL.

Like text areas, editor panes are typically managed by a scroll pane:

```
JScrollPane editorScrollPane = new JScrollPane(editorPane);
editorScrollPane.setVerticalScrollBarPolicy(
                JScrollPane.VERTICAL_SCROLLBAR_ALWAYS);
editorScrollPane.setPreferredSize(new Dimension(250, 145));
```

This short section shows a typical and basic use of an editor pane. However, many programs need to use editor panes in more sophisticated ways. To find out the types of things you can do with editor panes, and how they differ from text panes, refer to Concepts: About Editor Panes and Text Panes.

An Example of Using a Text Pane

The final text component in our tour is `JTextPane`, which is a `JEditorPane` subclass. Here's code from `TextSamplerDemo` that creates and initializes a text pane.

```
JTextPane textPane = new JTextPane();
String[] initString =
        { /* ...  fill array with initial text  ... */ };

String[] initStyles =
        { /* ...  fill array with names of styles  ... */ };
//Create the styles we need.
initStylesForTextPane(textPane);

Document doc = textPane.getDocument();

//Load the text pane with styled text.
try {
    for (int i=0; i < initString.length; i++) {
        doc.insertString(doc.getLength(), initString[i],
                         textPane.getStyle(initStyles[i]));
    }
} catch (BadLocationException ble) {
    System.err.println("Couldn't insert initial text.");
}
```

Briefly, this code hard-codes the initial text into an array and creates and hard-codes several *styles*--objects that represent different paragraph and character formats--into another array. Next, the code loops over the arrays, inserts the text into the text pane, and specifies the style to use for the inserted text. Although this makes for an interesting example and concisely shows off several features of `JTextPane`, "real-world" programs aren't likely to initialize a text pane this way. Instead, the program would use a text pane to save out a document, which would then be used to intialize the text pane.

To find out the types of things you can do with text panes, and how they differ from editor panes, refer to Concepts: About Editor Panes and Text Panes.

Now that you've seen all of the text components in action, it's time to learn about `JTextComponent` and the features it provides to all of its subclasses. Proceed to the next section, General Rules for Using Text Components.

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```
import java.awt.*;
import java.awt.event.*;
import java.util.Hashtable;

import javax.swing.*;
import javax.swing.text.*;
import javax.swing.event.*;
import javax.swing.undo.*;

public class TextComponentDemo extends JFrame {
    JTextPane textPane;
    LimitedStyledDocument lsd;
    JTextArea changeLog;
    String newline = "\n";
    static final int MAX_CHARACTERS = 300;
    Hashtable actions;

    //undo helpers
    protected UndoAction undoAction;
    protected RedoAction redoAction;
    protected UndoManager undo = new UndoManager();

    public TextComponentDemo() {
        //some initial setup
        super("TextComponentDemo");

        //Create the document for the text area.
        lsd = new LimitedStyledDocument(MAX_CHARACTERS);

        //Create the text pane and configure it.
        textPane = new JTextPane(lsd);  //All right! No 60's jokes.
        textPane.setCaretPosition(0);
        textPane.setMargin(new Insets(5,5,5,5));
        JScrollPane scrollPane = new JScrollPane(textPane);
        scrollPane.setPreferredSize(new Dimension(200, 200));

        //Create the text area for the status log and configure it.
        changeLog = new JTextArea(5, 30);
        changeLog.setEditable(false);
        JScrollPane scrollPaneForLog = new JScrollPane(changeLog);

        //Create a split pane for the change log and the text area.
        JSplitPane splitPane = new JSplitPane(
                                       JSplitPane.VERTICAL_SPLIT,
                                       scrollPane, scrollPaneForLog);
        splitPane.setOneTouchExpandable(true);

        //Create the status area.
        JPanel statusPane = new JPanel(new GridLayout(1, 1));
        CaretListenerLabel caretListenerLabel =
                new CaretListenerLabel("Caret Status");
        statusPane.add(caretListenerLabel);

        //Add the components to the frame.
        JPanel contentPane = new JPanel(new BorderLayout());
        contentPane.add(splitPane, BorderLayout.CENTER);
        contentPane.add(statusPane, BorderLayout.SOUTH);
        setContentPane(contentPane);

        //Set up the menu bar.
        createActionTable(textPane);
        JMenu editMenu = createEditMenu();
        JMenu styleMenu = createStyleMenu();
        JMenuBar mb = new JMenuBar();
        mb.add(editMenu);
        mb.add(styleMenu);
        setJMenuBar(mb);

        //Add some key bindings to the keymap.
        addKeymapBindings();

        //Put the initial text into the text pane.
        initDocument();

        //Start watching for undoable edits and caret changes.
        lsd.addUndoableEditListener(new MyUndoableEditListener());
        textPane.addCaretListener(caretListenerLabel);
        lsd.addDocumentListener(new MyDocumentListener());
    }

    //This listens for and reports caret movements.
    protected class CaretListenerLabel extends JLabel implements CaretListener {
        public CaretListenerLabel (String label) {
            super(label);
        }

        public void caretUpdate(CaretEvent e) {
            //Get the location in the text.
            int dot = e.getDot();
            int mark = e.getMark();
            if (dot == mark) {  // no selection
                try {
                    Rectangle caretCoords = textPane.modelToView(dot);
                    //Convert it to view coordinates.
                    setText("caret: text position: " + dot
                            + ", view location = ["
                            + caretCoords.x + ", "
                            + caretCoords.y + "]"
                            + newline);
                } catch (BadLocationException ble) {
                    setText("caret: text position: " + dot + newline);
                }
            } else if (dot < mark) {
                setText("selection from: " + dot
                        + " to " + mark + newline);
            } else {
                setText("selection from: " + mark
                        + " to " + dot + newline);
            }
        }
    }

    //This one listens for edits that can be undone.
    protected class MyUndoableEditListener
                    implements UndoableEditListener {
        public void undoableEditHappened(UndoableEditEvent e) {
            //Remember the edit and update the menus.
            undo.addEdit(e.getEdit());
            undoAction.updateUndoState();
            redoAction.updateRedoState();
        }
    }

    //And this one listens for any changes to the document.
    protected class MyDocumentListener
                    implements DocumentListener {
        public void insertUpdate(DocumentEvent e) {
            displayEditInfo(e);
        }
        public void removeUpdate(DocumentEvent e) {
            displayEditInfo(e);
        }
        public void changedUpdate(DocumentEvent e) {
            displayEditInfo(e);
        }
        private void displayEditInfo(DocumentEvent e) {
            Document doc = (Document)e.getDocument();
            int changeLength = e.getLength();
            changeLog.append(e.getType().toString() + ": " +
                changeLength + " character" +
                ((changeLength == 1) ? ". " : "s. ") +
                " Text length = " + doc.getLength() + "." + newline);
        }
    }

    //Add a couple of emacs key bindings to the key map for navigation.
    protected void addKeymapBindings() {
        //Add a new key map to the keymap hierarchy.
        Keymap keymap = textPane.addKeymap("MyEmacsBindings",
                                           textPane.getKeymap());

        //Ctrl-b to go backward one character
        Action action = getActionByName(DefaultEditorKit.backwardAction);
        KeyStroke key = KeyStroke.getKeyStroke(KeyEvent.VK_B, Event.CTRL_MASK);
        keymap.addActionForKeyStroke(key, action);

        //Ctrl-f to go forward one character
        action = getActionByName(DefaultEditorKit.forwardAction);
        key = KeyStroke.getKeyStroke(KeyEvent.VK_F, Event.CTRL_MASK);
        keymap.addActionForKeyStroke(key, action);

        //Ctrl-p to go up one line
        action = getActionByName(DefaultEditorKit.upAction);
        key = KeyStroke.getKeyStroke(KeyEvent.VK_P, Event.CTRL_MASK);
        keymap.addActionForKeyStroke(key, action);

        //Ctrl-n to go down one line
        action = getActionByName(DefaultEditorKit.downAction);
        key = KeyStroke.getKeyStroke(KeyEvent.VK_N, Event.CTRL_MASK);
        keymap.addActionForKeyStroke(key, action);

        textPane.setKeymap(keymap);
    }

    //Create the edit menu.
    protected JMenu createEditMenu() {
        JMenu menu = new JMenu("Edit");

        //Undo and redo are actions of our own creation.
        undoAction = new UndoAction();
        menu.add(undoAction);

        redoAction = new RedoAction();
        menu.add(redoAction);

        menu.addSeparator();
        //These actions come from the default editor kit.
        //Get the ones we want and stick them in the menu.
        menu.add(getActionByName(DefaultEditorKit.cutAction));
        menu.add(getActionByName(DefaultEditorKit.copyAction));
        menu.add(getActionByName(DefaultEditorKit.pasteAction));

        menu.addSeparator();

        menu.add(getActionByName(DefaultEditorKit.selectAllAction));
        return menu;
    }

    //Create the style menu.
    protected JMenu createStyleMenu() {
        JMenu menu = new JMenu("Style");

        Action action = new StyledEditorKit.BoldAction();
        action.putValue(Action.NAME, "Bold");
        menu.add(action);

        action = new StyledEditorKit.ItalicAction();
        action.putValue(Action.NAME, "Italic");
        menu.add(action);

        action = new StyledEditorKit.UnderlineAction();
        action.putValue(Action.NAME, "Underline");
        menu.add(action);

        menu.addSeparator();

        menu.add(new StyledEditorKit.FontSizeAction("12", 12));
        menu.add(new StyledEditorKit.FontSizeAction("14", 14));
        menu.add(new StyledEditorKit.FontSizeAction("18", 18));

        menu.addSeparator();

        menu.add(new StyledEditorKit.FontFamilyAction("Serif",
                                                      "Serif"));
        menu.add(new StyledEditorKit.FontFamilyAction("SansSerif",
                                                      "SansSerif"));

        menu.addSeparator();

        menu.add(new StyledEditorKit.ForegroundAction("Red",
                                                      Color.red));
        menu.add(new StyledEditorKit.ForegroundAction("Green",
                                                      Color.green));
        menu.add(new StyledEditorKit.ForegroundAction("Blue",
                                                      Color.blue));
        menu.add(new StyledEditorKit.ForegroundAction("Black",
                                                      Color.black));

        return menu;
    }

    protected void initDocument() {
        String initString[] =
                { "Use the mouse to place the caret.",
                  "Use the edit menu to cut, copy, paste, and select text.",
                  "Also to undo and redo changes.",
                  "Use the style menu to change the style of the text.",
                  "Use these emacs key bindings to move the caret:",
                "ctrl-f, ctrl-b, ctrl-n, ctrl-p." };

        SimpleAttributeSet[] attrs = initAttributes(initString.length);

        try {
            for (int i = 0; i < initString.length; i ++) {
                lsd.insertString(lsd.getLength(), initString[i] + newline,
                        attrs[i]);
            }
        } catch (BadLocationException ble) {
            System.err.println("Couldn't insert initial text.");
        }
    }

    protected SimpleAttributeSet[] initAttributes(int length) {
        //Hard-code some attributes.
        SimpleAttributeSet[] attrs = new SimpleAttributeSet[length];

        attrs[0] = new SimpleAttributeSet();
        StyleConstants.setFontFamily(attrs[0], "SansSerif");
        StyleConstants.setFontSize(attrs[0], 16);

        attrs[1] = new SimpleAttributeSet(attrs[0]);
        StyleConstants.setBold(attrs[1], true);

        attrs[2] = new SimpleAttributeSet(attrs[0]);
        StyleConstants.setItalic(attrs[2], true);

        attrs[3] = new SimpleAttributeSet(attrs[0]);
        StyleConstants.setFontSize(attrs[3], 20);

        attrs[4] = new SimpleAttributeSet(attrs[0]);
        StyleConstants.setFontSize(attrs[4], 12);

        attrs[5] = new SimpleAttributeSet(attrs[0]);
        StyleConstants.setForeground(attrs[5], Color.red);

        return attrs;
    }

    //The following two methods allow us to find an
    //action provided by the editor kit by its name.
    private void createActionTable(JTextComponent textComponent) {
        actions = new Hashtable();
        Action[] actionsArray = textComponent.getActions();
        for (int i = 0; i < actionsArray.length; i++) {
            Action a = actionsArray[i];
            actions.put(a.getValue(Action.NAME), a);
        }
    }

    private Action getActionByName(String name) {
        return (Action)(actions.get(name));
    }

    class UndoAction extends AbstractAction {
        public UndoAction() {
            super("Undo");
            setEnabled(false);
        }

        public void actionPerformed(ActionEvent e) {
            try {
                undo.undo();
            } catch (CannotUndoException ex) {
                System.out.println("Unable to undo: " + ex);
                ex.printStackTrace();
            }
            updateUndoState();
            redoAction.updateRedoState();
        }

        protected void updateUndoState() {
            if (undo.canUndo()) {
                setEnabled(true);
                putValue(Action.NAME, undo.getUndoPresentationName());
            } else {
                setEnabled(false);
                putValue(Action.NAME, "Undo");
            }
        }
    }

    class RedoAction extends AbstractAction {
        public RedoAction() {
            super("Redo");
            setEnabled(false);
        }

        public void actionPerformed(ActionEvent e) {
            try {
                undo.redo();
            } catch (CannotRedoException ex) {
                System.out.println("Unable to redo: " + ex);
                ex.printStackTrace();
            }
            updateRedoState();
            undoAction.updateUndoState();
        }

        protected void updateRedoState() {
            if (undo.canRedo()) {
                setEnabled(true);
                putValue(Action.NAME, undo.getRedoPresentationName());
            } else {
                setEnabled(false);
                putValue(Action.NAME, "Redo");
            }
        }
    }

    //The standard main method.
    public static void main(String[] args) {
        final TextComponentDemo frame = new TextComponentDemo();
        frame.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
            public void windowActivated(WindowEvent e) {
                frame.textPane.requestFocus();
            }
        });

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

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

public class LimitedStyledDocument extends DefaultStyledDocument {
    int maxCharacters;

    public LimitedStyledDocument(int maxChars) {
        maxCharacters = maxChars;
    }

    public void insertString(int offs, String str, AttributeSet a)
        throws BadLocationException {

        //This rejects the entire insertion if it would make
        //the contents too long. Another option would be
        //to truncate the inserted string so the contents
        //would be exactly maxCharacters in length.
        if ((getLength() + str.length()) <= maxCharacters)
            super.insertString(offs, str, a);
        else
            Toolkit.getDefaultToolkit().beep();
    }
}
```

Trail: Creating a GUI with JFC/Swing
Lesson: Swing Features and Concepts

More Swing Features and Concepts

This lesson has discussed some of the major concepts you need to know to build Swing GUIs -- the containment hierarchy, layout management, event handling, painting, and threads. Along the way, we touched upon related topics, such as borders. This section tells you about some of the Swing features that we haven't yet discussed:

- Features that `JComponent` provides
- Icons
- Actions
- Pluggable Look & Feel support
- Support for assistive technologies
- Separate data and state models

Features that `JComponent` Provides

Except for the top-level containers, all components that begin with `J` inherit from the `JComponent` class. They get many features from `JComponent`, such as the ability to have borders, tool tips, and a configurable look and feel. They also inherit many convenient methods. For details about what `JComponent` provides, see The JComponent Class◆.

Icons

Many Swing components -- notably buttons and labels -- can display images. You specify these images as `Icon` objects. See How to Use Icons◆ for instructions and a list of examples that use icons.

Actions

With `Action` objects, the Swing API provides special support for sharing data and state between two or more components that can generate action events. For example, if you have a button and a menu item that perform the same function, consider using an `Action` object to coordinate the text, icon, and enabled state for the two components. For details, see How to Use Actions◆.

Pluggable Look & Feel

A single program can have any one of several looks and feels. You can let the user determine the look and feel, or you can specify the look and feel programatically. See How to Set the Look and Feel◆ for details.

Support for Assistive Technologies

Assistive technologies such as screen readers can use the Accessibility API to get information from Swing components. Because support for the Accessibility API is built into the Swing components, your Swing program will probably work just fine with assistive technologies, even if you do nothing special. With very little extra effort, however, you can make your program function even more smoothly with assistive technologies, which might well expand its market. See How to Support Assistive Technologies◆ for details.

Separate Data and State Models

Most noncontainer Swing components have models. A button (`JButton`), for example, has a model (`ButtonModel`) that stores the button's state -- what its keyboard mnemonic is, whether it's enabled, selected, or pressed, and so on. Some components have multiple models. A list (`JList`), for example, uses a `ListModel` to hold the list's contents, and a `ListSelectionModel` to track the list's current selection.

You don't usually need to know about the models that a component uses. For example, almost all programs that use buttons deal directly with the `JButton` object, and don't deal at all with the `ButtonModel` object.

Why then do separate models exist? Because they give you the ability to work with components more efficiently and to easily share data and state between components. One common case is when a component, such as a list or table, contains lots of data. It can be much faster to manage the data by directly working with a data model than by having the component forward each data request to the model. You can use the component's default model, or you can implement your own.

For information about models, see the how-to pages for individual components. Also, The

Anatomy of a Swing-Based Program discusses some custom models used by that section's featured program, `Converter`.

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Trail: Creating a GUI with JFC/Swing
Lesson: Using Swing Components

Concepts: About Editor Panes and Text Panes

Two Swing classes support styled text: `JEditorPane` and its subclass `JTextPane`. Several facts about editor panes and text panes were sprinkled throughout the previous four sections. Here we list the facts again, to collect them in one place and to provide a bit more detail. The information here should help you understand the differences between editor panes and text panes, and when to use which.

- An editor pane or a text pane can easily be loaded with text from a URL using the `setPage` method. The `JEditorPane` class also provides constructors that let you initialize an editor pane from a URL. `JTextPane` has no such constructors. See Using an Editor Pane to Display Text from a URL for an example of using this feature to load an uneditable editor pane with HTML.

  Be aware that the document and editor kit might change when using the `setPage` method. For example, if an editor pane contains plain text (the default), and you load it with HTML, the document will change to an `HTMLDocument` instance and the editor kit will change to an `HTMLEditorKit` instance. If your program uses the `setPage` method, make sure the code adjusts for possible changes to the pane's document and editor kit instances (re-register document listeners on the new document, and so on).

- Editor panes, by default, know how to read, write, and edit plain, HTML, and RTF text. Text panes inherit this capability but impose certain limitations. A text pane insists that its document implement the `StyledDocument` interface. `HTMLDocument` and `RTFDocument` are both `StyledDocuments` so HTML and RTF work as expected within a text pane. If you load a text pane with plain text though, the text pane's document is not a `PlainDocument` as you might expect, but a `DefaultStyledDocument`.

- To support a custom text format, implement an editor kit that can read, write, and edit text of that format. Then call the `registerEditorKitForContentType` to register your kit with the `JEditorPane` class. By registering an editor kit in this way, all editor panes and text panes in your program will be able to read, write, and edit the new format. However, if the new editor kit is not a `StyledEditorKit`, text panes will not support the new format.

- As mentioned previously, a text pane requires that its document be an instance of a class that implements the `StyledDocument` interface. The Swing text package provides a default implementation of this interface, `DefaultStyledDocument`, which is the document text panes use by default. A text pane also requires that its editor kit be an instance of a `StyledEditorKit` (or a subclass). Be aware that the `read` and `write` methods for `StyleEditorKit` write plain text.

- Through its styled document and styled editor kit, text panes provide support for named styles and logical styles. The `JTextPane` class itself contains many methods for working with styles that simply call methods in its document or editor kit.

- Through the API provided in the `JTextPane` class, you can embed images and components in a text pane. You can embed images in an editor pane, too, but only by including the images in an HTML or RTF file.

The next section provides API tables for all text components, including editor panes and text panes, and a list of examples that use text components.

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The Java^{TM} Tutorial

Trail: Creating a GUI with JFC/Swing
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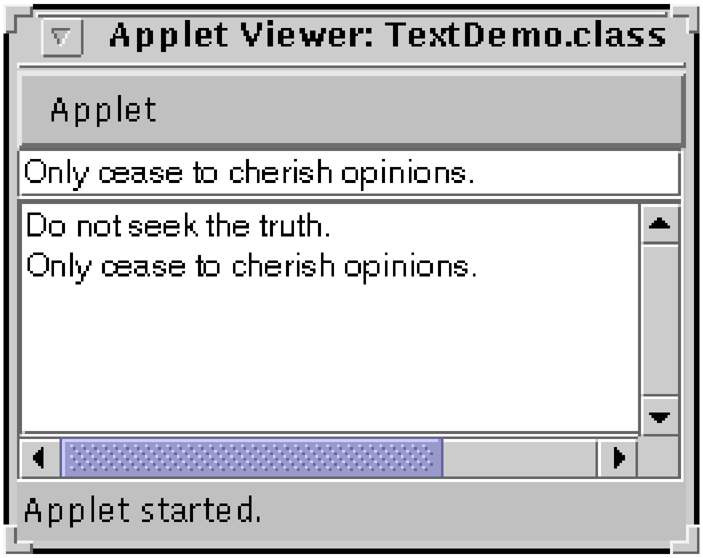
Run TextDemo

Since you can't run the applet, here's a picture of it:



Only cease to cherish opinions.

Do not seek the truth.
Only cease to cherish opinions.

Applet started.

Note: Because the preceding applet uses the Swing 1.1 API, it requires Java Plug-in 1.1.2 or Java Plug-in 1.2. It won't work with Java Plug-in 1.1.1 or uncustomized 1.1 browsers. For more information about running applets in the tutorial, refer to About Our Examples. That page includes a section about Downloading Java Plug-in.

```
/*
 * Swing Version
 */

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

public class TextDemo extends JApplet implements ActionListener {
    JTextField textField;
    JTextArea textArea;
    String newline = "\n";

    //Hack to avoid annoying error message (1.1).
    public TextDemo() {
        getRootPane().putClientProperty("defeatSystemEventQueueCheck",
                                        Boolean.TRUE);
    }

    public void init() {
        textField = new JTextField(20);
        textField.addActionListener(this);

        textArea = new JTextArea(5, 20);
        textArea.setEditable(false);
        JScrollPane scrollPane = new JScrollPane(textArea,
                                       JScrollPane.VERTICAL_SCROLLBAR_ALWAYS,
                                       JScrollPane.HORIZONTAL_SCROLLBAR_ALWAYS);

        //Add Components to the Applet.
        GridBagLayout gridBag = new GridBagLayout();
        Container contentPane = getContentPane();
        contentPane.setLayout(gridBag);
        GridBagConstraints c = new GridBagConstraints();
        c.gridwidth = GridBagConstraints.REMAINDER;

        c.fill = GridBagConstraints.HORIZONTAL;
        gridBag.setConstraints(textField, c);
        contentPane.add(textField);

        c.fill = GridBagConstraints.BOTH;
        c.weightx = 1.0;
        c.weighty = 1.0;
        gridBag.setConstraints(scrollPane, c);
        contentPane.add(scrollPane);
    }

    public void actionPerformed(ActionEvent evt) {
        String text = textField.getText();
        textArea.append(text + newline);
        textField.selectAll();
    }
}
```

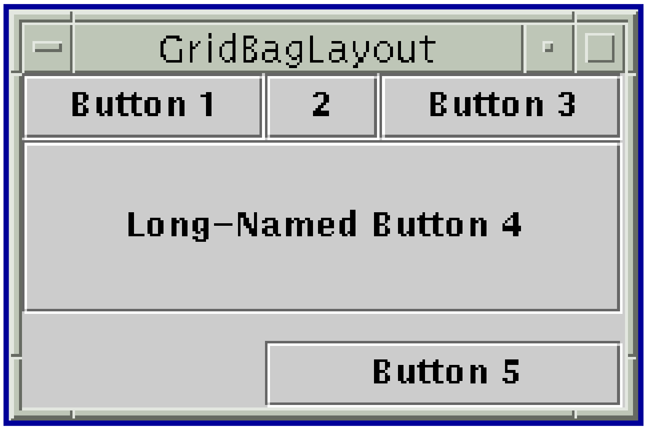
```
import java.awt.*;
import java.awt.event.*;

import javax.swing.*;
import javax.swing.event.*;
import javax.swing.text.*;

import java.text.*;

public class TextFieldDemo extends JFrame {
    //Values for the text fields
    private double amount = 100000;
    private double rate = 7.5;  //7.5 %
    private int numPeriods = 30;
    private double payment = 0.0;

    //Labels to identify the text fields
    private JLabel amountLabel;
    private JLabel rateLabel;
    private JLabel numPeriodsLabel;
    private JLabel paymentLabel;

    //Strings for the labels
    private static String amountString = "Loan Amount: ";
    private static String rateString = "APR (%): ";
    private static String numPeriodsString = "Years: ";
    private static String paymentString = "Monthly Payment: ";

    //Text fields for data entry
    private DecimalField amountField;
    private DecimalField rateField;
    private WholeNumberField numPeriodsField;
    private DecimalField paymentField;

    //Formats to format and parse numbers
    private NumberFormat moneyFormat;
    private NumberFormat percentFormat;
    private DecimalFormat paymentFormat;

    private boolean focusIsSet = false;

    public TextFieldDemo() {
        super("TextFieldDemo");

        setUpFormats();

        payment = computePayment(amount, rate, numPeriods);

        //Create the labels.
        amountLabel = new JLabel(amountString);
        rateLabel = new JLabel(rateString);
        numPeriodsLabel = new JLabel(numPeriodsString);
        paymentLabel = new JLabel(paymentString);

        //Create the text fields and set them up.
        MyDocumentListener myDocumentListener = new MyDocumentListener();

        amountField = new DecimalField(amount, 10, moneyFormat);
        amountField.getDocument().addDocumentListener(myDocumentListener);
        amountField.getDocument().putProperty("name", "amount");

        rateField = new DecimalField(rate, 10, percentFormat);
        rateField.getDocument().addDocumentListener(myDocumentListener);
        rateField.getDocument().putProperty("name", "rate");

        numPeriodsField = new WholeNumberField(numPeriods, 10);
        numPeriodsField.getDocument().addDocumentListener(myDocumentListener);
        numPeriodsField.getDocument().putProperty("name", "numPeriods");

        paymentField = new DecimalField(payment, 10, paymentFormat);
        paymentField.setEditable(false);
        paymentField.setForeground(Color.red);

        //Tell accessibility tools about label/textfield pairs.
        amountLabel.setLabelFor(amountField);
        rateLabel.setLabelFor(rateField);
        numPeriodsLabel.setLabelFor(numPeriodsField);
        paymentLabel.setLabelFor(paymentField);

        //Layout the labels in a panel.
        JPanel labelPane = new JPanel();
        labelPane.setLayout(new GridLayout(0, 1));
        labelPane.add(amountLabel);
        labelPane.add(rateLabel);
        labelPane.add(numPeriodsLabel);
        labelPane.add(paymentLabel);

        //Layout the text fields in a panel.
        JPanel fieldPane = new JPanel();
        fieldPane.setLayout(new GridLayout(0, 1));
        fieldPane.add(amountField);
        fieldPane.add(rateField);
        fieldPane.add(numPeriodsField);
        fieldPane.add(paymentField);

        //Put the panels in another panel, labels on left,
        //text fields on right.
        JPanel contentPane = new JPanel();
        contentPane.setBorder(BorderFactory.createEmptyBorder(20, 20, 20, 20));
        contentPane.setLayout(new BorderLayout());
        contentPane.add(labelPane, BorderLayout.CENTER);
        contentPane.add(fieldPane, BorderLayout.EAST);

        setContentPane(contentPane);
    }

    class MyDocumentListener implements DocumentListener {
        public void insertUpdate(DocumentEvent e) {
            calculateValue(e);
        }
        public void removeUpdate(DocumentEvent e) {
            calculateValue(e);
        }
        public void changedUpdate(DocumentEvent e) {
            // we won't ever get this with PlainDocument
        }
        private void calculateValue(DocumentEvent e) {
            Document whatsup = e.getDocument();
            if (whatsup.getProperty("name").equals("amount"))
                amount = amountField.getValue();
            else if (whatsup.getProperty("name").equals("rate"))
                rate = rateField.getValue();
            else if (whatsup.getProperty("name").equals("numPeriods"))
                numPeriods = numPeriodsField.getValue();
            payment = computePayment(amount, rate, numPeriods);
            paymentField.setValue(payment);
        }
    }

    public static void main(String[] args) {
        final TextFieldDemo demo = new TextFieldDemo();

        demo.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }

            //Whenever window gets the focus, let the
            //TextFieldDemo set the initial focus.
            public void windowActivated(WindowEvent e) {
                demo.setFocus();
            }
        });
        demo.pack();
        demo.setVisible(true);
    }

    private void setFocus() {
        if (!focusIsSet) {
            amountField.requestFocus();
            focusIsSet = true;
        }
    }

    // Compute the monthly payment based on the loan amount,
    // APR, and length of loan.
    double computePayment(double loanAmt, double rate, int numPeriods) {
        double I, partial1, denominator, answer;

        I = rate / 100.0 / 12.0;         // get monthly rate from annual
        numPeriods *= 12;        // get number of months
        partial1 = Math.pow((1 + I), (0.0 - numPeriods));
        denominator = (1 - partial1) / I;
        answer = (-1 * loanAmt) / denominator;
        return answer;
    }

    // Create and set up number formats. These objects also
    // parse numbers input by user.
    private void setUpFormats() {
        moneyFormat = NumberFormat.getNumberInstance();
        //XXXX: Workaround. With an empty positive suffix
        //the format allows letters in the number.
        ((DecimalFormat)moneyFormat).setPositiveSuffix(" ");

        percentFormat = NumberFormat.getNumberInstance();
        percentFormat.setMinimumFractionDigits(3);
        //XXXX: Workaround. With an empty positive suffix
        //the format allows letters in the number.
        ((DecimalFormat)percentFormat).setPositiveSuffix(" ");

        paymentFormat = (DecimalFormat)NumberFormat.getNumberInstance();
        paymentFormat.setMaximumFractionDigits(2);
        paymentFormat.setNegativePrefix("(");
        paymentFormat.setNegativeSuffix(")");
    }
}
```

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

import java.awt.Toolkit;
import java.text.NumberFormat;
import java.text.ParseException;
import java.util.Locale;

public class WholeNumberField extends JTextField {
    private Toolkit toolkit;
    private NumberFormat integerFormatter;

    public WholeNumberField(int value, int columns) {
        super(columns);
        toolkit = Toolkit.getDefaultToolkit();
        integerFormatter = NumberFormat.getNumberInstance(Locale.US);
        integerFormatter.setParseIntegerOnly(true);
        setValue(value);
    }

    public int getValue() {
        int retVal = 0;
        try {
            retVal = integerFormatter.parse(getText()).intValue();
        } catch (ParseException e) {
            // This should never happen because insertString allows
            // only properly formatted data to get in the field.
            toolkit.beep();
        }
        return retVal;
    }

    public void setValue(int value) {
        setText(integerFormatter.format(value));
    }

    protected Document createDefaultModel() {
        return new WholeNumberDocument();
    }

    protected class WholeNumberDocument extends PlainDocument {
        public void insertString(int offs,
                                 String str,
                                 AttributeSet a)
                throws BadLocationException {
            char[] source = str.toCharArray();
            char[] result = new char[source.length];
            int j = 0;

            for (int i = 0; i < result.length; i++) {
                if (Character.isDigit(source[i]))
                    result[j++] = source[i];
                else {
                    toolkit.beep();
                    System.err.println("insertString: " + source[i]);
                }
            }
            super.insertString(offs, new String(result, 0, j), a);
        }
    }
}
```

Trail: Creating a GUI with JFC/Swing
Lesson: Laying Out Components Within a Container

How to Use GridBagLayout

Here's an applet that shows a `GridBagLayout` in action.

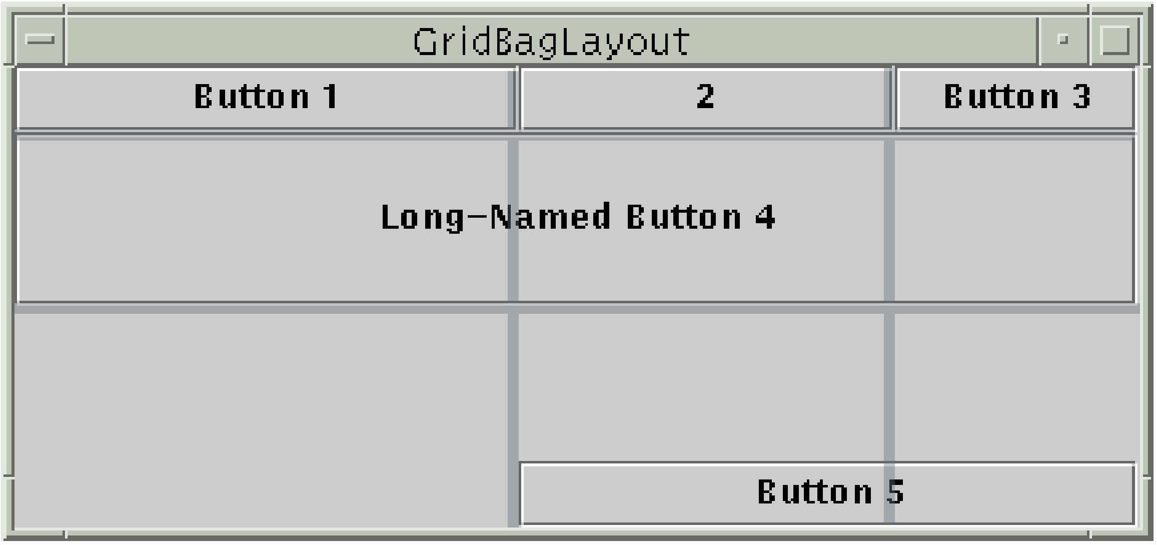


This is a picture of the applet's GUI. To run the applet, click the picture. The applet will appear in a new browser window.

`GridBagLayout` is the most flexible -- and complex -- layout manager the Java platform provides. A `GridBagLayout` places components in a grid of rows and columns, allowing specified components to span multiple rows or columns. Not all rows necessarily have the same height. Similarly, not all columns necessarily have the same width. Essentially, `GridBagLayout` places components in rectangles (cells) in a grid, and then uses the components' preferred sizes to determine how big the cells should be.

The following figure shows the grid for the preceding applet. As you can see, the grid has three rows and three columns. The button in the second row spans all the columns; the button in the third row spans the two right columns.

If you enlarge the window as shown in the following figure, you'll notice that the bottom row, which contains Button 5, gets all the new vertical space. The new horizontal space is split evenly among all the columns. This resizing behavior is based on weights the program assigns to individual components in the `GridBagLayout`. You'll also notice that each component takes up all the available horizontal space -- but not (as you can see with button 5) all the available vertical space. This behavior is also specified by the program.



The way the program specifies the size and position characteristics of its components is by specifying *constraints* for each component, To specify constraints, you set instance variables in a `GridBagConstraints` object and tell the `GridBagLayout` (with the `setConstraints` method) to associate the constraints with the component.

The following sections explain the constraints you can set and provide examples.

Specifying Constraints

This page tells you what instance variables `GridBagConstraints` has, what values you can set them to, and how to associate the resulting `GridBagConstraints` with a component.

The Example Explained

This page puts it all together, explaining the code for the program on this page.

The GridBagLayout API

The `GridBagLayout` and `GridBagConstraints` classes each have only one constructor, with no arguments. Instead of invoking methods on a `GridBagConstraints` object, you manipulate its instance variables, as described in Specifying Constraints. Generally, the only method you invoke on a `GridBagLayout` object is `setConstraints`, as demonstrated in The Example Explained.

Examples that Use GridBagLayout

You can find examples of using `GridBagLayout` throughout this tutorial. The follwing table lists a few.

Example	Where Described	Notes
`GridBagWindow`	This section	Uses many features -- weights, insets, internal padding, horizontal fill, exact cell positioning, multi-column cells, and anchoring (component positioning within a cell).
`TextSamplerDemo`	Using Text Components◆	Aligns two pairs of labels and text fields, plus adds a label across the full width of the container.
`ContainerEventDemo`	How to Write a Container Listener◆	Positions five components within a container, using weights, fill, and relative positioning.

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

public class PasswordDemo {
    public static void main(String[] argv) {
        final JFrame f = new JFrame("PasswordDemo");

        JLabel label = new JLabel("Enter the password: ");
        JPasswordField passwordField = new JPasswordField(10);
        passwordField.setEchoChar('#');
        passwordField.addActionListener(new ActionListener() {
            public void actionPerformed(ActionEvent e) {
                JPasswordField input = (JPasswordField)e.getSource();
                char[] password = input.getPassword();
                if (isPasswordCorrect(password)) {
                    JOptionPane.showMessageDialog(f,
                        "Success! You typed the right password.");
                } else {
                    JOptionPane.showMessageDialog(f,
                        "Invalid password. Try again.",
                        "Error Message",
                        JOptionPane.ERROR_MESSAGE);
                }
            }
        });

        JPanel contentPane = new JPanel(new BorderLayout());
        contentPane.setBorder(BorderFactory.createEmptyBorder(20, 20, 20, 20));
        contentPane.add(label, BorderLayout.WEST);
        contentPane.add(passwordField, BorderLayout.CENTER);

        f.setContentPane(contentPane);
        f.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) { System.exit(0); }
        });
        f.pack();
        f.setVisible(true);
    }

    private static boolean isPasswordCorrect(char[] input) {
        char[] correctPassword = { 'b', 'u', 'g', 'a', 'b', 'o', 'o' };
        if (input.length != correctPassword.length)
            return false;
        for (int i = 0;  i < input.length; i ++)
            if (input[i] != correctPassword[i])
                return false;
        return true;
    }
}
```

Trail: Creating a GUI with JFC/Swing
Lesson: Using Swing Components

Summary of Text

Because `JTextComponent` and its subclasses have too many features to be completely described in this tutorial, please periodically search The Swing Connection for pointers to other text documentation. Also, check our book.html file for references to further documentation and examples. For API tables and examples of text fields and password fields, see The Text Field and Password Field API and Examples that Use Text Fields and Password Fields.

This section has two parts:

- The Text API
- Examples that Use Text Components

The Text API

The tables in this section cover just part of the text API. For more information about the text API, see the API documentation for `JTextComponent`◆ and for the various classes and interfaces in the text package◆. Also see The JComponent Class, which describes the API that the text components inherit from `JComponent`.

The API for text falls into these categories:

- Swing Text Component Classes
- Setting Attributes
- Converting Positions Between the Model and The View
- Classes and Interfaces that Represent Documents
- Useful Methods for Working with Documents
- Manipulating the Current Selection
- Manipulating Carets and Selection Highlighters
- Text Editing Commands
- Binding KeyStrokes to Actions

- Reading and Writing Text
- Displaying Text from a URL

Swing Text Component Classes

Class	Description
JTextComponent	The abstract superclass of all Swing text components. See General Rules for Using Text Components.
JTextField	An optionally editable, single-line, plain text component. See How to Use Text Fields.
JPasswordField	An optionally editable, single-line, plain text component that masks its content. See Providing a Password Field.
JTextArea	An optionally editable, multi-line, plain text component. See Using a Text Area.
JEditorPane	An optionally editable, multi-line, styled text component. See Concepts: About Editor Panes and Text Panes.
JTextPane	An optionally editable, multi-line, styled text component with support for named attributes. See Concepts: About Editor Panes and Text Panes.

Setting Attributes

Method	Description
void setDisabledTextColor(Color) Color getDisabledTextColor() *(in JTextComponent)*	Set or get the color used to display text when the text component is disabled.
void setOpaque(boolean) boolean getOpaque() *(in JTextComponent)*	Set or get whether the text component is completely opaque.
void setMargin(Insets) Insets getMargin() *(in JTextComponent)*	Set or get the margin between the text and the text component's border.
void setEditable(boolean) boolean isEditable() *(in JTextComponent)*	Set or get whether the user can edit the text in the text component.

Converting Positions Between the Model and the View

Method	Description

`int viewToModel(Point)` *(in `JTextComponent`)*	Convert the specified point in the view coordinate system to a position within the text.
`Rectangle modelToView(int)` *(in `JTextComponent`)*	Convert the specified position within the text to a rectangle in the view coordinate system.

Classes and Interfaces that Represent Documents

Interface or Class	**Description**
`Document` *(an interface)*	Defines the API that must be implemented by all documents.
`AbstractDocument` *(an interface)*	An abstract superclass implementation of the `Document` interface. This is the superclass for all documents provided by the Swing text package.
`PlainDocument` *(a class)*	Implements the `Document` interface. This is the default document for the plain text components (text field, password field, and text area). Additionally used by editor pane and text pane when loading plain text or text of an unknown format.
`StyledDocument` *(an interface)*	A `Document` subinterface. Defines the API that must be implemented by documents that support styled text. `JTextPane` requires that its document be of this type.
`DefaultStyledDocument` *(a class)*	Implements the `StyledDocument` interface. The default document for `JTextPane`.

Useful Methods for Working with Documents

Method	**Description**

`setDocument(Document)`
`Document getDocument()`
(in `JTextComponent`)
	Set or get the document for a text component.

`Document createDefaultModel()` *(in `JTextField`)*	Override this method in text field and its subclasses to create a custom document instead of the default `PlainDocument`. Creating a Validated Text Field provides an example of overriding this method.

`void insertString(int, String, AttributeSet)`
`void remove(int, int)`
(in `Document`)
	These methods are commonly overridden by custom documents. For an example of a custom document that overrides both of these methods, see Creating a Validated Text Field.

`void addDocumentListener(DocumentListener)`
`void removeDocumentListener(DocumentListener)`
(in `Document`)
	Add or remove a document listener to a document. See Listening for Changes on a Document.

`void addUndoableEditListener(UndoableEditListener)`
`void removeUndoableEditListener(UndoableEditlistener)`
(in `Document`)
	Add or remove an undoable edit listener to a document. Undoable edit listeners are used in Implementing Undo and Redo.

`int getLength()`
`Position getStartPosition()`
`Position getEndPosition()`
`String getText(int, int)`
(in `Document`)
	`Document` methods that return useful information about the document.

`Object getProperty(Object)`
`void putProperty(Object, Object)`
(in `Document`)
`Dictionary getDocumentProperties()`
`void setDocumentProperties(Dictionary)`
(in `AbstractDocument`)
	A `Document` maintains a set of properties that you can manipulate with these methods. The example described in [Using a Document Listener on a Text Field]() uses a property to name text components so that a shared document listener can identify the document that generated the event.

Manipulating the Current Selection

Method	**Description**
`String getSelectedText()`	Get the currently selected text.

`void selectAll()`
`void select(int, int)`
(in `JTextComponent`)
	Select all text or select text within a start and end range.

`void setSelectionStart(int)`
`void setSelectionEnd(int)`
`int getSelectionStart()`
`int getSelectionEnd()`
(in `JTextComponent`)
	Set or get extent of the current selection by index.

`void setSelectedTextColor(Color)`
`Color getSelectedTextColor()`
(in `JTextComponent`)
	Set or get the color of selected text.

`void setSelectionColor(Color)`
`Color getSelectionColor()`
`(in JTextComponent)`
	Set or get the background color of selected text.

Manipulating Carets and Selection Highlighters

Interface, Class, or Method	**Description**
`Caret` *(an interface)*	Defines the API for objects that represent an insertion point within documents.

`DefaultCaret` *(a class)*	The default caret used by all text components.

`void setCaret(Caret)`
`Caret getCaret()`
(in `JTextComponent`)
	Set or get the caret object used by a text component.

`void setCaretColor(Color)`
`Color getCaretColor()`
(in `JTextComponent`)
	Set or get the color of the caret.

`void setCaretPosition(Position)`
`void moveCaretPosition(int)`
`Position getCaretPosition()`
(in `JTextComponent`)
	Set or get the current position of the caret within the document.

`void addCaretListener(CaretListener)`
`void removeCaretListener(CaretListener)`
(in `JTextComponent`)
	Add or remove a caret listener to a text component.

`Highlighter` *(an interface)*	Defines the API for objects used to highlight the current selection.
`DefaultHighlighter` *(a class)*	The default highlighter used by all text components.

`void setHighlighter(Highlighter)`
`Highlighter getHighlighter()`
(in `JTextComponent`)
	Set or get the highlighter used by a text component.

Text Editing Commands

Class or Method	**Description**

`void cut()`
`void copy()`
`void paste()`
`void replaceSelection(String)`
(in `JTextComponent`)
	Cut, copy, and paste text using the system clipboard.

`EditorKit` *(a class)*	Edit, read, and write text of a particular format.
`DefaultEditorKit` *(a class)*	A concrete subclass of `EditorKit` that provides the basic text editing capabilities.
`StyledEditorKit` *(a class)*	A subclass of `Default EditorKit` that provides additional editing capabilities for styled text.
`String` *`xxxx`*`Action` *(in `DefaultEditorKit`)*	The names of all the actions supported by the default editor kit.

BeepAction CopyAction CutAction DefaultKeyTypedAction InsertBreakAction InsertContentAction InsertTabAction PasteAction *(in DefaultEditorKit)*	Inner classes that implement various text editing commands.
AlignmentAction BoldAction FontFamilyAction FontSizeAction ForegroundAction ItalicAction StyledTextAction UnderlineAction *(in StyledEditorKit)*	Inner classes that implement various editing commands for styled text.
Action[] getActions() *(in JTextComponent)*	Get the actions supported by this component. This method gets the array of actions from the editor kit if one is used by the component.

Binding KeyStrokes to Actions

Interface or Method	**Description**
Keymap *(an interface)*	An interface for managing a set of key bindings. A key binding is represented by a keystroke/action pair.
Keymap addKeymap(nm, Keymap) Keymap removeKeymap(nm) Keymap getKeymap(nm) *(in JTextComponent)*	Add or remove a keymap to the keymap hierarchy. Also get a keymap by name. Note that these are class methods. The keymap hierarchy is shared by all text components.
void loadKeymap(Keymap, KeyBinding[], Action[]) *(in JTextComponent)*	Adds a set of key bindings to the specified keymap. This is a class method.
void setKeymap(Keymap) Keymap getKeymap() *(in JTextComponent)*	Set or get the currently active keymap for a particular text component.

`void addActionForKeyStroke(KeyStroke, Action)`
`Action getAction(KeyStroke)`
`KeyStroke[] getKeyStrokesForAction(Action)`
(in `Keymap`)
	Set or get keystroke/action binding from a keymap.

`boolean isLocallyDefined(KeyStroke)` *(in `Keymap`)*	Get whether the specified keystroke is bound to an action in a keymap.

`void removeKeyStrokeBinding(KeyStroke)`
`void removeBindings()`
(in `Keymap`)
	Remove one or all key bindings from a keymap.

`void setDefaultAction(Action)`
`Action getDefaultAction()`
(in `Keymap`)
	Set or get the default action. This action is fired if a keystroke is not explicitly bound to an action.

`Action[] getBoundActions()`
`KeyStroke[] getBoundKeyStrokes()`
(in `Keymap`)
	Get an array containing all of the bound actions or keystrokes in a keymap.

Reading and Writing Text

Method	**Description**

`void JTextComponent.read(Reader, Object)`
`void JTextComponent.write(Writer)`
(in `JTextComponent`)
	Read or write text.

`void read(Reader, Document, int)`
`void read(InputStream, Document, int)`
(in `EditorKit`)
	Read text from a stream into a document.

`void write(Writer, Document, int, int)`
`void write(OutputStream, Document, int, int)`
(in `EditorKit`)
	Write text from a document to a stream.

Displaying Text from a URL

Method or Constructor	**Description**

`JEditorPane(URL)`
`JEditorPane(String)`
(in `JEditorPane`)
	Create an editor pane loaded with the text at the specified URL.

`setPage(URL)`
`setPage(String)`
(in `JEditorPane`)
	Load an editor pane (or text pane) with the text at the specified URL.

`URL getPage()` *(in `JEditorPane`)*	Get the URL for the editor pane's (or text pane's) current page.

Examples that Use Text Components

This table shows some of the examples that use text components and where those examples are described. To get started with text, you might want to run these programs and examine their code to find one that does something similar to what you want to do. For text and password field examples, don't forget to look at Examples that Use Text Fields and Password Fields.

Example	Where Described	Notes
`TextSamplerDemo`	An Example of Using Each Text Component	Uses one of each of Swing's text components.
`TextComponentDemo`	General Rules for Using Text Components	Provides a customized text pane. Illustrates many text component features.
`ToolBarDemo2`	How to Use Tool Bars	Puts a text field in a tool bar.
`CustomDialog.java` ◆	How to Use Dialogs	Puts a validated text field in a dialog. Part of `DialogDemo` (under the More Dialogs tab).
`TreeDemo`	How to Use Trees	Uses an editor pane to display help loaded from an HTML file.

```
import javax.swing.JOptionPane;
import javax.swing.JDialog;
import javax.swing.JTextField;
import java.beans.*; //Property change stuff
import java.awt.*;
import java.awt.event.*;

class CustomDialog extends JDialog {
    private String typedText = null;

    private String magicWord;
    private JOptionPane optionPane;

    public String getValidatedText() {
        return typedText;
    }

    public CustomDialog(Frame aFrame, String aWord, DialogDemo parent) {
        super(aFrame, true);
        final DialogDemo dd = parent;

        magicWord = aWord.toUpperCase();
        setTitle("Quiz");

        final String msgString1 = "What was Dr. SEUSS's real last name?";
        final String msgString2 = "(The answer is \"" + magicWord
                                  + "\".)";
        final JTextField textField = new JTextField(10);
        Object[] array = {msgString1, msgString2, textField};

        final String btnString1 = "Enter";
        final String btnString2 = "Cancel";
        Object[] options = {btnString1, btnString2};

        optionPane = new JOptionPane(array,
                                    JOptionPane.QUESTION_MESSAGE,
                                    JOptionPane.YES_NO_OPTION,
                                    null,
                                    options,
                                    options[0]);
        setContentPane(optionPane);
        setDefaultCloseOperation(DO_NOTHING_ON_CLOSE);
        addWindowListener(new WindowAdapter() {
                public void windowClosing(WindowEvent we) {
                /*
                 * Instead of directly closing the window,
                 * we're going to change the JOptionPane's
                 * value property.
                 */
                    optionPane.setValue(new Integer(
                                        JOptionPane.CLOSED_OPTION));
            }
        });

        textField.addActionListener(new ActionListener() {
            public void actionPerformed(ActionEvent e) {
                optionPane.setValue(btnString1);
            }
        });

        optionPane.addPropertyChangeListener(new PropertyChangeListener() {
            public void propertyChange(PropertyChangeEvent e) {
                String prop = e.getPropertyName();

                if (isVisible()
                 && (e.getSource() == optionPane)
                 && (prop.equals(JOptionPane.VALUE_PROPERTY) ||
                     prop.equals(JOptionPane.INPUT_VALUE_PROPERTY))) {
                    Object value = optionPane.getValue();

                    if (value == JOptionPane.UNINITIALIZED_VALUE) {
                        //ignore reset
                        return;
                    }

                    // Reset the JOptionPane's value.
                    // If you don't do this, then if the user
                    // presses the same button next time, no
                    // property change event will be fired.
                    optionPane.setValue(
                            JOptionPane.UNINITIALIZED_VALUE);

                    if (value.equals(btnString1)) {
                            typedText = textField.getText();
                        String ucText = typedText.toUpperCase();
                        if (ucText.equals(magicWord)) {
                            // we're done; dismiss the dialog
                            setVisible(false);
                        } else {
                            // text was invalid
                            textField.selectAll();
                            JOptionPane.showMessageDialog(
                                            CustomDialog.this,
                                            "Sorry, \"" + typedText + "\" "
                                            + "isn't a valid response.\n"
                                            + "Please enter "
                                            + magicWord + ".",
                                            "Try again",
                                            JOptionPane.ERROR_MESSAGE);
                            typedText = null;
                        }
                    } else { // user closed dialog or clicked cancel
                        dd.setLabel("It's OK.  "
                                 + "We won't force you to type "
                                 + magicWord + ".");
                        typedText = null;
                        setVisible(false);
                    }
                }
            }
        });
    }
}
```

```
<APPLET CODE="FocusEventDemo.class"
        ARCHIVE="example-swing/focus.jar"
        WIDTH="400" HEIGHT="200"
        ALT="Your browser understands the applet tag but isn't displaying any applet.">

Since you can't run the applet,
here's a picture of it:

#usemacro UI_FIGURE (
    NAME FocusEventDemo.gif
    W 400
    H 200
    ALT A snapshot of FocusEventDemo, which demonstrates the events that are fired when the
keyboard focus changes.

)

</APPLET>
```

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

public class InternalFrameEventDemo
                     extends JFrame
                     implements InternalFrameListener,
                                ActionListener {
    JTextArea display;
    JDesktopPane desktop;
    JInternalFrame displayWindow;
    JInternalFrame listenedToWindow;
    static final String SHOW = "show";
    static final String CLEAR = "clear";
    String newline = "\n";
    static final int desktopWidth = 500;
    static final int desktopHeight = 300;

    public InternalFrameEventDemo(String title) {
        super(title);

        //Set up the GUI.
        desktop = new JDesktopPane();
        desktop.putClientProperty("JDesktopPane.dragMode",
                                  "outline");
        //Because we use pack, it's not enough to call setSize.
        //We must set the desktop's preferred size.
        desktop.setPreferredSize(new Dimension(desktopWidth, desktopHeight));
        setContentPane(desktop);

        createDisplayWindow();
        desktop.add(displayWindow); //DON'T FORGET THIS!!!
        Dimension displaySize = displayWindow.getSize();
        displayWindow.setSize(desktopWidth, displaySize.height);
    }

    //Create the window that displays event information.
    protected void createDisplayWindow() {
        JButton b1 = new JButton("Show internal frame");
        b1.setActionCommand(SHOW);
        b1.addActionListener(this);

        JButton b2 = new JButton("Clear event info");
        b2.setActionCommand(CLEAR);
        b2.addActionListener(this);

        display = new JTextArea(3, 30);
        display.setEditable(false);
        JScrollPane textScroller = new JScrollPane(display);
        //Have to supply a preferred size, or else the scroll
        //area will try to stay as large as the text area.
        textScroller.setPreferredSize(new Dimension(200, 75));
        textScroller.setMinimumSize(new Dimension(10, 10));

        displayWindow = new JInternalFrame("Event Watcher",
                                           true,  //resizable
                                           false, //not closable
                                           false, //not maximizable
                                           true); //iconifiable
        JPanel contentPane = new JPanel();
        contentPane.setBorder(BorderFactory.createEmptyBorder(10,10,10,10));
        contentPane.setLayout(new BoxLayout(contentPane,
                                            BoxLayout.Y_AXIS));
        b1.setAlignmentX(CENTER_ALIGNMENT);
        contentPane.add(b1);
        contentPane.add(Box.createRigidArea(new Dimension(0, 5)));
        contentPane.add(textScroller);
        contentPane.add(Box.createRigidArea(new Dimension(0, 5)));
        b2.setAlignmentX(CENTER_ALIGNMENT);
        contentPane.add(b2);

        displayWindow.setContentPane(contentPane);
        displayWindow.pack();
        displayWindow.show();  //necessary as of 1.3
    }

    //Create the listened-to window.
    protected void createListenedToWindow() {
        listenedToWindow = new JInternalFrame("Event Generator",
                                              true,  //resizable
                                              true,  //closable
                                              true,  //maximizable
                                              true); //iconifiable
        //The next statement is necessary to work around bug 4138031.
        listenedToWindow.setDefaultCloseOperation(
                                WindowConstants.DISPOSE_ON_CLOSE);
        listenedToWindow.setSize(300, 100);
    }

    public void internalFrameClosing(InternalFrameEvent e) {
        displayMessage("Internal frame closing", e);
    }

    public void internalFrameClosed(InternalFrameEvent e) {
        displayMessage("Internal frame closed", e);
        listenedToWindow = null;
    }

    public void internalFrameOpened(InternalFrameEvent e) {
        //XXX: We don't seem to get any of these.
        displayMessage("Internal frame opened", e);
    }

    public void internalFrameIconified(InternalFrameEvent e) {
        displayMessage("Internal frame iconified", e);
    }

    public void internalFrameDeiconified(InternalFrameEvent e) {
        displayMessage("Internal frame deiconified", e);
    }

    public void internalFrameActivated(InternalFrameEvent e) {
        displayMessage("Internal frame activated", e);
    }

    public void internalFrameDeactivated(InternalFrameEvent e) {
        displayMessage("Internal frame deactivated", e);
    }

    void displayMessage(String prefix, InternalFrameEvent e) {
        String s = prefix + ": " + e.getSource();
        display.append(s + newline);
    }
    public void actionPerformed(ActionEvent e) {
        if (e.getActionCommand().equals(SHOW)) {
            //XXX: Can't reuse internal frame (bug 4138031).
            //listenedToWindow.setVisible(true);

            //XXX: Instead, create a new internal frame.
            if (listenedToWindow == null) {
                createListenedToWindow();
                listenedToWindow.addInternalFrameListener(this);
                desktop.add(listenedToWindow);
                listenedToWindow.setLocation(
                    desktopWidth/2 - listenedToWindow.getWidth()/2,
                    desktopHeight - listenedToWindow.getHeight());
                listenedToWindow.show();  //necessary as of 1.3
            }
        } else {
            display.setText("");
        }
    }

    public static void main(String[] args) {
        JFrame frame = new InternalFrameEventDemo(
                "InternalFrameEventDemo");

        //Quit this app when the big window closes.
        frame.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });

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

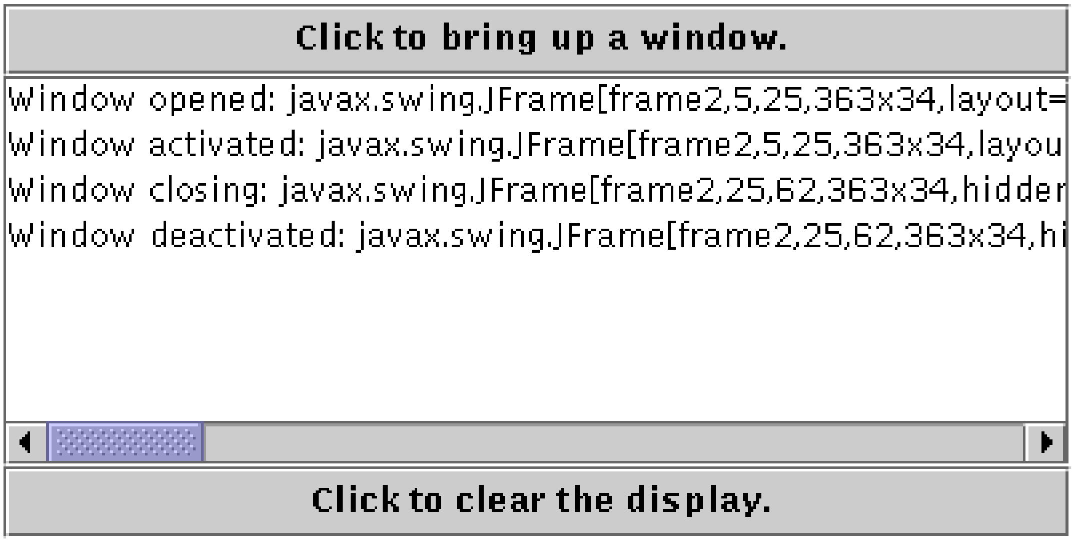
```java
/*
 * Swing version.
 */

import javax.swing.*;

import java.awt.Dimension;
import java.awt.BorderLayout;

import java.awt.event.ActionListener;
import java.awt.event.ActionEvent;
import java.awt.event.WindowEvent;
import java.awt.event.WindowListener;

public class WindowEventDemo extends JApplet
                             implements WindowListener,
                                        ActionListener {
    JTextArea display;
    JFrame window;
    JButton b1, b2;
    static final String SHOW = "show";
    static final String CLEAR = "clear";
    final static String newline = "\n";

    public void init() {
        b1 = new JButton("Click to bring up a window.");
        b1.setActionCommand(SHOW);
        b1.addActionListener(this);

        b2 = new JButton("Click to clear the display.");
        b2.setActionCommand(CLEAR);
        b2.addActionListener(this);

        display = new JTextArea();
        display.setEditable(false);
        JScrollPane scrollPane = new JScrollPane(display);
        scrollPane.setPreferredSize(new Dimension(200, 75));

        JPanel contentPane = new JPanel();
        contentPane.setLayout(new BorderLayout());
        contentPane.add(b1, BorderLayout.NORTH);
        contentPane.add(scrollPane, BorderLayout.CENTER);
        contentPane.add(b2, BorderLayout.SOUTH);
        setContentPane(contentPane);

        //Create but don't show window.
        window = new JFrame("Window Event Window");
        window.addWindowListener(this);
        JLabel l = new JLabel("The applet listens to this window"
                            + " for window events.");
        window.getContentPane().add(l, BorderLayout.CENTER);
        window.pack();
    }

    public void stop() {
        window.setVisible(false);
    }

    public void windowClosing(WindowEvent e) {
        window.setVisible(false);
        displayMessage("Window closing", e);
    }
    public void windowClosed(WindowEvent e) {
        displayMessage("Window closed", e);
    }

    public void windowOpened(WindowEvent e) {
        displayMessage("Window opened", e);
    }

    public void windowIconified(WindowEvent e) {
        displayMessage("Window iconified", e);
    }

    public void windowDeiconified(WindowEvent e) {
        displayMessage("Window deiconified", e);
    }

    public void windowActivated(WindowEvent e) {
        displayMessage("Window activated", e);
    }

    public void windowDeactivated(WindowEvent e) {
        displayMessage("Window deactivated", e);
    }

    void displayMessage(String prefix, WindowEvent e) {
        display.append(prefix
                       + ": "
                       + e.getWindow()
                       + newline);
    }

    public void actionPerformed(ActionEvent e) {
        if (e.getActionCommand() == SHOW) {
            window.pack();
            window.setVisible(true);
        } else {
            display.setText("");
        }
    }
}
```

The Java^{TM} Tutorial

Trail: Creating a GUI with JFC/Swing
Lesson: Writing Event Listeners

Run WindowEventDemo

Since you can't run the applet, here's a picture of it:



```
Window opened: javax.swing.JFrame[frame2,5,25,363x34,layout=
Window activated: javax.swing.JFrame[frame2,5,25,363x34,layou
Window closing: javax.swing.JFrame[frame2,25,62,363x34,hidden
Window deactivated: javax.swing.JFrame[frame2,25,62,363x34,hi
```

Note: Because the preceding applet uses the Swing 1.1 API, it requires Java Plug-in 1.1.2 or Java Plug-in 1.2. It won't work with Java Plug-in 1.1.1 or uncustomized 1.1 browsers. For more information about running applets in the tutorial, refer to About Our Examples. That page includes a section about Downloading Java Plug-in.

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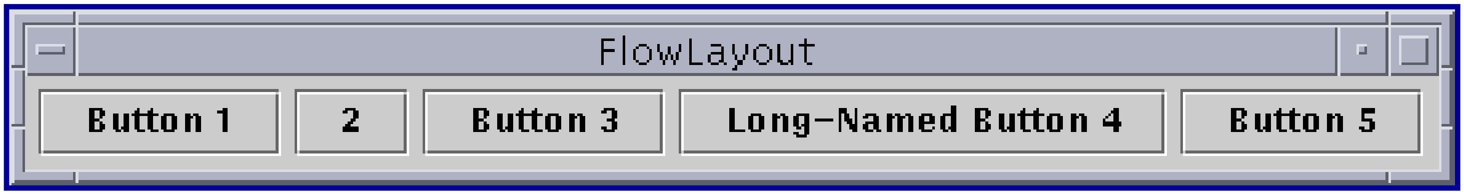
Trail: Creating a GUI with JFC/Swing
Lesson: Laying Out Components Within a Container

How to Use FlowLayout

The `FlowLayout` class provides a very simple layout manager that is used, by default, by `JPanel`s. Here's an applet that shows a flow layout in action:



This is a picture of the applet's GUI. To run the applet, click the picture. The applet will appear in a new browser window.

`FlowLayout` puts components in a row, sized at their preferred size. If the horizontal space in the container is too small to put all the components in one row, `FlowLayout` uses multiple rows. Within each row, components are centered (the default), left-aligned, or right-aligned as specified when the `FlowLayout` is created.

Below is the code that creates the `FlowLayout` and the components it manages. You can find the whole program in `FlowWindow.java`. The program runs either within an applet (with the help of `AppletButton`) or as an application.

```
Container contentPane = getContentPane();
contentPane.setLayout(new FlowLayout());

contentPane.add(new JButton("Button 1"));
contentPane.add(new JButton("2"));
contentPane.add(new JButton("Button 3"));
contentPane.add(new JButton("Long-Named Button 4"));
contentPane.add(new JButton("Button 5"));
```

The FlowLayout API

The `FlowLayout` class has three constructors:

```
public FlowLayout()
public FlowLayout(int alignment)
public FlowLayout(int alignment,
                  int horizontalGap, int verticalGap)
```

The *`alignment`* argument must have the value `FlowLayout.LEFT`, `FlowLayout.CENTER`, or `FlowLayout.RIGHT`. The *`horizontalGap`* and *`verticalGap`* arguments specify the number of pixels to put between components. If you don't specify a gap value, `FlowLayout` uses `5` for the default gap value.

Examples that Use FlowLayout

The following table lists some of the examples that use flow layout.

Example	Where Described	Notes
`FlowWindow`	This page	Sets up a content pane to use `FlowLayout`.
`ButtonDemo`	How to Use Buttons, Check Boxes, and Radio Buttons◆	Uses the default `FlowLayout` of a `JPanel`.

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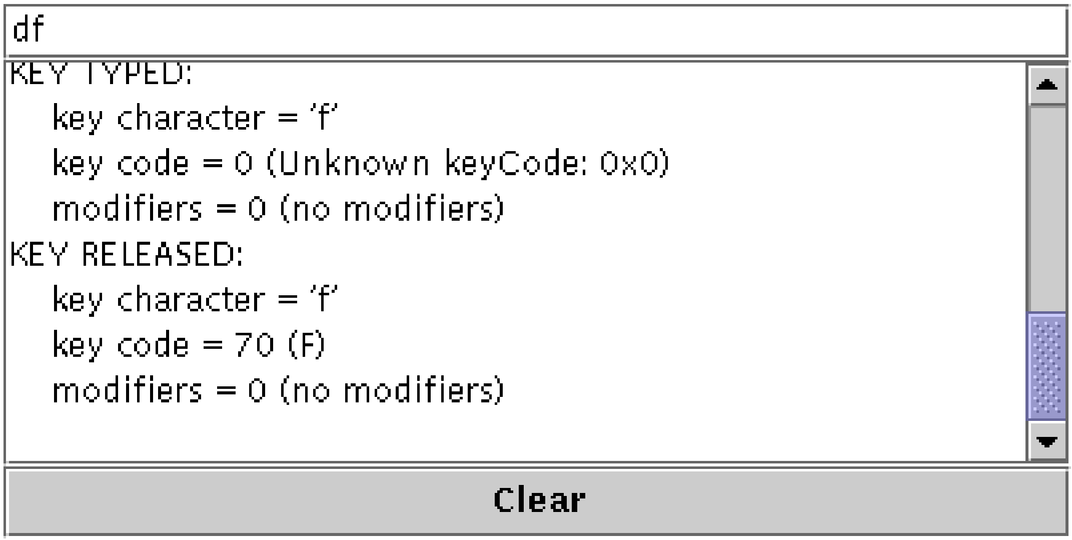
```
/*
 * Swing version
 */

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

public class KeyEventDemo extends JApplet
                          implements KeyListener,
                                     ActionListener {
    JTextArea displayArea;
    JTextField typingArea;
    static final String newline = "\n";

    public void init() {
        JButton button = new JButton("Clear");
        button.addActionListener(this);

        typingArea = new JTextField(20);
        typingArea.addKeyListener(this);

        displayArea = new JTextArea();
        displayArea.setEditable(false);
        JScrollPane scrollPane = new JScrollPane(displayArea);
        scrollPane.setPreferredSize(new Dimension(375, 125));

        JPanel contentPane = new JPanel();
        contentPane.setLayout(new BorderLayout());
        contentPane.add(typingArea, BorderLayout.NORTH);
        contentPane.add(scrollPane, BorderLayout.CENTER);
        contentPane.add(button, BorderLayout.SOUTH);
        setContentPane(contentPane);
    }

    /** Handle the key typed event from the text field. */
    public void keyTyped(KeyEvent e) {
        displayInfo(e, "KEY TYPED: ");
    }

    /** Handle the key pressed event from the text field. */
    public void keyPressed(KeyEvent e) {
        displayInfo(e, "KEY PRESSED: ");
    }

    /** Handle the key released event from the text field. */
    public void keyReleased(KeyEvent e) {
        displayInfo(e, "KEY RELEASED: ");
    }

    /** Handle the button click. */
    public void actionPerformed(ActionEvent e) {
        //Clear the text components.
        displayArea.setText("");
        typingArea.setText("");

        //Return the focus to the typing area.
        typingArea.requestFocus();
    }

    /*
     * We have to jump through some hoops to avoid
     * trying to print non-printing characters
     * such as Shift.  (Not only do they not print,
     * but if you put them in a String, the characters
     * afterward won't show up in the text area.)
     */
    protected void displayInfo(KeyEvent e, String s){
        String charString, keyCodeString, modString, tmpString;

        char c = e.getKeyChar();
        int keyCode = e.getKeyCode();
        int modifiers = e.getModifiers();

        if (Character.isISOControl(c)) {
            charString = "key character = "
                       + "(an unprintable control character)";
        } else {
            charString = "key character = '"
                       + c + "'";
        }

        keyCodeString = "key code = " + keyCode
                        + " ("
                        + KeyEvent.getKeyText(keyCode)
                        + ")";

        modString = "modifiers = " + modifiers;
        tmpString = KeyEvent.getKeyModifiersText(modifiers);
        if (tmpString.length() > 0) {
            modString += " (" + tmpString + ")";
        } else {
            modString += " (no modifiers)";
        }

        displayArea.append(s + newline
                           + "    " + charString + newline
                           + "    " + keyCodeString + newline
                           + "    " + modString + newline);
    }
}
```

The Java^{TM} Tutorial

Trail: Creating a GUI with JFC/Swing
Lesson: Writing Event Listeners

Run KeyEventDemo

Since you can't run the applet, here's a picture of it:



```
df
```

```
KEY TYPED:
   key character = 'f'
   key code = 0 (Unknown keyCode: 0x0)
   modifiers = 0 (no modifiers)
KEY RELEASED:
   key character = 'f'
   key code = 70 (F)
   modifiers = 0 (no modifiers)
```

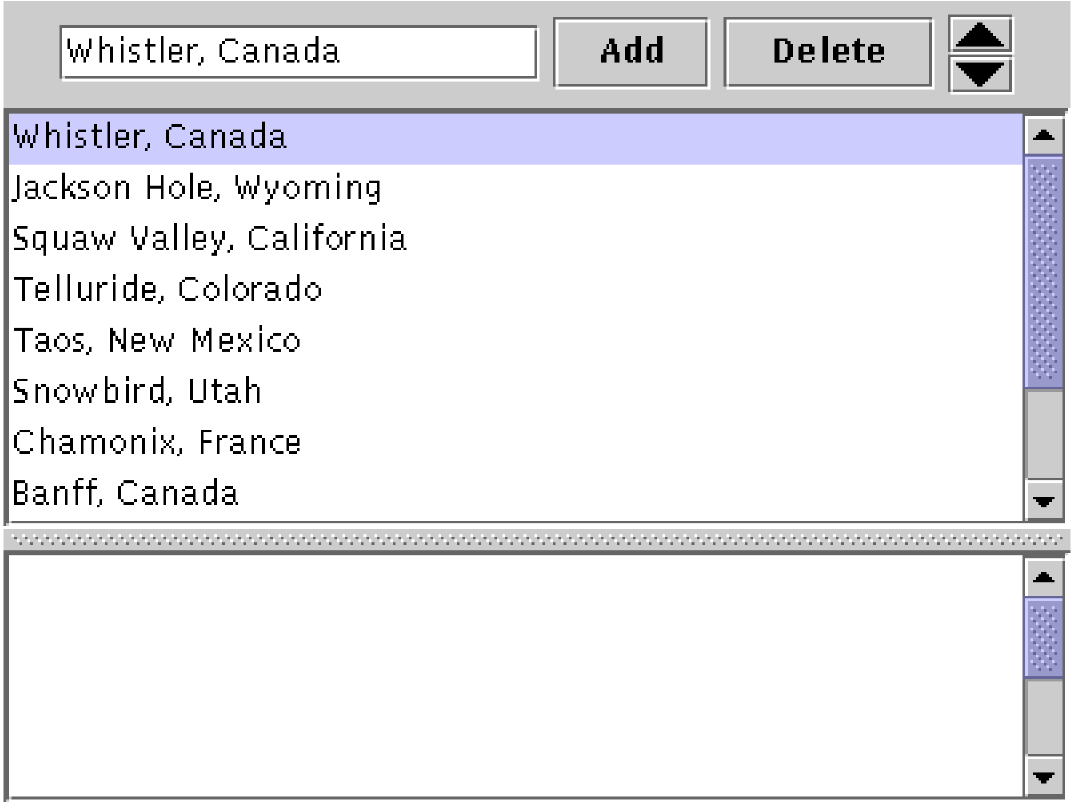
Note: Because the preceding applet uses the Swing 1.1 API, it requires Java Plug-in 1.1.2 or Java Plug-in 1.2. It won't work with Java Plug-in 1.1.1 or uncustomized 1.1 browsers. For more information about running applets in the tutorial, refer to About Our Examples. That page includes a section about Downloading Java Plug-in.

```
<APPLET CODE="KeyEventDemo.class"
        ARCHIVE="example-swing/key.jar"
        WIDTH="400" HEIGHT="200"
        ALT="Your browser understands the applet tag but isn't displaying any applet.">

Since you can't run the applet,
here's a picture of it:

#usemacro UI_FIGURE (
    NAME KeyEventDemo.gif
    W 400
    H 200
    ALT A snapshot of KeyEventDemo, which demonstrates the events that are fired when the user
types at the keyboard.

)

</APPLET>
```

Trail: Creating a GUI with JFC/Swing
Lesson: Writing Event Listeners

Run ListDataEventDemo

Since you can't run the applet, here's a picture of it:



Whistler, Canada
Jackson Hole, Wyoming
Squaw Valley, California
Telluride, Colorado
Taos, New Mexico
Snowbird, Utah
Chamonix, France
Banff, Canada

Note: Because the preceding applet uses the Swing 1.1 API, it requires Java Plug-in 1.1.2 or Java Plug-in 1.2. It won't work with Java Plug-in 1.1.1 or uncustomized 1.1 browsers. For more information about running applets in the tutorial, refer to About Our Examples. That page includes a section about Downloading Java Plug-in.

```
import java.awt.*;
import java.awt.event.*;
import javax.swing.*;
import javax.swing.event.*;
import java.net.URL;

public class ListDataEventDemo extends JApplet
                               implements ListSelectionListener {
    private JList list;
    private DefaultListModel listModel;

    private static final String addString = "Add";
    private static final String deleteString = "Delete";
    private static final String upString = "Move up";
    private static final String downString = "Move down";

    private JButton addButton;
    private JButton deleteButton;
    private JButton upButton;
    private JButton downButton;

    private JTextField nameField;
    private JTextArea log;
    static private String newline = "\n";

    public void init() {
        //Create and populate the list model.
        listModel = new DefaultListModel();
        listModel.addElement("Whistler, Canada");
        listModel.addElement("Jackson Hole, Wyoming");
        listModel.addElement("Squaw Valley, California");
        listModel.addElement("Telluride, Colorado");
        listModel.addElement("Taos, New Mexico");
        listModel.addElement("Snowbird, Utah");
        listModel.addElement("Chamonix, France");
        listModel.addElement("Banff, Canada");
        listModel.addElement("Arapahoe Basin, Colorado");
        listModel.addElement("Kirkwood, California");
        listModel.addElement("Sun Valley, Idaho");
        listModel.addListDataListener(new MyListDataListener());

        //Create the list and put it in a scroll pane.
        list = new JList(listModel);
        list.setSelectionMode(
            ListSelectionModel.SINGLE_INTERVAL_SELECTION);
        list.setSelectedIndex(0);
        list.addListSelectionListener(this);
        JScrollPane listScrollPane = new JScrollPane(list);

        //Create the list modifying buttons.
        addButton = new JButton(addString);
        addButton.setActionCommand(addString);
        addButton.addActionListener(new AddButtonListener());

        deleteButton = new JButton(deleteString);
        deleteButton.setActionCommand(deleteString);
        deleteButton.addActionListener(
            new DeleteButtonListener());

        upButton = new JButton(
            new ImageIcon(getURL("images/up.gif")));
        upButton.setMargin(new Insets(0,0,0,0));
        upButton.setActionCommand(upString);
        upButton.addActionListener(new UpDownListener());

        downButton = new JButton(
            new ImageIcon(getURL("images/down.gif")));
        downButton.setMargin(new Insets(0,0,0,0));
        downButton.setActionCommand(downString);
        downButton.addActionListener(new UpDownListener());

        JPanel upDownPanel = new JPanel(new GridLayout(2, 1));
        upDownPanel.add(upButton);
        upDownPanel.add(downButton);

        //Create the text field for entering new names.
        nameField = new JTextField(15);
        nameField.addActionListener(new AddButtonListener());
        String name = listModel.getElementAt(list.getSelectedIndex())
                               .toString();
        nameField.setText(name);

        //Create a control panel (uses the default FlowLayout).
        JPanel buttonPane = new JPanel();
        buttonPane.add(nameField);
        buttonPane.add(addButton);
        buttonPane.add(deleteButton);
        buttonPane.add(upDownPanel);

        //Create the log for reporting list data events.
        log = new JTextArea(10, 20);
        JScrollPane logScrollPane = new JScrollPane(log);

        //Create a split pane for the log and the list.
        JSplitPane splitPane = new JSplitPane(JSplitPane.VERTICAL_SPLIT,
                                        listScrollPane, logScrollPane);

        Container contentPane = getContentPane();
        contentPane.add(buttonPane, BorderLayout.NORTH);
        contentPane.add(splitPane, BorderLayout.CENTER);
    }

    class MyListDataListener implements ListDataListener {
        public void contentsChanged(ListDataEvent e) {
            log.append("contentsChanged: " + e.getIndex0() +
                       ", " + e.getIndex1() + newline);
        }
        public void intervalAdded(ListDataEvent e) {
            log.append("intervalAdded: " + e.getIndex0() +
                       ", " + e.getIndex1() + newline);
        }
        public void intervalRemoved(ListDataEvent e) {
            log.append("intervalRemoved: " + e.getIndex0() +
                       ", " + e.getIndex1() + newline);
        }
    }

    class DeleteButtonListener implements ActionListener {
        public void actionPerformed(ActionEvent e) {
            /*
             * This method can be called only if
             * there's a valid selection,
             * so go ahead and remove whatever's selected.
             */
            ListSelectionModel lsm = list.getSelectionModel();
            int firstSelected = lsm.getMinSelectionIndex();
            int lastSelected = lsm.getMaxSelectionIndex();
            listModel.removeRange(firstSelected, lastSelected);

            int size = listModel.size();

            if (size == 0) {
            //List is empty: disable delete, up, and down buttons.
                deleteButton.setEnabled(false);
                upButton.setEnabled(false);
                downButton.setEnabled(false);

            } else {
            //Adjust the selection.
                if (firstSelected == listModel.getSize()) {
                //Removed item in last position.
                    firstSelected--;
                }
                list.setSelectedIndex(firstSelected);
            }
        }
    }

    /** A listener shared by the text field and add button. */
    class AddButtonListener implements ActionListener {
        public void actionPerformed(ActionEvent e) {
            if (nameField.getText().equals("")) {
            //User didn't type in a name...
                Toolkit.getDefaultToolkit().beep();
                return;
            }

            int index = list.getSelectedIndex();
            int size = listModel.getSize();

            //If no selection or if item in last position is selected,
            //add the new one to end of list, and select new one.
            if (index == -1 || (index+1 == size)) {
                listModel.addElement(nameField.getText());
                list.setSelectedIndex(size);

            //Otherwise insert the new one after the current selection,
            //and select new one.
            } else {
                listModel.insertElementAt(nameField.getText(), index+1);
                list.setSelectedIndex(index+1);
            }
        }
    }

    //Listen for clicks on the up and down arrow buttons.
    class UpDownListener implements ActionListener {
        public void actionPerformed(ActionEvent e) {
            //This method can be called only when
            //there's a valid selection,
            //so go ahead and move the list item.
            int moveMe = list.getSelectedIndex();

            if (e.getActionCommand().equals(upString)) {
            //UP ARROW BUTTON
```

```
                if (moveMe != 0) {
                //not already at top
                    swap(moveMe, moveMe-1);
                    list.setSelectedIndex(moveMe-1);
                    list.ensureIndexIsVisible(moveMe-1);
                }
            } else {
            //DOWN ARROW BUTTON
                if (moveMe != listModel.getSize()-1) {
                //not already at bottom
                    swap(moveMe, moveMe+1);
                    list.setSelectedIndex(moveMe+1);
                    list.ensureIndexIsVisible(moveMe+1);
                }
            }
        }
    }

    //Swap two elements in the list.
    private void swap(int a, int b) {
        Object aObject = listModel.getElementAt(a);
        Object bObject = listModel.getElementAt(b);
        listModel.set(a, bObject);
        listModel.set(b, aObject);
    }

    //Listener method for list selection changes.
    public void valueChanged(ListSelectionEvent e) {
        if (e.getValueIsAdjusting() == false) {

            if (list.getSelectedIndex() == -1) {
            //No selection: disable delete, up, and down buttons.
                deleteButton.setEnabled(false);
                upButton.setEnabled(false);
                downButton.setEnabled(false);
                nameField.setText("");

            } else if (list.getSelectedIndices().length > 1) {
            //Multiple selection: disable up and down buttons.
                deleteButton.setEnabled(true);
                upButton.setEnabled(false);
                downButton.setEnabled(false);

            } else {
            //Single selection: permit all operations.
                deleteButton.setEnabled(true);
                upButton.setEnabled(true);
                downButton.setEnabled(true);
                nameField.setText(list.getSelectedValue().toString());
            }
        }
    }

    protected URL getURL(String filename) {
        URL codeBase = this.getCodeBase();
        URL url = null;

        try {
            url = new URL(codeBase, filename);
        } catch (java.net.MalformedURLException e) {
            System.out.println("Couldn't create image: badly specified URL");
            return null;
        }

        return url;
    }
}
```

```
<APPLET code="ListDataEventDemo.class"
        codebase="example-swing/"
        archive="listdata.jar"
        WIDTH="400" HEIGHT="300"
        ALT="Your browser understands the applet tag but isn't displaying any applet.">

Since you can't run the applet,
here's a picture of it:

#usemacro UI_FIGURE (
    NAME ListDataEventDemo.gif
    W 400
    H 300
    ALT A snapshot of ListDataEventDemo, which demonstrates evens that occur when the content of a list changes.

)

</APPLET>
```

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

import java.util.*;

//SplitPaneDemo itself is not a visible component.
public class SplitPaneDemo implements ListSelectionListener {
    private Vector imageNames;
    private JLabel picture;
    private JList list;
    private JSplitPane splitPane;

    public SplitPaneDemo() {
        //Read image names from a properties file
        ResourceBundle imageResource;
        try {
            imageResource = ResourceBundle.getBundle("imagenames");
            String imageNamesString = imageResource.getString("images");
            imageNames = parseList(imageNamesString);
        } catch (MissingResourceException e) {
            System.err.println();
            System.err.println("Can't find the properties file " +
                               "that contains the image names.");
            System.err.println("Its name should be imagenames.properties, " +
                               "and it should");
            System.err.println("contain a single line that specifies " +
                               "one or more image");
            System.err.println("files to be found in a directory " +
                               "named images.  Example:");
            System.err.println();
            System.err.println("    images=Bird.gif Cat.gif Dog.gif");
            System.err.println();
            System.exit(1);
        }

        //Create the list of images and put it in a scroll pane
        list = new JList(imageNames);
        list.setSelectionMode(ListSelectionModel.SINGLE_SELECTION);
        list.setSelectedIndex(0);
        list.addListSelectionListener(this);
        JScrollPane listScrollPane = new JScrollPane(list);

        //Set up the picture label and put it in a scroll pane
        ImageIcon firstImage = new ImageIcon("images/" +
                                     (String)imageNames.firstElement());
        picture = new JLabel(firstImage);
        picture.setPreferredSize(new Dimension(firstImage.getIconWidth(),
                                               firstImage.getIconHeight()));
        JScrollPane pictureScrollPane = new JScrollPane(picture);

        //Create a split pane with the two scroll panes in it
        splitPane = new JSplitPane(JSplitPane.HORIZONTAL_SPLIT,
                                   listScrollPane, pictureScrollPane);
        splitPane.setOneTouchExpandable(true);
        splitPane.setDividerLocation(150);

        //Provide minimum sizes for the two components in the split pane
        Dimension minimumSize = new Dimension(100, 50);
        listScrollPane.setMinimumSize(minimumSize);
        pictureScrollPane.setMinimumSize(minimumSize);
        //Provide a preferred size for the split pane
        splitPane.setPreferredSize(new Dimension(400, 200));
    }

    //Used by SplitPaneDemo2
    public JList getImageList() {
        return list;
    }

    public JSplitPane getSplitPane() {
        return splitPane;
    }

    public void valueChanged(ListSelectionEvent e) {
        if (e.getValueIsAdjusting())
            return;

        JList theList = (JList)e.getSource();
        if (theList.isSelectionEmpty()) {
            picture.setIcon(null);
        } else {
            int index = theList.getSelectedIndex();
            ImageIcon newImage = new ImageIcon("images/" +
                                     (String)imageNames.elementAt(index));
            picture.setIcon(newImage);
            picture.setPreferredSize(new Dimension(newImage.getIconWidth(),
                                               newImage.getIconHeight() ));
            picture.revalidate();
        }
    }

    protected static Vector parseList(String theStringList) {
        Vector v = new Vector(10);
        StringTokenizer tokenizer = new StringTokenizer(theStringList, " ");
        while (tokenizer.hasMoreTokens()) {
            String image = tokenizer.nextToken();
            v.addElement(image);
        }
        return v;
    }

    public static void main(String s[]) {
        JFrame frame = new JFrame("SplitPaneDemo");

        frame.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {System.exit(0);}
        });

        SplitPaneDemo splitPaneDemo = new SplitPaneDemo();
        frame.getContentPane().add(splitPaneDemo.getSplitPane());
        frame.pack();
        frame.setVisible(true);
    }
}
```

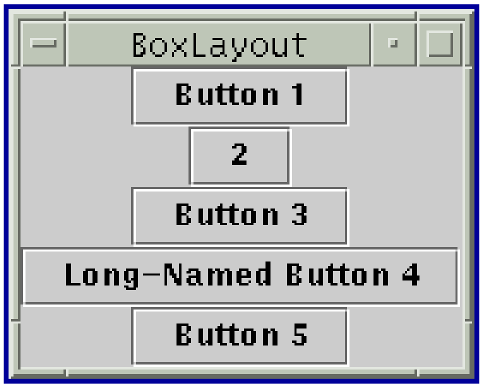
```
images=Bird.gif Cat.gif Dog.gif Rabbit.gif Pig.gif all.gif blue.gif doggy/T1.gif dukeWaveRed.gif
geek/geek-cght.gif green.gif kathyCosmo.gif lainesTongue.gif left.gif middle.gif red.gif right.gif
smallbabies.jpeg sophie.gif stickerface.gif tumble/T7.gif yellow.gif youngdad.jpeg
```

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

public class ListDemo extends JFrame
                      implements ListSelectionListener {
    private JList list;
    private DefaultListModel listModel;

    private static final String hireString = "Hire";
    private static final String fireString = "Fire";
    private JButton fireButton;
    private JTextField employeeName;

    public ListDemo() {
        super("ListDemo");

        listModel = new DefaultListModel();
        listModel.addElement("Alison Huml");
        listModel.addElement("Kathy Walrath");
        listModel.addElement("Lisa Friendly");
        listModel.addElement("Mary Campione");

        //Create the list and put it in a scroll pane
        list = new JList(listModel);
        list.setSelectionMode(ListSelectionModel.SINGLE_SELECTION);
        list.setSelectedIndex(0);
        list.addListSelectionListener(this);
        JScrollPane listScrollPane = new JScrollPane(list);

        JButton hireButton = new JButton(hireString);
        hireButton.setActionCommand(hireString);
        hireButton.addActionListener(new HireListener());

        fireButton = new JButton(fireString);
        fireButton.setActionCommand(fireString);
        fireButton.addActionListener(new FireListener());

        employeeName = new JTextField(10);
        employeeName.addActionListener(new HireListener());
        String name = listModel.getElementAt(
                              list.getSelectedIndex()).toString();
        employeeName.setText(name);

        //Create a panel that uses FlowLayout (the default).
        JPanel buttonPane = new JPanel();
        buttonPane.add(employeeName);
        buttonPane.add(hireButton);
        buttonPane.add(fireButton);

        Container contentPane = getContentPane();
        contentPane.add(listScrollPane, BorderLayout.CENTER);
        contentPane.add(buttonPane, BorderLayout.SOUTH);
    }

    class FireListener implements ActionListener {
        public void actionPerformed(ActionEvent e) {
            //This method can be called only if
            //there's a valid selection
            //so go ahead and remove whatever's selected.
            int index = list.getSelectedIndex();
            listModel.remove(index);

            int size = listModel.getSize();

            if (size == 0) {
            //Nobody's left, disable firing.
                fireButton.setEnabled(false);

            } else {
            //Adjust the selection.
                if (index == listModel.getSize())//removed item in last position
                    index--;
                list.setSelectedIndex(index);   //otherwise select same index
            }
        }
    }

    //This listener is shared by the text field and the hire button
    class HireListener implements ActionListener {
        public void actionPerformed(ActionEvent e) {

            //User didn't type in a name...
            if (employeeName.getText().equals("")) {
                Toolkit.getDefaultToolkit().beep();
                return;
            }

            int index = list.getSelectedIndex();
            int size = listModel.getSize();

            //If no selection or if item in last position is selected,
            //add the new hire to end of list, and select new hire.
            if (index == -1 || (index+1 == size)) {
                listModel.addElement(employeeName.getText());
                list.setSelectedIndex(size);

            //Otherwise insert the new hire after the current selection,
            //and select new hire.
            } else {
                listModel.insertElementAt(employeeName.getText(), index+1);
                list.setSelectedIndex(index+1);
            }
        }
    }

    public void valueChanged(ListSelectionEvent e) {
        if (e.getValueIsAdjusting() == false) {

            if (list.getSelectedIndex() == -1) {
            //No selection, disable fire button.
                fireButton.setEnabled(false);
                employeeName.setText("");

            } else {
            //Selection, update text field.
                fireButton.setEnabled(true);
                String name = list.getSelectedValue().toString();
                employeeName.setText(name);
            }
        }
    }

    public static void main(String s[]) {
        JFrame frame = new ListDemo();

        frame.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });

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

Trail: Creating a GUI with JFC/Swing
Lesson: Laying Out Components Within a Container

How to Use BoxLayout

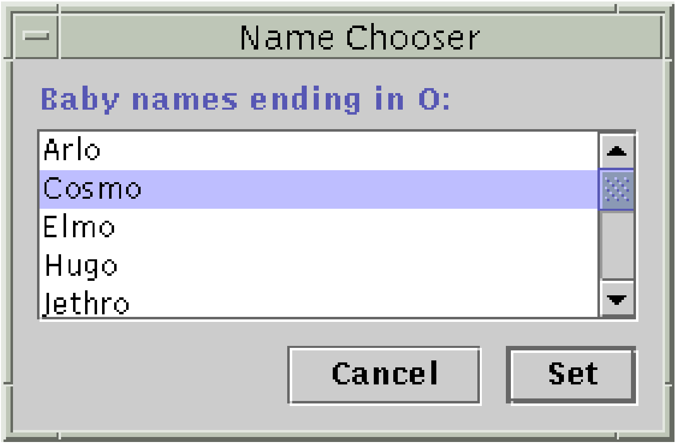
The Swing packages include a general purpose layout manager named BoxLayout. BoxLayout either stacks its components on top of each other (with the first component at the top) or places them in a tight row from left to right -- your choice. You might think of it as a full-featured version of FlowLayout. Here is an applet that demonstrates using BoxLayout to display a centered column of components:



This is a picture of the applet's GUI. To run the applet, click the picture. The applet will appear in a new browser window.

By creating one or more lightweight containers that use BoxLayout, you can achieve some layouts for which the more complex GridBagLayout is often used. BoxLayout is also useful in some situations where you might consider using GridLayout or BorderLayout. One big difference between BoxLayout and the existing AWT layout managers is that BoxLayout respects each component's maximum size and X/Y alignment. We'll discuss that later.

The following figure shows a GUI that uses two instances of BoxLayout. In the top part of the GUI, a top-to-bottom box layout places a label above a scroll pane. In the bottom part of the GUI, a left-to-right box layout places two buttons next to each other. A BorderLayout combines the two parts of the GUI and ensures that any excess space is given to the scroll pane.



The following code, taken from ListDialog.java, lays out the GUI. This code is in the constructor for the dialog, which is implemented as a `JDialog` subclass. The bold lines of code set up the box layouts and add components to them.

```
JScrollPane listScroller = new JScrollPane(list);
listScroller.setPreferredSize(new Dimension(250, 80));
listScroller.setMinimumSize(new Dimension(250, 80));
listScroller.setAlignmentX(LEFT_ALIGNMENT);
...
//Lay out the label and scroll pane from top to bottom.
JPanel listPane = new JPanel();
listPane.setLayout(new BoxLayout(listPane, BoxLayout.Y_AXIS));
JLabel label = new JLabel(labelText);
listPane.add(label);
listPane.add(Box.createRigidArea(new Dimension(0,5)));
listPane.add(listScroller);
listPane.setBorder(BorderFactory.createEmptyBorder(10,10,10,10));

//Lay out the buttons from left to right.
JPanel buttonPane = new JPanel();
buttonPane.setLayout(new BoxLayout(buttonPane, BoxLayout.X_AXIS));
buttonPane.setBorder(BorderFactory.createEmptyBorder(0, 10, 10, 10));
buttonPane.add(Box.createHorizontalGlue());
buttonPane.add(cancelButton);
buttonPane.add(Box.createRigidArea(new Dimension(10, 0)));
buttonPane.add(setButton);

//Put everything together, using the content pane's BorderLayout.
Container contentPane = getContentPane();
contentPane.add(listPane, BorderLayout.CENTER);
contentPane.add(buttonPane, BorderLayout.SOUTH);
```

The first bold line creates a top-to-bottom box layout and sets it up as the layout manager for `listPane`. The two arguments to the `BoxLayout` constructor are the container that it manages and the axis along with the components will be laid out. The next three bold lines add the label and scroll pane to the container, separating them with a *rigid area* -- an invisible lightweight component used to add space between components. In this case, the rigid area has no width and puts exactly 5 pixels between the label and scroll pane. Rigid areas are discussed later, in Using Invisible Components as Filler.

The next chunk of bold code creates a left-to-right box layout and sets it up for the `buttonPane` container. Then the code adds two buttons to the container, using a rigid area to put 10 pixels between the buttons. To make the buttons be placed at the right side of their container, the first component added to the container is *glue*. This glue is an invisible lightweight component that grows as necessary to absorb any extra space in its container. Glue is discussed in Using Invisible Components as Filler.

As an alternative to using invisible components, you can sometimes use empty borders to create space around components. For example, the preceding code snippet uses empty borders to put 10 pixels between all sides of the dialog and its contents, and between the two parts of the contents. Borders are completely independent of layout managers. They're simply how Swing components draw their edges. See How to Use Borders◆ for more information.

The following sections discuss `BoxLayout` in more detail:

- Box layout features
- Using invisible components as filler
- Fixing alignment problems
- Specifying component sizes
- The box layout API
- Examples that use box layouts

Don't let the length of the `BoxLayout` discussion scare you! You can probably use `BoxLayout` with the information you already have. If you run into trouble or you want to take advantage of `BoxLayout`'s power, read on.

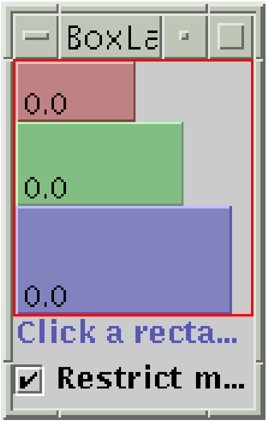
Box Layout Features

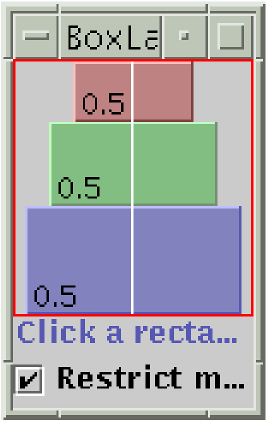
As we said before, a `BoxLayout` arranges components either from top to bottom or from left to right. As it arranges components, the box layout takes the components' alignments and minimum, preferred, and maximum sizes into account. In this section, we'll talk about top-to-bottom (Y axis) layout. The same concepts apply to left-to-right layout. You simply substitute X for Y, height for width, and so on.

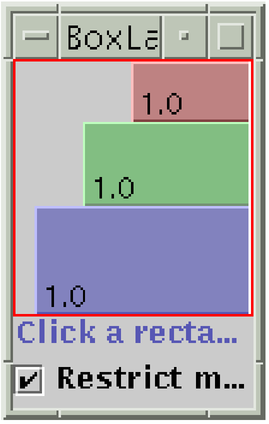
When a `BoxLayout` lays out components from top to bottom, it tries to size each component at the component's preferred height. If the amount of vertical space is not ideal, the box layout tries to adjust each components' height so that the components fill the available amount of space. However, the components might not fit exactly, since `BoxLayout` respects each component's requested minimum and maximum heights. Any extra space appears at the bottom of the container.

A top-to-bottom box layout tries to make all of its container's components equally wide -- as wide as the largest preferred width. If the container is forced to be wider than that, then the box layout tries to make all the components as wide as the container. If the components aren't all the same width (due to restricted maximum size or to any of them having strict left or right alignment), then X alignment comes into play.

The X alignments affect not only the components' positions relative to each other, but also the location of the components (as a group) within their container. The following figures illustrate alignment of components that have restricted maximum widths.





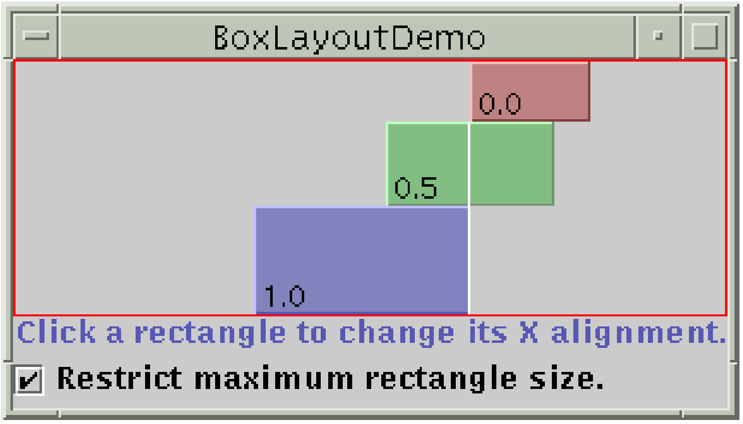


In the first figure, all three components have an X alignment of 0.0 (`Component.LEFT_ALIGNMENT`). This means that the components' left sides should be aligned. Furthermore, it means that all three components are positioned as far left in their container as possible.

In the second figure, all three components have an X alignment of 0.5 (`Component.CENTER_ALIGNMENT`). This means that the components' centers should be aligned, and that the components should be positioned in the horizontal center of their container.

In the third figure, the components have an X alignment of 1.0 (`Component.RIGHT_ALIGNMENT`). You can guess what that means for the components' alignment and position relative to their container.

You might be wondering what happens when the components have both restricted maximum sizes and different X alignments. The next figure shows an example of this:

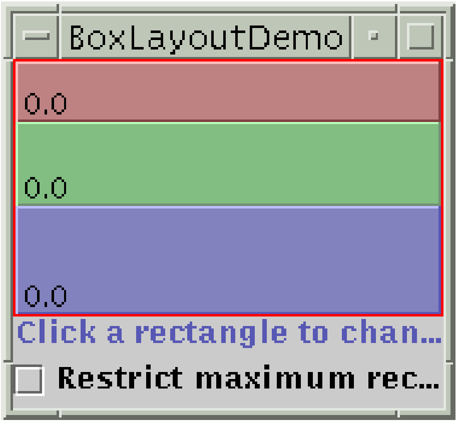


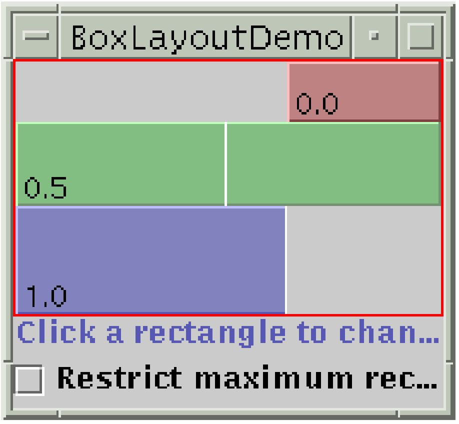
Click a rectangle to change its X alignment.

☑ Restrict maximum rectangle size.

As you can see, the left side of the component with an X alignment of 0.0 (`Component.LEFT_ALIGNMENT`) is aligned with the center of the component that has the 0.5 X alignment (`Component.CENTER_ALIGNMENT`), which is aligned with the right side of the component that has an X alignment of 1.0 (`Component.RIGHT_ALIGNMENT`). Mixed alignments like this are further discussed in Fixing Alignment Problems.

What if none of the components has a maximum width? Well, if all the components have identical X alignment, then all components are made as wide as their container. If the X alignments are different, then any component with an X alignment of 0.0 (left) or 1.0 (right) will be smaller. All components with an intermediate X alignment (such as center) will be as wide as their container. Here are two examples:





To get to know BoxLayout better, you can run your own experiments with BoxLayoutDemo.

Try this:

1. Compile and run BoxLayoutDemo. The source files are `BoxLayoutDemo.java` and `BLDComponent.java`.
   See Getting Started with Swing if you need help compiling or running this application. You'll see a window like the one above that contains three rectangles. Each rectangle is an instance of `BLDComponent`, which is a `JComponent` subclass.
2. Click inside one of the rectangles.
   This is how you change the rectangle's X alignment.
3. Click the check box at the bottom of the window.
   This turns off restricted sizing for all the rectangles.
4. Make the window taller.
   This makes the rectangles' container larger than the sum of the rectangles' preferred sizes. The container is a `JPanel` that has a red outline, so that you can tell where the container's edges are.

Using Invisible Components as Filler

Each component controlled by a box layout butts up against its neighboring components. If you want to have space between components, you can either add an empty border to one or both components, or insert invisible components to provide the space. You can create invisible components with the help of the `Box` class.

The `Box` class defines a nested class, `Box.Filler` that provides invisible components. The `Box` class provides convenience methods to help you create common kinds of filler. The following table gives details about creating invisible components with `Box` and `Box.Filler`.

Type		Size Constraints	How to Create
rigid area		□	`Box.createRigidArea(size)`
glue	horizontal	←●→	`Box.createHorizontalGlue()`
	vertical	↕	`Box.createVerticalGlue()`

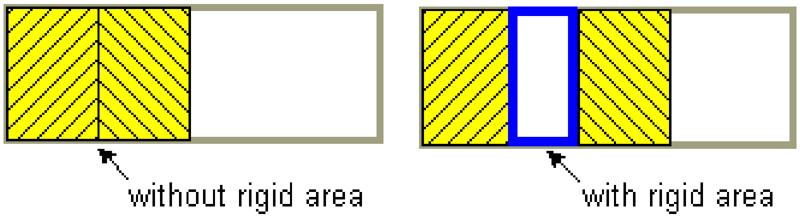
custom `Box.Filler`		*(as specified)*	`new Box.Filler(minSize, prefSize,`
			`maxSize)`

Here's how you generally use each type of filler:

Rigid area

Use this when you want a fixed-size space between two components. For example, to put 5 pixels between two components in a left-to-right box, you can use this code:

```
container.add(firstComponent);
container.add(Box.createRigidArea(new Dimension(5,0)));
container.add(secondComponent);
```

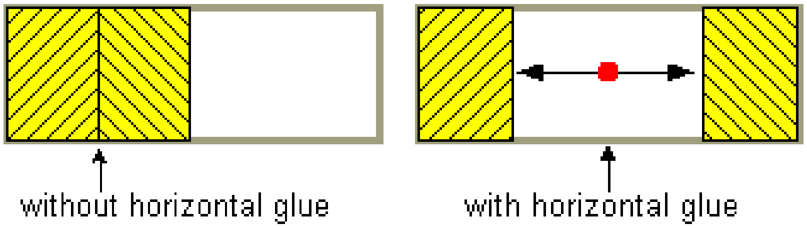


Note: The `Box`class provides another kind of filler for putting fixed space between components: a vertical or horizontal strut. Unfortunately, struts have unlimited maximum heights or widths (for horizontal and vertical struts, respectively). This means that if you use a horizontal box within a vertical box, for example, the horizontal box can sometimes become too tall. For this reason, we recommend that you use rigid areas instead of struts.

Glue

Use this to specify where excess space in a layout should go. Think of it as semi-wet glue -- stretchy and expandable, yet taking up no space unless you pull apart the components that it's sticking to. For example, by putting horizontal glue between two components in a left-to-right box, you make any extra space go between those components, instead of to the right of all the components. Here's an example of making the space in a left-to-right box go between two components, instead of to the right of the components:

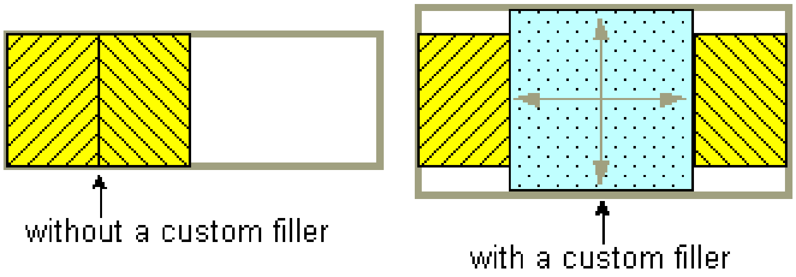
```
container.add(firstComponent);
container.add(Box.createHorizontalGlue());
container.add(secondComponent);
```



Custom `Box.Filler`

Use this to specify a component with whatever minimum, preferred, and maximum sizes you want. For example, to create some filler in a left-to-right layout that puts at least 5 pixels between two components and ensures that the container has a minimum height of 100 pixels, you could use this code:

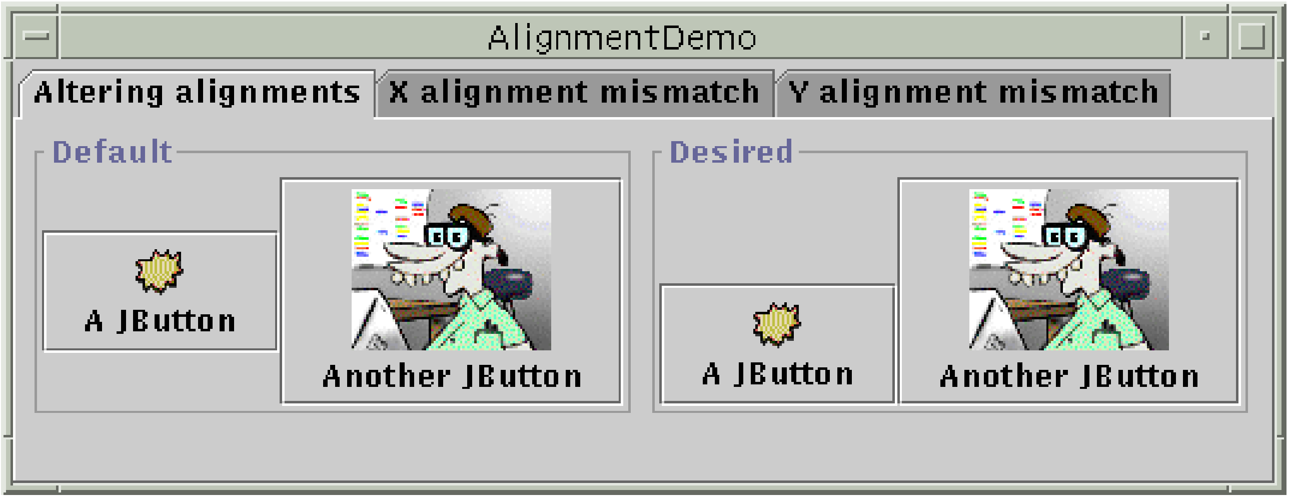
```
container.add(firstComponent);
Dimension minSize = new Dimension(5, 100);
Dimension prefSize = new Dimension(5, 100);
Dimension maxSize = new Dimension(Short.MAX_VALUE, 100);
container.add(new Box.Filler(minSize, prefSize, maxSize));
container.add(secondComponent);
```



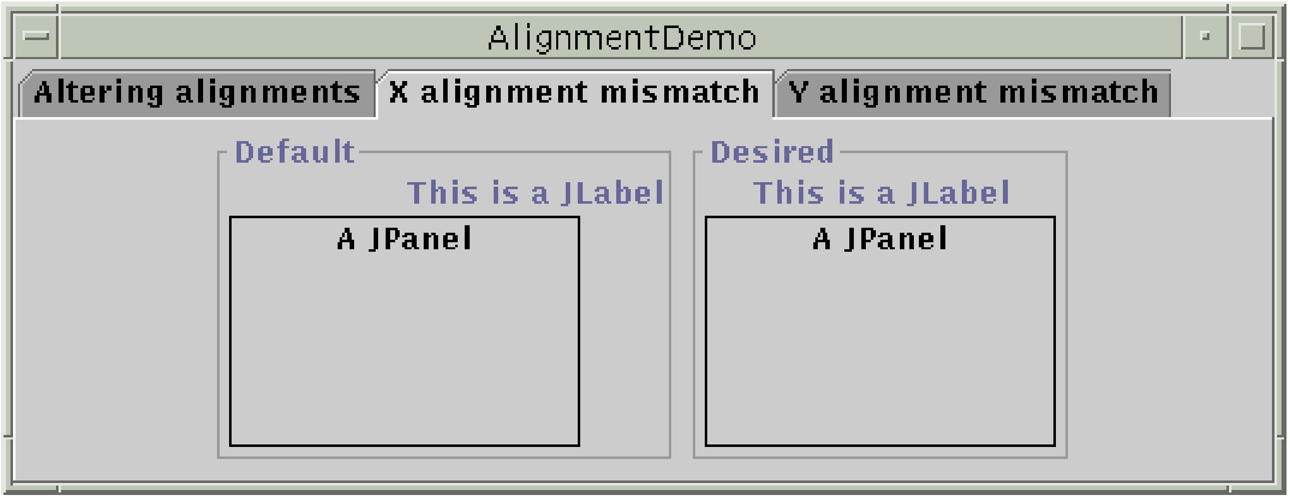
Fixing Alignment Problems

Two types of alignment problems sometimes occur with `BoxLayout`:

- A group of components all have the same alignment, but you want to change their alignment to make them look better. For example, instead of having the centers of a group of left-to-right buttons all in a line, you might want the bottoms of the buttons to be aligned. Here's an example:



- Two or more components controlled by a `BoxLayout` have different default alignments, which causes them to be mis-aligned. For example, as the following shows, if a label and a panel are in a top-to-bottom box layout, the label's left edge is, by default, aligned with the center of the panel.



In general, all the components controlled by a top-to-bottom `BoxLayout` object should have the same X alignment. Similarly, all the components controlled by a left-to-right `Boxlayout` should generally have the same Y alignment. You can set a `JComponent`'s X alignment by invoking its `setAlignmentX` method. An alternative available to all components is to override the `getAlignmentX` method in a custom subclass of the component class. Similarly, you set the Y alignment of a component by invoking the `setAlignmentY` method or by overriding `getAlignmentY`.

Here is an example, taken from `AlignmentDemo`, of changing the Y alignments of two buttons so that the buttons' bottoms are aligned:

```
button1.setAlignmentY(Component.BOTTOM_ALIGNMENT);
button2.setAlignmentY(Component.BOTTOM_ALIGNMENT);
```

By default, most components have center X and Y alignment. However, buttons, combo boxes, labels, and menu items have a different default X alignment value: `LEFT_ALIGNMENT`. The previous picture shows what happens if you put a left-aligned component such as a label together with a center-aligned component in a container controlled by a top-to-bottom `BoxLayout`.

The `AlignmentDemo` program gives examples of fixing mismatched alignment problems. Usually, it's as simple as making an offending button or label be center aligned. For example:

```
label.setAlignmentX(Component.CENTER_ALIGNMENT);
```

Specifying Component Sizes

As we mentioned before, `BoxLayout` pays attention to a component's requested minimum, preferred, and maximum sizes. While you're fine tuning the layout, you might need to adjust these sizes.

Sometimes the need to adjust the size is obvious. For example, a button's maximum size is generally the same as its preferred size. If you want the button to be drawn wider when additional space is available, then you need to change its maximum size.

Sometimes, however, the need to adjust size is not so obvious. You might be getting unexpected results with a box layout, and you might not know why. In this case, it's usually best to treat the problem as an alignment problem first. If adjusting the alignments doesn't help, then you might have a size problem. We'll discuss this further a bit later.

Note: Although `BoxLayout` pays attention to a component's maximum size, most layout managers do not. For example, if you put a button in the south part of a `BorderLayout`, the button will probably be wider than its preferred width, no matter what the button's maximum size is. `BoxLayout`, on the other hand, never makes a button wider than its maximum size.

You can change the minimum, preferred, and maximum sizes in two ways:

- By invoking the appropriate `set`*`Xxx`*`Size` method (which is defined by the `JComponent` class). For example:

  ```
  comp.setMinimumSize(new Dimension(50, 25));
  comp.setPreferredSize(new Dimension(50, 25));
  comp.setMaximumSize(new Dimension(Short.MAX_VALUE,
                                    Short.MAX_VALUE));
  ```

- By overriding the appropriate `get`*`Xxx`*`Size` method. For example:

```
    ...//in a subclass of a component class:
    public Dimension getMaximumSize() {
        size = getPreferredSize();
        size.width = Short.MAX_VALUE;
        return size;
    }
```

If you're running into trouble with a box layout and you've ruled out alignment problems, then the trouble might well be size-related. For example, if the container controlled by the box layout is taking up too much space, then one or more of the components in the container probably needs to have its maximum size restricted.

Help!: Please send us mail (with "swing" in the subject) if you discover other common box layout problems, especially those that are size related.

You can use two techniques to track down size trouble in a box layout:

- Add a garish line border to the outside of the Swing components in question. This lets you see what size they really are. For example:

```
    comp.setBorder(BorderFactory.createCompoundBorder(
                       BorderFactory.createLineBorder(Color.red),
                       comp.getBorder()));
```

- Use good old `System.out.println` to print the components' minimum, preferred, and maximum sizes, and perhaps their bounds.

The Box Layout API

The following tables list the commonly used `BoxLayout` and `Box` constructors and methods. The API for using box layouts falls into these categories:

- Creating `BoxLayout` objects
- Creating space fillers
- Other useful methods

Creating `BoxLayout` Objects

Constructor or Method	Purpose

`BoxLayout(Container, int)`	Creates a `BoxLayout` instance that controls the specified `Container`. The integer argument specifies whether the container's components should be laid out left to right (`BoxLayout.X_AXIS`) or top to bottom (`BoxLayout.Y_AXIS`).
`Box(int)`	Creates a `Box` -- a lightweight container that uses a `BoxLayout` with the specified alignment (`BoxLayout.X_AXIS` or `BoxLayout.Y_AXIS`). Note that a `Box` is *not* a `JComponent` -- it's implemented as a subclass of `Container`. This makes it as lightweight as possible, but it lacks `JComponent` features such as borders. If you want a simple `JComponent` as a container, use `JPanel`◆.
`static Box createHorizontalBox()`	Creates a `Box` that lays out its components from left to right.
`static Box createVerticalBox()`	Creates a `Box` that lays out its components from top to bottom.

Creating Space Fillers

Constructor or Method	**Purpose**
`Component createRigidArea(Dimension)`	Create a rigid lightweight component.

`Component createHorizontalGlue()`
`Component createVerticalGlue()`
`Component createGlue()`
	Create a glue lightweight component. Horizontal glue and vertical glue can be very useful.

`Component createHorizontalStrut()`
`Component createVerticalStrut()`
	Create a "strut" lightweight component. We recommend using rigid areas instead of struts.

`Box.Filler(Dimension, Dimension, Dimension)`	Creates a lightweight component with the specified minimum, preferred, and maximum sizes (with the arguments specified in that order). See the custom `Box.Filler` discussion, earlier in this section, for details.

Other Useful Methods

Method	**Purpose**
`void changeShape(Dimension, Dimension, Dimension)` *(in `Box.Filler`)*	Change the minimum, preferred, and maximum sizes of the recipient `Box.Filler` object. The layout changes accordingly.

Examples that Use Box Layouts

The following table lists some of the many examples that use box layouts.

Example	Where Described	Notes
`BoxWindow`	This page	Uses a box layout to create a centered column of components.
`AlignmentDemo`	This page	Demonstrates how to fix common alignment problems. Uses two image files: `images/middle.gif` and `images/geek-cght.gif`.
`BoxLayoutDemo`	This page	Lets you play with alignments and maximum sizes.
`ListDialog`	This page	A simple yet realistic example of using both a top-to-bottom box layout and a left-to-right one. Uses horizontal glue, rigid areas, and empty borders. Also sets the X alignment of a component.
`InternalFrameEventDemo`	How to Write an Internal Frame Listener◆	Uses a top-to-bottom layout to center buttons and a scroll pane in an internal frame.
`MenuGlueDemo`	Customizing Menu Layout◆	Shows how to right-align a menu in the menu bar, using a glue component.
`MenuLayoutDemo`	Customizing Menu Layout◆	Shows how to customize menu layout by changing the menu bar to use a top-to-bottom box layout, and the popup menu to use a left-to-right box layout.
`ConversionPanel.java`◆	Layout Management and Borders◆	Aligns two components in different box-layout-controlled containers by setting the components' widths to be the same, and their containers' widths to be the same.

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```
import javax.swing.JTable;
import javax.swing.JScrollPane;
import javax.swing.JPanel;
import javax.swing.JFrame;
import java.awt.*;
import java.awt.event.*;

public class SimpleTableDemo extends JFrame {
    private boolean DEBUG = true;

    public SimpleTableDemo() {
        super("SimpleTableDemo");

        Object[][] data = {
            {"Mary", "Campione",
             "Snowboarding", new Integer(5), new Boolean(false)},
            {"Alison", "Huml",
             "Rowing", new Integer(3), new Boolean(true)},
            {"Kathy", "Walrath",
             "Chasing toddlers", new Integer(2), new Boolean(false)},
            {"Mark", "Andrews",
             "Speed reading", new Integer(20), new Boolean(true)},
            {"Angela", "Lih",
             "Teaching high school", new Integer(4), new Boolean(false)}
        };

        String[] columnNames = {"First Name",
                                "Last Name",
                                "Sport",
                                "# of Years",
                                "Vegetarian"};

        final JTable table = new JTable(data, columnNames);
        table.setPreferredScrollableViewportSize(new Dimension(500, 70));

        if (DEBUG) {
            table.addMouseListener(new MouseAdapter() {
                public void mouseClicked(MouseEvent e) {
                    printDebugData(table);
                }
            });
        }

        //Create the scroll pane and add the table to it.
        JScrollPane scrollPane = new JScrollPane(table);

        //Add the scroll pane to this window.
        getContentPane().add(scrollPane, BorderLayout.CENTER);

        addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });
    }

    private void printDebugData(JTable table) {
        int numRows = table.getRowCount();
        int numCols = table.getColumnCount();
        javax.swing.table.TableModel model = table.getModel();

        System.out.println("Value of data: ");
        for (int i=0; i < numRows; i++) {
            System.out.print("    row " + i + ":");
            for (int j=0; j < numCols; j++) {
                System.out.print("  " + model.getValueAt(i, j));
            }
            System.out.println();
        }
        System.out.println("--------------------------");
    }

    public static void main(String[] args) {
        SimpleTableDemo frame = new SimpleTableDemo();
        frame.pack();
        frame.setVisible(true);
    }
}
```

```java
import javax.swing.JTable;
import javax.swing.table.AbstractTableModel;
import javax.swing.table.TableColumn;
import javax.swing.DefaultCellEditor;
import javax.swing.table.TableCellRenderer;
import javax.swing.table.DefaultTableCellRenderer;
import javax.swing.JScrollPane;
import javax.swing.JComboBox;
import javax.swing.JFrame;
import javax.swing.SwingUtilities;
import javax.swing.JOptionPane;
import java.awt.*;
import java.awt.event.*;

public class TableRenderDemo extends JFrame {
    private boolean DEBUG = true;

    public TableRenderDemo() {
        super("TableRenderDemo");

        MyTableModel myModel = new MyTableModel();
        JTable table = new JTable(myModel);
        table.setPreferredScrollableViewportSize(new Dimension(500, 70));

        //Create the scroll pane and add the table to it.
        JScrollPane scrollPane = new JScrollPane(table);

        //Set up column sizes.
        initColumnSizes(table, myModel);

        //Fiddle with the Sport column's cell editors/renderers.
        setUpSportColumn(table.getColumnModel().getColumn(2));

        //Add the scroll pane to this window.
        getContentPane().add(scrollPane, BorderLayout.CENTER);

        addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });
    }

    /*
     * This method picks good column sizes.
     * If all column heads are wider than the column's cells'
     * contents, then you can just use column.sizeWidthToFit().
     */
    private void initColumnSizes(JTable table, MyTableModel model) {
        TableColumn column = null;
        Component comp = null;
        int headerWidth = 0;
        int cellWidth = 0;
        Object[] longValues = model.longValues;

        for (int i = 0; i < 5; i++) {
            column = table.getColumnModel().getColumn(i);

            try {
                comp = column.getHeaderRenderer().
                                 getTableCellRendererComponent(
                                     null, column.getHeaderValue(),
                                     false, false, 0, 0);
                headerWidth = comp.getPreferredSize().width;
            } catch (NullPointerException e) {
                System.err.println("Null pointer exception!");
                System.err.println("  getHeaderRenderer returns null in 1.3.");
                System.err.println("  The replacement is getDefaultRenderer.");
            }

            comp = table.getDefaultRenderer(model.getColumnClass(i)).
                             getTableCellRendererComponent(
                                 table, longValues[i],
                                 false, false, 0, i);
            cellWidth = comp.getPreferredSize().width;

            if (DEBUG) {
                System.out.println("Initializing width of column "
                                   + i + ". "
                                   + "headerWidth = " + headerWidth
                                   + "; cellWidth = " + cellWidth);
            }

            //XXX: Before Swing 1.1 Beta 2, use setMinWidth instead.
            column.setPreferredWidth(Math.max(headerWidth, cellWidth));
        }
    }

    public void setUpSportColumn(TableColumn sportColumn) {
        //Set up the editor for the sport cells.
        JComboBox comboBox = new JComboBox();
        comboBox.addItem("Snowboarding");
        comboBox.addItem("Rowing");
        comboBox.addItem("Chasing toddlers");
        comboBox.addItem("Speed reading");
        comboBox.addItem("Teaching high school");
        comboBox.addItem("None");
        sportColumn.setCellEditor(new DefaultCellEditor(comboBox));

        //Set up tool tips for the sport cells.
        DefaultTableCellRenderer renderer =
                new DefaultTableCellRenderer();
        renderer.setToolTipText("Click for combo box");
        sportColumn.setCellRenderer(renderer);

        //Set up tool tip for the sport column header.
        TableCellRenderer headerRenderer = sportColumn.getHeaderRenderer();
        if (headerRenderer instanceof DefaultTableCellRenderer) {
            ((DefaultTableCellRenderer)headerRenderer).setToolTipText(
                     "Click the sport to see a list of choices");
        }
    }

    class MyTableModel extends AbstractTableModel {
        final String[] columnNames = {"First Name",
                                      "Last Name",
                                      "Sport",
                                      "# of Years",
                                      "Vegetarian"};
        final Object[][] data = {
            {"Mary", "Campione",
             "Snowboarding", new Integer(5), new Boolean(false)},
            {"Alison", "Huml",
             "Rowing", new Integer(3), new Boolean(true)},
            {"Kathy", "Walrath",
             "Chasing toddlers", new Integer(2), new Boolean(false)},
            {"Mark", "Andrews",
             "Speed reading", new Integer(20), new Boolean(true)},
            {"Angela", "Lih",
             "Teaching high school", new Integer(4), new Boolean(false)}
        };
        public final Object[] longValues = {"Angela", "Andrews",
                                            "Teaching high school",
                                            new Integer(20), Boolean.TRUE};

        public int getColumnCount() {
            return columnNames.length;
        }

        public int getRowCount() {
            return data.length;
        }

        public String getColumnName(int col) {
            return columnNames[col];
        }

        public Object getValueAt(int row, int col) {
            return data[row][col];
        }

        /*
         * JTable uses this method to determine the default renderer/
         * editor for each cell.  If we didn't implement this method,
         * then the last column would contain text ("true"/"false"),
         * rather than a check box.
         */
        public Class getColumnClass(int c) {
            return getValueAt(0, c).getClass();
        }

        /*
         * Don't need to implement this method unless your table's
         * editable.
         */
        public boolean isCellEditable(int row, int col) {
            //Note that the data/cell address is constant,
            //no matter where the cell appears onscreen.
            if (col < 2) {
                return false;
            } else {
                return true;
            }
        }

        /*
         * Don't need to implement this method unless your table's
         * data can change.
         */
        public void setValueAt(Object value, int row, int col) {
            if (DEBUG) {
                System.out.println("Setting value at " + row + "," + col
                                   + " to " + value
                                   + " (an instance of "
                                   + value.getClass() + ")");
            }
```

```
            if (data[0][col] instanceof Integer
                    && !(value instanceof Integer)) {
                //With JFC/Swing 1.1 and JDK 1.2, we need to create
                //an Integer from the value; otherwise, the column
                //switches to contain Strings.  Starting with v 1.3,
                //the table automatically converts value to an Integer,
                //so you only need the code in the 'else' part of this
                //'if' block.
                try {
                    data[row][col] = new Integer(value.toString());
                    fireTableCellUpdated(row, col);
                } catch (NumberFormatException e) {
                    JOptionPane.showMessageDialog(TableRenderDemo.this,
                        "The \"" + getColumnName(col)
                        + "\" column accepts only integer values.");
                }
            } else {
                data[row][col] = value;
                fireTableCellUpdated(row, col);
            }

            if (DEBUG) {
                System.out.println("New value of data:");
                printDebugData();
            }
        }

        private void printDebugData() {
            int numRows = getRowCount();
            int numCols = getColumnCount();

            for (int i=0; i < numRows; i++) {
                System.out.print("    row " + i + ":");
                for (int j=0; j < numCols; j++) {
                    System.out.print("  " + data[i][j]);
                }
                System.out.println();
            }
            System.out.println("--------------------------");
        }
    }

    public static void main(String[] args) {
        TableRenderDemo frame = new TableRenderDemo();
        frame.pack();
        frame.setVisible(true);
    }
}
```

```
import javax.swing.JTable;
import javax.swing.ListSelectionModel;
import javax.swing.event.ListSelectionListener;
import javax.swing.event.ListSelectionEvent;
import javax.swing.JScrollPane;
import javax.swing.JPanel;
import javax.swing.JFrame;
import java.awt.*;
import java.awt.event.*;

public class SimpleTableSelectionDemo extends JFrame {
    private boolean DEBUG = false;
    private boolean ALLOW_COLUMN_SELECTION = false;
    private boolean ALLOW_ROW_SELECTION = true;

    public SimpleTableSelectionDemo() {
        super("SimpleTableSelectionDemo");

        Object[][] data = {
            {"Mary", "Campione",
             "Snowboarding", new Integer(5), new Boolean(false)},
            {"Alison", "Huml",
             "Rowing", new Integer(3), new Boolean(true)},
            {"Kathy", "Walrath",
             "Chasing toddlers", new Integer(2), new Boolean(false)},
            {"Mark", "Andrews",
             "Speed reading", new Integer(20), new Boolean(true)},
            {"Angela", "Lih",
             "Teaching high school", new Integer(4), new Boolean(false)}
        };

        String[] columnNames = {"First Name",
                                "Last Name",
                                "Sport",
                                "# of Years",
                                "Vegetarian"};

        final JTable table = new JTable(data, columnNames);
        table.setPreferredScrollableViewportSize(new Dimension(500, 70));

        table.setSelectionMode(ListSelectionModel.SINGLE_SELECTION);
        if (ALLOW_ROW_SELECTION) { // true by default
            ListSelectionModel rowSM = table.getSelectionModel();
            rowSM.addListSelectionListener(new ListSelectionListener() {
                public void valueChanged(ListSelectionEvent e) {
                    //Ignore extra messages.
                    if (e.getValueIsAdjusting()) return;

                    ListSelectionModel lsm = (ListSelectionModel)e.getSource();
                    if (lsm.isSelectionEmpty()) {
                        System.out.println("No rows are selected.");
                    } else {
                        int selectedRow = lsm.getMinSelectionIndex();
                        System.out.println("Row " + selectedRow
                                           + " is now selected.");
                    }
                }
            });
        } else {
            table.setRowSelectionAllowed(false);
        }
        if (ALLOW_COLUMN_SELECTION) { // false by default
            if (ALLOW_ROW_SELECTION) {
                //We allow both row and column selection, which
                //implies that we *really* want to allow individual
                //cell selection.
                table.setCellSelectionEnabled(true);
            }
            table.setColumnSelectionAllowed(true);
            ListSelectionModel colSM =
                table.getColumnModel().getSelectionModel();
            colSM.addListSelectionListener(new ListSelectionListener() {
                public void valueChanged(ListSelectionEvent e) {
                    //Ignore extra messages.
                    if (e.getValueIsAdjusting()) return;

                    ListSelectionModel lsm = (ListSelectionModel)e.getSource();
                    if (lsm.isSelectionEmpty()) {
                        System.out.println("No columns are selected.");
                    } else {
                        int selectedCol = lsm.getMinSelectionIndex();
                        System.out.println("Column " + selectedCol
                                           + " is now selected.");
                    }
                }
            });
        }

        if (DEBUG) {
            table.addMouseListener(new MouseAdapter() {
                public void mouseClicked(MouseEvent e) {
                    printDebugData(table);
                }
            });
        }

        //Create the scroll pane and add the table to it.
        JScrollPane scrollPane = new JScrollPane(table);

        //Add the scroll pane to this window.
        getContentPane().add(scrollPane, BorderLayout.CENTER);

        addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });
    }

    private void printDebugData(JTable table) {
        int numRows = table.getRowCount();
        int numCols = table.getColumnCount();
        javax.swing.table.TableModel model = table.getModel();

        System.out.println("Value of data: ");
        for (int i=0; i < numRows; i++) {
            System.out.print("    row " + i + ":");
            for (int j=0; j < numCols; j++) {
                System.out.print("  " + model.getValueAt(i, j));
            }
            System.out.println();
        }
        System.out.println("--------------------------");
    }

    public static void main(String[] args) {
        SimpleTableSelectionDemo frame = new SimpleTableSelectionDemo();
        frame.pack();
        frame.setVisible(true);
    }
}
```

```java
import javax.swing.JTable;
import javax.swing.table.AbstractTableModel;
import javax.swing.JScrollPane;
import javax.swing.JFrame;
import javax.swing.SwingUtilities;
import javax.swing.JOptionPane;
import java.awt.*;
import java.awt.event.*;

public class TableDemo extends JFrame {
    private boolean DEBUG = true;

    public TableDemo() {
        super("TableDemo");

        MyTableModel myModel = new MyTableModel();
        JTable table = new JTable(myModel);
        table.setPreferredScrollableViewportSize(new Dimension(500, 70));

        //Create the scroll pane and add the table to it.
        JScrollPane scrollPane = new JScrollPane(table);

        //Add the scroll pane to this window.
        getContentPane().add(scrollPane, BorderLayout.CENTER);

        addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });
    }

    class MyTableModel extends AbstractTableModel {
        final String[] columnNames = {"First Name",
                                      "Last Name",
                                      "Sport",
                                      "# of Years",
                                      "Vegetarian"};
        final Object[][] data = {
            {"Mary", "Campione",
             "Snowboarding", new Integer(5), new Boolean(false)},
            {"Alison", "Huml",
             "Rowing", new Integer(3), new Boolean(true)},
            {"Kathy", "Walrath",
             "Chasing toddlers", new Integer(2), new Boolean(false)},
            {"Mark", "Andrews",
             "Speed reading", new Integer(20), new Boolean(true)},
            {"Angela", "Lih",
             "Teaching high school", new Integer(4), new Boolean(false)}
        };

        public int getColumnCount() {
            return columnNames.length;
        }

        public int getRowCount() {
            return data.length;
        }

        public String getColumnName(int col) {
            return columnNames[col];
        }
        public Object getValueAt(int row, int col) {
            return data[row][col];
        }

        /*
         * JTable uses this method to determine the default renderer/
         * editor for each cell.  If we didn't implement this method,
         * then the last column would contain text ("true"/"false"),
         * rather than a check box.
         */
        public Class getColumnClass(int c) {
            return getValueAt(0, c).getClass();
        }

        /*
         * Don't need to implement this method unless your table's
         * editable.
         */
        public boolean isCellEditable(int row, int col) {
            //Note that the data/cell address is constant,
            //no matter where the cell appears onscreen.
            if (col < 2) {
                return false;
            } else {
                return true;
            }
        }

        /*
         * Don't need to implement this method unless your table's
         * data can change.
         */
        public void setValueAt(Object value, int row, int col) {
            if (DEBUG) {
                System.out.println("Setting value at " + row + "," + col
                                   + " to " + value
                                   + " (an instance of "
                                   + value.getClass() + ")");
            }

            if (data[0][col] instanceof Integer
                    && !(value instanceof Integer)) {
                //With JFC/Swing 1.1 and JDK 1.2, we need to create
                //an Integer from the value; otherwise, the column
                //switches to contain Strings.  Starting with v 1.3,
                //the table automatically converts value to an Integer,
                //so you only need the code in the 'else' part of this
                //'if' block.
                //XXX: See TableEditDemo.java for a better solution!!!
                try {
                    data[row][col] = new Integer(value.toString());
                    fireTableCellUpdated(row, col);
                } catch (NumberFormatException e) {
                    JOptionPane.showMessageDialog(TableDemo.this,
                        "The \"" + getColumnName(col)
                        + "\" column accepts only integer values.");
                }
            } else {
                data[row][col] = value;
                fireTableCellUpdated(row, col);
            }

            if (DEBUG) {
                System.out.println("New value of data:");
                printDebugData();
            }
        }

        private void printDebugData() {
            int numRows = getRowCount();
            int numCols = getColumnCount();

            for (int i=0; i < numRows; i++) {
                System.out.print("    row " + i + ":");
                for (int j=0; j < numCols; j++) {
                    System.out.print("  " + data[i][j]);
                }
                System.out.println();
            }
            System.out.println("--------------------------");
        }
    }

    public static void main(String[] args) {
        TableDemo frame = new TableDemo();
        frame.pack();
        frame.setVisible(true);
    }
}
```

```
import javax.swing.JTable;
import javax.swing.table.AbstractTableModel;

import javax.swing.DefaultCellEditor;

import javax.swing.JScrollPane;
import javax.swing.JFrame;
import javax.swing.SwingUtilities;
import java.awt.*;
import java.awt.event.*;

/**
 * This is exactly like TableDemo, except that it uses a
 * custom cell editor to validate integer input.
 */
public class TableEditDemo extends JFrame {
    private boolean DEBUG = true;

    public TableEditDemo() {
        super("TableEditDemo");

        MyTableModel myModel = new MyTableModel();
        JTable table = new JTable(myModel);
        table.setPreferredScrollableViewportSize(new Dimension(500, 70));

        //Create the scroll pane and add the table to it.
        JScrollPane scrollPane = new JScrollPane(table);

        //Set up real input validation for the integer column.
        setUpIntegerEditor(table);

        //Add the scroll pane to this window.
        getContentPane().add(scrollPane, BorderLayout.CENTER);

        addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });
    }

    private void setUpIntegerEditor(JTable table) {
        //Set up the editor for the integer cells.
        final WholeNumberField integerField = new WholeNumberField(0, 5);
        integerField.setHorizontalAlignment(WholeNumberField.RIGHT);

        DefaultCellEditor integerEditor =
            new DefaultCellEditor(integerField) {
                //Override DefaultCellEditor's getCellEditorValue method
                //to return an Integer, not a String:
                public Object getCellEditorValue() {
                    return new Integer(integerField.getValue());
                }
            };
        table.setDefaultEditor(Integer.class, integerEditor);
    }

    class MyTableModel extends AbstractTableModel {
        final String[] columnNames = {"First Name",
                                      "Last Name",
                                      "Sport",
                                      "# of Years",
                                      "Vegetarian"};
        final Object[][] data = {
            {"Mary", "Campione",
             "Snowboarding", new Integer(5), new Boolean(false)},
            {"Alison", "Huml",
             "Rowing", new Integer(3), new Boolean(true)},
            {"Kathy", "Walrath",
             "Chasing toddlers", new Integer(2), new Boolean(false)},
            {"Mark", "Andrews",
             "Speed reading", new Integer(20), new Boolean(true)},
            {"Angela", "Lih",
             "Teaching high school", new Integer(4), new Boolean(false)}
        };

        public int getColumnCount() {
            return columnNames.length;
        }

        public int getRowCount() {
            return data.length;
        }

        public String getColumnName(int col) {
            return columnNames[col];
        }

        public Object getValueAt(int row, int col) {
            return data[row][col];
        }

        /*
         * JTable uses this method to determine the default renderer/
         * editor for each cell.  If we didn't implement this method,
         * then the last column would contain text ("true"/"false"),
         * rather than a check box.
         */
        public Class getColumnClass(int c) {
            return getValueAt(0, c).getClass();
        }

        /*
         * Don't need to implement this method unless your table's
         * editable.
         */
        public boolean isCellEditable(int row, int col) {
            //Note that the data/cell address is constant,
            //no matter where the cell appears onscreen.
            if (col < 2) {
                return false;
            } else {
                return true;
            }
        }

        public void setValueAt(Object value, int row, int col) {
            if (DEBUG) {
                System.out.println("Setting value at " + row + "," + col
                                   + " to " + value
                                   + " (an instance of "
                                   + value.getClass() + ")");
            }

            data[row][col] = value;
            fireTableCellUpdated(row, col);

            if (DEBUG) {
                System.out.println("New value of data:");
                printDebugData();
            }
        }

        private void printDebugData() {
            int numRows = getRowCount();
            int numCols = getColumnCount();

            for (int i=0; i < numRows; i++) {
                System.out.print("    row " + i + ":");
                for (int j=0; j < numCols; j++) {
                    System.out.print("  " + data[i][j]);
                }
                System.out.println();
            }
            System.out.println("--------------------------");
        }
    }

    public static void main(String[] args) {
        TableEditDemo frame = new TableEditDemo();
        frame.pack();
        frame.setVisible(true);
    }
}
```

```
import javax.swing.JTable;
import javax.swing.table.AbstractTableModel;
import javax.swing.DefaultCellEditor;
import javax.swing.table.TableCellRenderer;

import javax.swing.JLabel;
import javax.swing.JDialog;
import javax.swing.JButton;
import javax.swing.JCheckBox;
import javax.swing.JColorChooser;
import javax.swing.BorderFactory;
import javax.swing.border.Border;

import javax.swing.JScrollPane;
import javax.swing.JFrame;
import javax.swing.SwingUtilities;
import java.awt.*;
import java.awt.event.*;

/**
 * This is like TableEditDemo, except that it substitutes a
 * Favorite Color column for the Last Name column and specifies
 * a custom cell renderer and editor for the color data.
 */
public class TableDialogEditDemo extends JFrame {
    private boolean DEBUG = false;

    public TableDialogEditDemo() {
        super("TableDialogEditDemo");

        MyTableModel myModel = new MyTableModel();
        JTable table = new JTable(myModel);
        table.setPreferredScrollableViewportSize(new Dimension(500, 70));

        //Create the scroll pane and add the table to it.
        JScrollPane scrollPane = new JScrollPane(table);

        //Set up renderer and editor for the Favorite Color column.
        setUpColorRenderer(table);
        setUpColorEditor(table);

        //Set up real input validation for integer data.
        setUpIntegerEditor(table);

        //Add the scroll pane to this window.
        getContentPane().add(scrollPane, BorderLayout.CENTER);

        addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });
    }

    class ColorRenderer extends JLabel
                        implements TableCellRenderer {
        Border unselectedBorder = null;
        Border selectedBorder = null;
        boolean isBordered = true;

        public ColorRenderer(boolean isBordered) {
            super();
            this.isBordered = isBordered;
            setOpaque(true); //MUST do this for background to show up.
        }

        public Component getTableCellRendererComponent(
                                JTable table, Object color,
                                boolean isSelected, boolean hasFocus,
                                int row, int column) {
            setBackground((Color)color);
            if (isBordered) {
                if (isSelected) {
                    if (selectedBorder == null) {
                        selectedBorder = BorderFactory.createMatteBorder(2,5,2,5,
                                                  table.getSelectionBackground());
                    }
                    setBorder(selectedBorder);
                } else {
                    if (unselectedBorder == null) {
                        unselectedBorder = BorderFactory.createMatteBorder(2,5,2,5,
                                                  table.getBackground());
                    }
                    setBorder(unselectedBorder);
                }
            }
            return this;
        }
    }

    private void setUpColorRenderer(JTable table) {
        table.setDefaultRenderer(Color.class,
                                 new ColorRenderer(true));
    }

    //Set up the editor for the Color cells.
    private void setUpColorEditor(JTable table) {
        //First, set up the button that brings up the dialog.
        final JButton button = new JButton("") {
            public void setText(String s) {
                //Button never shows text -- only color.
            }
        };
        button.setBackground(Color.white);
        button.setBorderPainted(false);
        button.setMargin(new Insets(0,0,0,0));

        //Now create an editor to encapsulate the button, and
        //set it up as the editor for all Color cells.
        final ColorEditor colorEditor = new ColorEditor(button);
        table.setDefaultEditor(Color.class, colorEditor);

        //Set up the dialog that the button brings up.
        final JColorChooser colorChooser = new JColorChooser();
        ActionListener okListener = new ActionListener() {
            public void actionPerformed(ActionEvent e) {
                colorEditor.currentColor = colorChooser.getColor();
            }
        };
        final JDialog dialog = JColorChooser.createDialog(button,
                                        "Pick a Color",
                                        true,
                                        colorChooser,
                                        okListener,
                                        null); //XXXDoublecheck this is OK

        //Here's the code that brings up the dialog.
        button.addActionListener(new ActionListener() {
            public void actionPerformed(ActionEvent e) {
                button.setBackground(colorEditor.currentColor);
                colorChooser.setColor(colorEditor.currentColor);
                //Without the following line, the dialog comes up
                //in the middle of the screen.
                //dialog.setLocationRelativeTo(button);
                dialog.show();
            }
        });
    }

    /*
     * The editor button that brings up the dialog.
     * We extend DefaultCellEditor for convenience,
     * even though it mean we have to create a dummy
     * check box.  Another approach would be to copy
     * the implementation of TableCellEditor methods
     * from the source code for DefaultCellEditor.
     */
    class ColorEditor extends DefaultCellEditor {
        Color currentColor = null;

        public ColorEditor(JButton b) {
                super(new JCheckBox()); //Unfortunately, the constructor
                                        //expects a check box, combo box,
                                        //or text field.
            editorComponent = b;
            setClickCountToStart(1); //This is usually 1 or 2.

            //Must do this so that editing stops when appropriate.
            b.addActionListener(new ActionListener() {
                public void actionPerformed(ActionEvent e) {
                    fireEditingStopped();
                }
            });
        }

        protected void fireEditingStopped() {
            super.fireEditingStopped();
        }

        public Object getCellEditorValue() {
            return currentColor;
        }

        public Component getTableCellEditorComponent(JTable table,
                                                     Object value,
                                                     boolean isSelected,
                                                     int row,
                                                     int column) {
            ((JButton)editorComponent).setText(value.toString());
            currentColor = (Color)value;
            return editorComponent;
        }
    }

    private void setUpIntegerEditor(JTable table) {
        //Set up the editor for the integer cells.
        final WholeNumberField integerField = new WholeNumberField(0, 5);
        integerField.setHorizontalAlignment(WholeNumberField.RIGHT);

        DefaultCellEditor integerEditor =
            new DefaultCellEditor(integerField) {
                //Override DefaultCellEditor's getCellEditorValue method
                //to return an Integer, not a String:
                public Object getCellEditorValue() {
                    return new Integer(integerField.getValue());
                }
            };
        table.setDefaultEditor(Integer.class, integerEditor);
    }


    class MyTableModel extends AbstractTableModel {
        final String[] columnNames = {"First Name",
                                      "Favorite Color",
                                      "Sport",
                                      "# of Years",
                                      "Vegetarian"};
        final Object[][] data = {
            {"Mary", new Color(153, 0, 153),
             "Snowboarding", new Integer(5), new Boolean(false)},
            {"Alison", new Color(51, 51, 153),
             "Rowing", new Integer(3), new Boolean(true)},
            {"Kathy", new Color(51, 102, 51),
             "Chasing toddlers", new Integer(2), new Boolean(false)},
            {"Mark", Color.blue,
             "Speed reading", new Integer(20), new Boolean(true)},
            {"Philip", Color.pink,
             "Pool", new Integer(7), new Boolean(false)}
        };

        public int getColumnCount() {
            return columnNames.length;
        }

        public int getRowCount() {
            return data.length;
        }

        public String getColumnName(int col) {
            return columnNames[col];
        }

        public Object getValueAt(int row, int col) {
            return data[row][col];
        }

        /*
         * JTable uses this method to determine the default renderer/
         * editor for each cell.  If we didn't implement this method,
         * then the last column would contain text ("true"/"false"),
         * rather than a check box.
         */
        public Class getColumnClass(int c) {
            return getValueAt(0, c).getClass();
        }

        /*
         * Don't need to implement this method unless your table's
         * editable.
         */
        public boolean isCellEditable(int row, int col) {
            //Note that the data/cell address is constant,
            //no matter where the cell appears onscreen.
            if (col < 1) {
                return false;
            } else {
                return true;
            }
        }

        public void setValueAt(Object value, int row, int col) {
            if (DEBUG) {
                System.out.println("Setting value at " + row + "," + col
                                   + " to " + value
                                   + " (an instance of "
                                   + value.getClass() + ")");
            }

            data[row][col] = value;
            fireTableCellUpdated(row, col);

            if (DEBUG) {
                System.out.println("New value of data:");
                printDebugData();
            }
        }

        private void printDebugData() {
            int numRows = getRowCount();
            int numCols = getColumnCount();

            for (int i=0; i < numRows; i++) {
                System.out.print("    row " + i + ":");
                for (int j=0; j < numCols; j++) {
                    System.out.print("  " + data[i][j]);
                }
                System.out.println();
            }
            System.out.println("--------------------------");
        }
    }

    public static void main(String[] args) {
        TableDialogEditDemo frame = new TableDialogEditDemo();
        frame.pack();
        frame.setVisible(true);
    }
}
```

```
/**
 * A sorter for TableModels. The sorter has a model (conforming to TableModel)
 * and itself implements TableModel. TableSorter does not store or copy
 * the data in the TableModel, instead it maintains an array of
 * integers which it keeps the same size as the number of rows in its
 * model. When the model changes it notifies the sorter that something
 * has changed eg. "rowsAdded" so that its internal array of integers
 * can be reallocated. As requests are made of the sorter (like
 * getValueAt(row, col) it redirects them to its model via the mapping
 * array. That way the TableSorter appears to hold another copy of the table
 * with the rows in a different order. The sorting algorthm used is stable
 * which means that it does not move around rows when its comparison
 * function returns 0 to denote that they are equivalent.
 *
 * @version 1.5 12/17/97
 * @author Philip Milne
 */

import java.util.*;

import javax.swing.table.TableModel;
import javax.swing.event.TableModelEvent;

// Imports for picking up mouse events from the JTable.

import java.awt.event.MouseAdapter;
import java.awt.event.MouseEvent;
import java.awt.event.InputEvent;
import javax.swing.JTable;
import javax.swing.table.JTableHeader;
import javax.swing.table.TableColumnModel;

public class TableSorter extends TableMap {
    int             indexes[];
    Vector          sortingColumns = new Vector();
    boolean         ascending = true;
    int compares;

    public TableSorter() {
        indexes = new int[0]; // for consistency
    }

    public TableSorter(TableModel model) {
        setModel(model);
    }

    public void setModel(TableModel model) {
        super.setModel(model);
        reallocateIndexes();
    }

    public int compareRowsByColumn(int row1, int row2, int column) {
        Class type = model.getColumnClass(column);
        TableModel data = model;

        // Check for nulls.

        Object o1 = data.getValueAt(row1, column);
        Object o2 = data.getValueAt(row2, column);

        // If both values are null, return 0.
        if (o1 == null && o2 == null) {
            return 0;
        } else if (o1 == null) { // Define null less than everything.
            return -1;
        } else if (o2 == null) {
            return 1;
        }

        /*
         * We copy all returned values from the getValue call in case
         * an optimised model is reusing one object to return many
         * values.  The Number subclasses in the JDK are immutable and
         * so will not be used in this way but other subclasses of
         * Number might want to do this to save space and avoid
         * unnecessary heap allocation.
         */

        if (type.getSuperclass() == java.lang.Number.class) {
            Number n1 = (Number)data.getValueAt(row1, column);
            double d1 = n1.doubleValue();
            Number n2 = (Number)data.getValueAt(row2, column);
            double d2 = n2.doubleValue();

            if (d1 < d2) {
                return -1;
            } else if (d1 > d2) {
                return 1;
            } else {
                return 0;
            }
        } else if (type == java.util.Date.class) {
            Date d1 = (Date)data.getValueAt(row1, column);
            long n1 = d1.getTime();
            Date d2 = (Date)data.getValueAt(row2, column);
            long n2 = d2.getTime();

            if (n1 < n2) {
                return -1;
            } else if (n1 > n2) {
                return 1;
            } else {
                return 0;
            }
        } else if (type == String.class) {
            String s1 = (String)data.getValueAt(row1, column);
            String s2    = (String)data.getValueAt(row2, column);
            int result = s1.compareTo(s2);

            if (result < 0) {
                return -1;
            } else if (result > 0) {
                return 1;
            } else {
                return 0;
            }
        } else if (type == Boolean.class) {
            Boolean bool1 = (Boolean)data.getValueAt(row1, column);
            boolean b1 = bool1.booleanValue();
            Boolean bool2 = (Boolean)data.getValueAt(row2, column);
            boolean b2 = bool2.booleanValue();

            if (b1 == b2) {
                return 0;
            } else if (b1) { // Define false < true
                return 1;
            } else {
                return -1;
            }
        } else {
            Object v1 = data.getValueAt(row1, column);
            String s1 = v1.toString();
            Object v2 = data.getValueAt(row2, column);
            String s2 = v2.toString();
            int result = s1.compareTo(s2);

            if (result < 0) {
                return -1;
            } else if (result > 0) {
                return 1;
            } else {
                return 0;
            }
        }
    }

    public int compare(int row1, int row2) {
        compares++;
        for (int level = 0; level < sortingColumns.size(); level++) {
            Integer column = (Integer)sortingColumns.elementAt(level);
            int result = compareRowsByColumn(row1, row2, column.intValue());
            if (result != 0) {
                return ascending ? result : -result;
            }
        }
        return 0;
    }

    public void reallocateIndexes() {
        int rowCount = model.getRowCount();

        // Set up a new array of indexes with the right number of elements
        // for the new data model.
        indexes = new int[rowCount];

        // Initialise with the identity mapping.
        for (int row = 0; row < rowCount; row++) {
            indexes[row] = row;
        }
    }

    public void tableChanged(TableModelEvent e) {
        //System.out.println("Sorter: tableChanged");
        reallocateIndexes();

        super.tableChanged(e);
    }

    public void checkModel() {
        if (indexes.length != model.getRowCount()) {
            System.err.println("Sorter not informed of a change in model.");
        }
    }

    public void sort(Object sender) {
        checkModel();
        compares = 0;
        // n2sort();
        // qsort(0, indexes.length-1);
        shuttlesort((int[])indexes.clone(), indexes, 0, indexes.length);
        //System.out.println("Compares: "+compares);
    }

    public void n2sort() {
        for (int i = 0; i < getRowCount(); i++) {
            for (int j = i+1; j < getRowCount(); j++) {
                if (compare(indexes[i], indexes[j]) == -1) {
                    swap(i, j);
                }
            }
        }
    }

    // This is a home-grown implementation which we have not had time
    // to research - it may perform poorly in some circumstances. It
    // requires twice the space of an in-place algorithm and makes
    // NlogN assigments shuttling the values between the two
    // arrays. The number of compares appears to vary between N-1 and
    // NlogN depending on the initial order but the main reason for
    // using it here is that, unlike qsort, it is stable.
    public void shuttlesort(int from[], int to[], int low, int high) {
        if (high - low < 2) {
            return;
        }
        int middle = (low + high)/2;
        shuttlesort(to, from, low, middle);
        shuttlesort(to, from, middle, high);

        int p = low;
        int q = middle;

        /* This is an optional short-cut; at each recursive call,
        check to see if the elements in this subset are already
        ordered.  If so, no further comparisons are needed; the
        sub-array can just be copied.  The array must be copied rather
        than assigned otherwise sister calls in the recursion might
        get out of sinc.  When the number of elements is three they
        are partitioned so that the first set, [low, mid), has one
        element and and the second, [mid, high), has two. We skip the
        optimisation when the number of elements is three or less as
        the first compare in the normal merge will produce the same
        sequence of steps. This optimisation seems to be worthwhile
        for partially ordered lists but some analysis is needed to
        find out how the performance drops to Nlog(N) as the initial
        order diminishes - it may drop very quickly.  */

        if (high - low >= 4 && compare(from[middle-1], from[middle]) <= 0) {
            for (int i = low; i < high; i++) {
                to[i] = from[i];
            }
            return;
        }

        // A normal merge.

        for (int i = low; i < high; i++) {
            if (q >= high || (p < middle && compare(from[p], from[q]) <= 0)) {
                to[i] = from[p++];
            }
            else {
                to[i] = from[q++];
            }
        }
    }

    public void swap(int i, int j) {
        int tmp = indexes[i];
        indexes[i] = indexes[j];
        indexes[j] = tmp;
    }

    // The mapping only affects the contents of the data rows.
    // Pass all requests to these rows through the mapping array: "indexes".

    public Object getValueAt(int aRow, int aColumn) {
        checkModel();
        return model.getValueAt(indexes[aRow], aColumn);
    }

    public void setValueAt(Object aValue, int aRow, int aColumn) {
        checkModel();
        model.setValueAt(aValue, indexes[aRow], aColumn);
    }

    public void sortByColumn(int column) {
        sortByColumn(column, true);
    }

    public void sortByColumn(int column, boolean ascending) {
        this.ascending = ascending;
        sortingColumns.removeAllElements();
        sortingColumns.addElement(new Integer(column));
        sort(this);
        super.tableChanged(new TableModelEvent(this));
    }

    // There is no-where else to put this.
    // Add a mouse listener to the Table to trigger a table sort
    // when a column heading is clicked in the JTable.
    public void addMouseListenerToHeaderInTable(JTable table) {
        final TableSorter sorter = this;
        final JTable tableView = table;
        tableView.setColumnSelectionAllowed(false);
        MouseAdapter listMouseListener = new MouseAdapter() {
            public void mouseClicked(MouseEvent e) {
                TableColumnModel columnModel = tableView.getColumnModel();
                int viewColumn = columnModel.getColumnIndexAtX(e.getX());
                int column = tableView.convertColumnIndexToModel(viewColumn);
                if (e.getClickCount() == 1 && column != -1) {
                    //System.out.println("Sorting ...");
                    int shiftPressed = e.getModifiers()&InputEvent.SHIFT_MASK;
                    boolean ascending = (shiftPressed == 0);
                    sorter.sortByColumn(column, ascending);
                }
            }
        };
        JTableHeader th = tableView.getTableHeader();
        th.addMouseListener(listMouseListener);
    }
```

```
}
```

```
//1.3 changes: column.getHeaderRenderer() ->
//             table.getTableHeader().getDefaultRenderer()

import javax.swing.JTable;
import javax.swing.table.AbstractTableModel;
import javax.swing.table.TableColumn;
import javax.swing.DefaultCellEditor;
import javax.swing.table.TableCellRenderer;
import javax.swing.table.DefaultTableCellRenderer;
import javax.swing.JScrollPane;
import javax.swing.JComboBox;
import javax.swing.JFrame;
import javax.swing.SwingUtilities;
import javax.swing.JOptionPane;

import java.awt.*;
import java.awt.event.*;

public class TableRenderDemo extends JFrame {
    private boolean DEBUG = true;

    public TableRenderDemo() {
        super("TableRenderDemo");

        MyTableModel myModel = new MyTableModel();
        JTable table = new JTable(myModel);
        table.setPreferredScrollableViewportSize(new Dimension(500, 70));

        //Create the scroll pane and add the table to it.
        JScrollPane scrollPane = new JScrollPane(table);

        //Set up column sizes.
        initColumnSizes(table, myModel);

        //Fiddle with the Sport column's cell editors/renderers.
        setUpSportColumn(table, table.getColumnModel().getColumn(2));

        //Add the scroll pane to this window.
        getContentPane().add(scrollPane, BorderLayout.CENTER);

        addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });
    }

    /*
     * This method picks good column sizes.
     * If all column heads are wider than the column's cells'
     * contents, then you can just use column.sizeWidthToFit().
     */
    private void initColumnSizes(JTable table, MyTableModel model) {
        TableColumn column = null;
        Component comp = null;
        int headerWidth = 0;
        int cellWidth = 0;
        Object[] longValues = model.longValues;
        TableCellRenderer headerRenderer =
            table.getTableHeader().getDefaultRenderer();

        for (int i = 0; i < 5; i++) {
            column = table.getColumnModel().getColumn(i);
            comp = headerRenderer.getTableCellRendererComponent(
                                 null, column.getHeaderValue(),
                                 false, false, 0, 0);
            headerWidth = comp.getPreferredSize().width;

            comp = table.getDefaultRenderer(model.getColumnClass(i)).
                             getTableCellRendererComponent(
                                 table, longValues[i],
                                 false, false, 0, i);
            cellWidth = comp.getPreferredSize().width;

            if (DEBUG) {
                System.out.println("Initializing width of column "
                                   + i + ". "
                                   + "headerWidth = " + headerWidth
                                   + "; cellWidth = " + cellWidth);
            }

            //XXX: Before Swing 1.1 Beta 2, use setMinWidth instead.
            column.setPreferredWidth(Math.max(headerWidth, cellWidth));
        }
    }

    public void setUpSportColumn(JTable table,
                                 TableColumn sportColumn) {
        //Set up the editor for the sport cells.
        JComboBox comboBox = new JComboBox();
        comboBox.addItem("Snowboarding");
        comboBox.addItem("Rowing");
        comboBox.addItem("Chasing toddlers");
        comboBox.addItem("Speed reading");
        comboBox.addItem("Teaching high school");
        comboBox.addItem("None");
        sportColumn.setCellEditor(new DefaultCellEditor(comboBox));

        //Set up tool tips for the sport cells.
        DefaultTableCellRenderer renderer =
                new DefaultTableCellRenderer();
        renderer.setToolTipText("Click for combo box");
        sportColumn.setCellRenderer(renderer);

        //Set up tool tip for the sport column header.
        TableCellRenderer headerRenderer = table.getTableHeader().
                getDefaultRenderer();
        if (headerRenderer instanceof DefaultTableCellRenderer) {
            ((DefaultTableCellRenderer)headerRenderer).setToolTipText(
                "Click the sport to see a list of choices");
        }
    }

    class MyTableModel extends AbstractTableModel {
        final String[] columnNames = {"First Name",
                                      "Last Name",
                                      "Sport",
                                      "# of Years",
                                      "Vegetarian"};
        final Object[][] data = {
            {"Mary", "Campione",
             "Snowboarding", new Integer(5), new Boolean(false)},
            {"Alison", "Huml",
             "Rowing", new Integer(3), new Boolean(true)},
            {"Kathy", "Walrath",
             "Chasing toddlers", new Integer(2), new Boolean(false)},
            {"Sharon", "Zakhour",
             "Speed reading", new Integer(10), new Boolean(true)},
            {"Angela", "Lih",
             "Teaching high school", new Integer(4), new Boolean(false)}
        };
        public final Object[] longValues = {"Angela", "Andrews",
                                            "Teaching high school",
                                            new Integer(20), Boolean.TRUE};

        public int getColumnCount() {
            return columnNames.length;
        }

        public int getRowCount() {
            return data.length;
        }

        public String getColumnName(int col) {
            return columnNames[col];
        }

        public Object getValueAt(int row, int col) {
            return data[row][col];
        }

        /*
         * JTable uses this method to determine the default renderer/
         * editor for each cell.  If we didn't implement this method,
         * then the last column would contain text ("true"/"false"),
         * rather than a check box.
         */
        public Class getColumnClass(int c) {
            return getValueAt(0, c).getClass();
        }

        /*
         * Don't need to implement this method unless your table's
         * editable.
         */
        public boolean isCellEditable(int row, int col) {
            //Note that the data/cell address is constant,
            //no matter where the cell appears onscreen.
            if (col < 2) {
                return false;
            } else {
                return true;
            }
        }

        /*
         * Don't need to implement this method unless your table's
         * data can change.
         */
        public void setValueAt(Object value, int row, int col) {
            if (DEBUG) {
                System.out.println("Setting value at " + row + "," + col
                                   + " to " + value
                                   + " (an instance of "
                                   + value.getClass() + ")");
            }
            if (data[0][col] instanceof Integer) {
                //If we don't do something like this, the column
                //switches to contain Strings.
                try {
                    data[row][col] = new Integer((String)value);
                    fireTableCellUpdated(row, col);
                } catch (NumberFormatException e) {
                    JOptionPane.showMessageDialog(TableRenderDemo.this,
                        "The \"" + getColumnName(col)
                        + "\" column accepts only integer values.");
                }
            } else {
                data[row][col] = value;
                fireTableCellUpdated(row, col);
            }

            if (DEBUG) {
                System.out.println("New value of data:");
                printDebugData();
            }
        }

        private void printDebugData() {
            int numRows = getRowCount();
            int numCols = getColumnCount();

            for (int i=0; i < numRows; i++) {
                System.out.print("    row " + i + ":");
                for (int j=0; j < numCols; j++) {
                    System.out.print("  " + data[i][j]);
                }
                System.out.println();
            }
            System.out.println("--------------------------");
        }
    }

    public static void main(String[] args) {
        TableRenderDemo frame = new TableRenderDemo();
        frame.pack();
        frame.setVisible(true);
    }
}
```

```
/**
 * In a chain of data manipulators some behaviour is common. TableMap
 * provides most of this behavour and can be subclassed by filters
 * that only need to override a handful of specific methods. TableMap
 * implements TableModel by routing all requests to its model, and
 * TableModelListener by routing all events to its listeners. Inserting
 * a TableMap which has not been subclassed into a chain of table filters
 * should have no effect.
 *
 * @version 1.4 12/17/97
 * @author Philip Milne */

import javax.swing.table.*;
import javax.swing.event.TableModelListener;
import javax.swing.event.TableModelEvent;

public class TableMap extends AbstractTableModel
                      implements TableModelListener {
    protected TableModel model;

    public TableModel getModel() {
        return model;
    }

    public void setModel(TableModel model) {
        this.model = model;
        model.addTableModelListener(this);
    }

    // By default, implement TableModel by forwarding all messages
    // to the model.

    public Object getValueAt(int aRow, int aColumn) {
        return model.getValueAt(aRow, aColumn);
    }

    public void setValueAt(Object aValue, int aRow, int aColumn) {
        model.setValueAt(aValue, aRow, aColumn);
    }

    public int getRowCount() {
        return (model == null) ? 0 : model.getRowCount();
    }

    public int getColumnCount() {
        return (model == null) ? 0 : model.getColumnCount();
    }

    public String getColumnName(int aColumn) {
        return model.getColumnName(aColumn);
    }

    public Class getColumnClass(int aColumn) {
        return model.getColumnClass(aColumn);
    }

    public boolean isCellEditable(int row, int column) {
         return model.isCellEditable(row, column);
    }
//
// Implementation of the TableModelListener interface,
//
    // By default forward all events to all the listeners.
    public void tableChanged(TableModelEvent e) {
        fireTableChanged(e);
    }
}
```

```
import javax.swing.JTable;
import javax.swing.table.AbstractTableModel;
import javax.swing.JScrollPane;
import javax.swing.JFrame;
import javax.swing.SwingUtilities;
import javax.swing.JOptionPane;
import java.awt.*;
import java.awt.event.*;

public class TableSorterDemo extends JFrame {
    private boolean DEBUG = true;

    public TableSorterDemo() {
        super("TableSorterDemo");

        MyTableModel myModel = new MyTableModel();
        TableSorter sorter = new TableSorter(myModel); //ADDED THIS
        //JTable table = new JTable(myModel);          //OLD
        JTable table = new JTable(sorter);             //NEW
        sorter.addMouseListenerToHeaderInTable(table); //ADDED THIS
        table.setPreferredScrollableViewportSize(new Dimension(500, 70));

        //Create the scroll pane and add the table to it.
        JScrollPane scrollPane = new JScrollPane(table);

        //Add the scroll pane to this window.
        getContentPane().add(scrollPane, BorderLayout.CENTER);

        addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });
    }

    class MyTableModel extends AbstractTableModel {
        final String[] columnNames = {"First Name",
                                      "Last Name",
                                      "Sport",
                                      "# of Years",
                                      "Vegetarian"};
        final Object[][] data = {
            {"Mary", "Campione",
             "Snowboarding", new Integer(5), new Boolean(false)},
            {"Alison", "Huml",
             "Rowing", new Integer(3), new Boolean(true)},
            {"Kathy", "Walrath",
             "Chasing toddlers", new Integer(2), new Boolean(false)},
            {"Mark", "Andrews",
             "Speed reading", new Integer(20), new Boolean(true)},
            {"Angela", "Lih",
             "Teaching high school", new Integer(4), new Boolean(false)}
        };

        public int getColumnCount() {
            return columnNames.length;
        }

        public int getRowCount() {
            return data.length;
        }
        public String getColumnName(int col) {
            return columnNames[col];
        }

        public Object getValueAt(int row, int col) {
            return data[row][col];
        }

        /*
         * JTable uses this method to determine the default renderer/
         * editor for each cell.  If we didn't implement this method,
         * then the last column would contain text ("true"/"false"),
         * rather than a check box.
         */
        public Class getColumnClass(int c) {
            return getValueAt(0, c).getClass();
        }

        /*
         * Don't need to implement this method unless your table's
         * editable.
         */
        public boolean isCellEditable(int row, int col) {
            //Note that the data/cell address is constant,
            //no matter where the cell appears onscreen.
            if (col < 2) {
                return false;
            } else {
                return true;
            }
        }

        /*
         * Don't need to implement this method unless your table's
         * data can change.
         */
        public void setValueAt(Object value, int row, int col) {
            if (DEBUG) {
                System.out.println("Setting value at " + row + "," + col
                                   + " to " + value
                                   + " (an instance of "
                                   + value.getClass() + ")");
            }

            if (data[0][col] instanceof Integer
                    && !(value instanceof Integer)) {
                //With JFC/Swing 1.1 and JDK 1.2, we need to create
                //an Integer from the value; otherwise, the column
                //switches to contain Strings.  Starting with v 1.3,
                //the table automatically converts value to an Integer,
                //so you only need the code in the 'else' part of this
                //'if' block.
                try {
                    data[row][col] = new Integer(value.toString());
                    fireTableCellUpdated(row, col);
                } catch (NumberFormatException e) {
                    JOptionPane.showMessageDialog(TableSorterDemo.this,
                        "The \"" + getColumnName(col)
                        + "\" column accepts only integer values.");
                }
            } else {
                data[row][col] = value;
                fireTableCellUpdated(row, col);
            }

            if (DEBUG) {
                System.out.println("New value of data:");
                printDebugData();
            }
        }

        private void printDebugData() {
            int numRows = getRowCount();
            int numCols = getColumnCount();

            for (int i=0; i < numRows; i++) {
                System.out.print("    row " + i + ":");
                for (int j=0; j < numCols; j++) {
                    System.out.print("  " + data[i][j]);
                }
                System.out.println();
            }
            System.out.println("--------------------------");
        }
    }

    public static void main(String[] args) {
        TableSorterDemo frame = new TableSorterDemo();
        frame.pack();
        frame.setVisible(true);
    }
}
```

Trail: Creating a GUI with JFC/Swing

Lesson: User Interfaces that Swing: A Quick Start Guide

This lesson is a quick start guide to using Swing components to build user interfaces. This lesson is built around several progressively complicated examples.

Note: This material is covered in depth in the full Swing trail: Creating a GUI with JFC/Swing◆. This lesson is designed for readers who want to learn the basics quickly by examining some simple examples.

We cover many standard graphical user interface (GUI) components that the Java^{TM} 2 platform provides, such as buttons, labels, and text areas. The handling of events is also discussed, as are layout management and accessibility.

Overview of the Swing API◆
This page gives a quick overview of the history of the Swing package and how to compile and run Swing programs.

Your First Swing Program◆
This small example has all the code that every Swing application must have.

Example Two: `SwingApplication`◆
This section takes you through the code for a small Swing application. The topics covered include: look and feel, setting up buttons and labels, handling events, and adding borders.

Example Three: `CelsiusConverter`◆
The third example, a program that converts a given temperature from Celsius to Fahrenheit, illustrates how to add HTML and icons to components.

Example Four: `LunarPhases`◆

The fourth example covers how to set up multiple panels, compound borders, combo boxes, and how to load multiple images.

Example Five: `VoteDialog`◆

You can vote for your favorite political candidate in the final example, `VoteDialog`. This application illustrates the use of radio buttons and dialogs.

Layout Management◆

This section discusses how to position the components in a container.

Threads and Swing◆

Thread issues are discussed in this section, including the "Single-Thread Rule."

Summary◆

A summary of important concepts covered in this section.

Questions and Exercises◆

Try these questions and exercises to test what you've learned in this lesson.

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Lesson: Getting Started with Swing

About the JFC and Swing

This section answers four questions:

- What are the JFC and Swing?
- Which releases contain the Swing API?
- What Swing packages should I use?
- How are Swing components different from AWT components?

What Are the JFC and Swing?

JFC is short for Java™ Foundation Classes, which encompass a group of features to help people build graphical user interfaces (GUIs). The JFC was first announced at the 1997 JavaOne developer conference and is defined as containing the following features:

The Swing Components
Include everything from buttons to split panes to tables. You can see mugshots of all the components in A Visual Index to the Swing Components◆.

Pluggable Look and Feel Support
Gives any program that uses Swing components a choice of looks and feels. For example, the same program can use either the Java™ look and feel or the Windows look and feel. We expect many more look-and-feel packages -- including some that use sound instead of a visual "look" -- to become available from various sources.

Accessibility API
Enables assistive technologies such as screen readers and Braille displays to get information from the user interface.

Java 2D™ API (Java 2 Platform only)
Enables developers to easily incorporate high-quality 2D graphics, text, and images in applications and in applets.

Drag and Drop Support (Java 2 Platform only)
Provides the ability to drag and drop between a Java application and a native application.

The first three JFC features were implemented without any native code, relying only on the

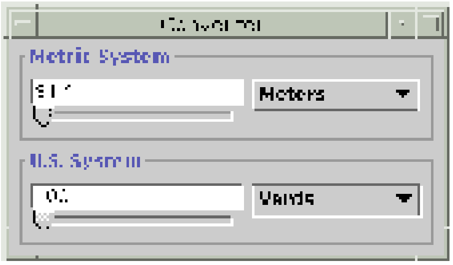
API defined in JDK 1.1. As a result, they could and did become available as an extension to JDK 1.1. This extension was released as JFC 1.1, which is sometimes called "the Swing release." The API in JFC 1.1 is often called "the Swing API."

Note: "Swing" was the codename of the project that developed the new components. Although it's an unofficial name, it's frequently used to refer to the new components and related API. It's immortalized in the package names for the Swing API, which begin with `javax.swing`.

This trail concentrates on the Swing components. We help you choose the appropriate ones for your GUI, tell you how to use them, and give you the background information you need to use them effectively. We discuss the Pluggable look and feel and Accessibility support when they affect how you write programs that use Swing components. This trail does not cover the JFC features that appear only in the Java 2 Platform. For information about those, refer to 2D Graphics and to the JFC Home Page.

The following snapshots show three views of a GUI that uses Swing components. Each picture shows the same program, but with a different look and feel. The program, called `Converter`, is discussed in detail at the end of the next lesson, Swing Features and Concepts.

Java look and feel



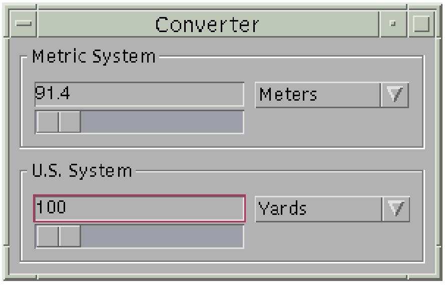
Metric System

Meters

U.S. System

Yards

CDE/Motif look and feel



Converter

Metric System

91.4

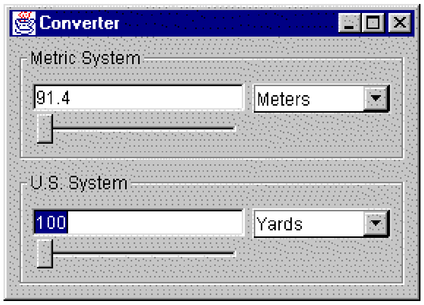
Meters

U.S. System

100

Yards

Windows look and feel



Converter

Metric System

91.4

Meters

U.S. System

100

Yards

Which Releases Contain the Swing API?

The Swing API is available in two forms:

- As a core part of the Java 2 Platform, Standard Edition (including v 1.2 and v 1.3)
- JFC 1.1 (for use with JDK 1.1)

We recommend that you use the latest version of the Java 2 Platform. However, you might need to use an earlier version if, for example, your software must run on platforms that don't yet support the latest version. It's a bit simpler to use the Java 2 Platform than JDK 1.1 because the JFC is built into the Java 2 Platform and you don't need to add libraries to be able to use the Swing API. However, if you need to use JDK 1.1, then adding the Swing API (using JFC 1.1) isn't difficult. Instructions for doing both are in Compiling and Running Swing Programs.

This trail concentrates on the Swing 1.1 API, which is present in the Java 2 Platform v 1.2 and in the release called "JFC 1.1 (with Swing 1.1)." Except where noted, the code in this trail works unchanged with either release and subsequent compatible releases, such as JFC 1.1 (with Swing 1.1.1) and the Java 2 Platform, Standard Edition, v 1.3.

Sun has released many versions of JFC 1.1, which are identified by the version of Swing API they contain. One previous version, for example, was called "JFC 1.1 (with Swing 1.0.3)." The last JFC 1.1 release was Swing version 1.1.1. It had the same API as Swing 1.1, but added many bug fixes, some performance improvements, and a few new capabilities such as HTML text in labels that required no API changes.

The following table shows some of the important releases containing Swing API. Bold font indicates the releases typically used in shipping products.

Swing API Version	**Corresponding JFC 1.1 Release**	**Corresponding Java 2 Platform Version (Standard Edition)**	**Comments**
Swing 1.0.3	**JFC 1.1** **(with Swing 1.0.3)**	*none*	The release of JFC 1.1 included in **Java Plug-in™ 1.1.1**.

Swing 1.1 ***Note:*** *This is the API this trail covers.*	**JFC 1.1 (with Swing 1.1)**	**v 1.2**, **v 1.2.1**	The first releases containing the final Swing 1.1 API supported for use in shipping products. **Java Plug-in 1.1.2** and **Java Plug-in 1.2** provide applet support for JDK 1.1 + Swing 1.1 and Java 2 Platform v 1.2, respectively.
Swing 1.1.1 ***Note:*** *This trail includes notes about this API.*	**JFC 1.1 (with Swing 1.1.1)** ***Note:*** *This is the last release that supports JDK 1.1.*	**v 1.2.2**	Adds performance enhancements, many bug fixes, and selected new functionality (requiring no API changes) to Swing 1.1. **Java Plug-in 1.1.3** and **Java Plug-in 1.2.2** provide applet support for JDK 1.1 + Swing 1.1.1 and Java 2 Platform v 1.2.2, respectively.
no separate "Swing" version number	*none*	**v 1.3**	Adds significant performance enhancements and bug fixes, along with some new features and API additions. For more information, see the release documentation, especially Swing Changes and New Features. **Java Plug-in 1.3** provides applet support for this release.

What Swing Packages Should I Use?

The Swing API is powerful, flexible -- and immense. For example, the 1.1 version of the API has 15 public packages: `javax.accessibility`, `javax.swing`, `javax.swing.border`, `javax.swing.colorchooser`, `javax.swing.event`, `javax.swing.filechooser`, `javax.swing.plaf`, `javax.swing.plaf.basic`, `javax.swing.plaf.metal`, `javax.swing.plaf.multi`, `javax.swing.table`, `javax.swing.text`, `javax.swing.text.html`, `javax.swing.tree`, and `javax.swing.undo`.

Fortunately, most programs use only a small subset of the API. This trail sorts out the API for you, giving you examples of common code and pointing you to methods and classes you're likely to need. Most of the code in this trail uses only one or two Swing packages:

- `javax.swing`
- `javax.swing.event` (not always required)

How Are Swing Components Different from AWT Components?

If you don't care about the AWT components, skip to the next section. You can get a more general introduction to the Swing components from A Quick Tour of a Swing Application's Code and from the Swing Features and Concepts◆ lesson.

The AWT components are those provided by the JDK 1.0 and 1.1 platforms. Although the Java 2 Platform still supports the AWT components, we strongly encourage you to use Swing components instead. You can identify Swing components because their names start with `J`. The AWT button class, for example, is named `Button`, while the Swing button class is named `JButton`. Additionally, the AWT components are in the `java.awt` package, while the Swing components are in the `javax.swing` package.

The biggest difference between the AWT components and Swing components is that the Swing components are implemented with absolutely no native code. Since Swing components aren't restricted to the least common denominator -- the features that are present on every platform -- they can have more functionality than AWT components. Because the Swing components have no native code, they can be be shipped as an add-on to JDK 1.1, in addition to being part of the Java 2 Platform.

Even the simplest Swing components have capabilities far beyond what the AWT components offer:

- Swing buttons and labels can display images instead of, or in addition to, text.
- You can easily add or change the borders drawn around most Swing components. For example, it's easy to put a box around the outside of a container or label.

- You can easily change the behavior or appearance of a Swing component by either invoking methods on it or creating a subclass of it.
- Swing components don't have to be rectangular. Buttons, for example, can be round.
- Assistive technologies such as screen readers can easily get information from Swing components. For example, a tool can easily get the text that's displayed on a button or label.

Swing lets you specify which look and feel your program's GUI uses. By contrast, AWT components always have the look and feel of the native platform.

Another interesting feature is that Swing components with state use models to keep the state. A `JSlider`, for instance, uses a `BoundedRangeModel` object to hold its current value and range of legal values. Models are set up automatically, so you don't have to deal with them unless you want to take advantage of the power they can give you.

If you're used to using AWT components, you need to be aware of a few gotchas when using Swing components:

- Programs should not, as a rule, use "heavyweight" components alongside Swing components. Heavyweight components include all the ready-to-use AWT components (such as `Menu` and `ScrollPane`) and all components that inherit from the AWT `Canvas` and `Panel` classes. This restriction exists because when Swing components (and all other "lightweight" components) overlap with heavyweight components, the heavyweight component is always painted on top. For more information, see Mixing Heavy and Light Components, an article in The Swing Connection.
- Swing components aren't thread safe. If you modify a visible Swing component -- invoking its `setText` method, for example -- from anywhere but an event handler, then you need to take special steps to make the modification execute on the event-dispatching thread. This isn't an issue for many Swing programs, since component-modifying code is typically in event handlers.
- The containment hierarchy for any window or applet that contains Swing components must have a Swing top-level container at the root of the hierarchy. For example, a main window should be implemented as a `JFrame` instance rather than as a `Frame` instance.
- You don't add components directly to a top-level container such as a `JFrame`. Instead, you add components to a container (called the *content pane*) that is itself contained by the `JFrame`.

Converting to Swing◆ tells you more about the differences between Swing components and AWT components.

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Trail: Creating a GUI with JFC/Swing
Lesson: Getting Started with Swing

Compiling and Running Swing Programs

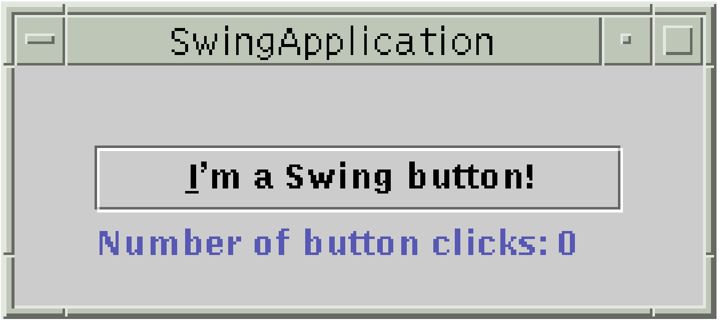
This section tells you how to compile and run a Swing application. The compilation instructions work for all Swing programs -- applets, as well as applications. If you're interested in Swing applets, you should also read Running Swing Applets. If you aren't yet interested in compiling and running Swing programs, you can skip directly to A Quick Tour of a Swing Application's Code, which guides you through the code for a simple application.

The instructions in this section assume that you're already comfortable with writing and compiling programs that use the Java platform. If you aren't, please go to the Getting Started◆ trail. In particular, you'll need to successfully follow the instructions in A Closer Look at HelloWorld◆ before you attempt to compile and run any Swing programs.

How you compile and run Swing programs depends on whether you're using JDK 1.1 or the Java 2 Platform. Using the Java 2 Platform is a bit simpler because Swing is built into it. Choose the instructions corresponding to the release you're using:

- **Java 2 Platform, v 1.2 or 1.3**
- **JDK 1.1 + JFC/Swing Release**

Both instructions tell you how to run a simple program, called `SwingApplication`, whose GUI looks like this:



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Trail: Creating a GUI with JFC/Swing
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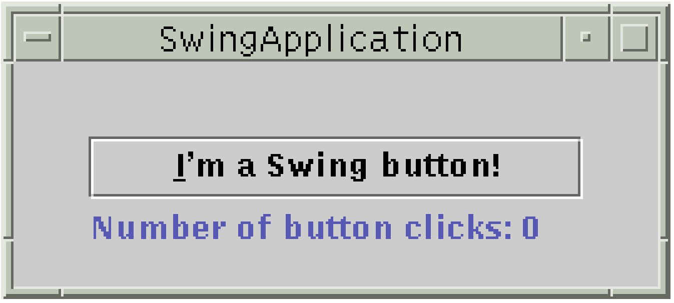
A Quick Tour of a Swing Application's Code

This section takes you through the code for the `SwingApplication` program. The next lesson, Swing Features and Concepts◆, provides full explanations of the topics introduced in this section. It also provides a bigger, more realistic example that you can use to expand and test your Swing knowledge.

`SwingApplication` brings up a window that looks like this:



Each time the user clicks the button, the label is updated. You can find the whole program in `SwingApplication.java`◆.

The code in `SwingApplication.java` accomplishes the following tasks:

- Importing Swing packages
- Choosing the look and feel
- Setting up the top-level container
- Setting up buttons and labels
- Adding components to containers
- Adding borders around components
- Handling events
- Dealing with thread issues
- Supporting assistive technologies

Importing Swing Packages

The following line imports the main Swing package:

```
import javax.swing.*;
```

Note: Early JFC 1.1 and Java 2 SDK v 1.2 beta releases used different names for the Swing packages. See Swing Package Names for details.

Most Swing programs also need to import the two main AWT packages:

```
import java.awt.*;
import java.awt.event.*;
```

Choosing the Look and Feel

Swing allows you to specify which look and feel your program uses -- Java look and feel, Windows look and feel, CDE/Motif look and feel, and so on. The bold code in the following snippet shows you how `SwingApplication` specifies the look and feel:

```
public static void main(String[] args) {
    try {
        UIManager.setLookAndFeel(
            UIManager.getCrossPlatformLookAndFeelClassName());
    } catch (Exception e) { }

    ...//Create and show the GUI...
}
```

The preceding code essentially says, "I don't care whether the user has chosen a look and feel -- use the cross-platform look and feel (the Java look and feel)." You already know what the Java look and feel looks like, since almost all of our screenshots show it.

For more information on specifying the look and feel, see How to Set the Look and Feel◆.

Setting Up the Top-Level Container

Every program that presents a Swing GUI contains at least one top-level Swing container. For most programs, the top-level Swing containers are instances of `JFrame`, `JDialog`, or (for applets) `JApplet`. Each `JFrame` object implements a single main window, and each `JDialog` implements a secondary window. Each `JApplet` object implements an applet's display area within a browser window. A top-level Swing container provides the support that Swing components need to perform their painting and event handling.

The `SwingApplication` example has only one top-level container, a `JFrame`. When the user closes the frame, the application exits. Here is the code that sets up and shows the frame:

```
public class SwingApplication {
    ...
    public static void main(String[] args) {
        ...
        JFrame frame = new JFrame("SwingApplication");
        //...create the components to go into the frame...
        //...stick them in a container named contents...
        frame.getContentPane().add(contents, BorderLayout.CENTER);

        //Finish setting up the frame, and show it.
        frame.addWindowListener(...);
        frame.pack();
        frame.setVisible(true);
    }
}
```

For more information about top-level containers, see Swing Components and the Containment Hierarchy.

Setting Up Buttons and Labels

Like most GUIs, the `SwingApplication` GUI contains a button and a label. (Unlike most GUIs, that's about all that `SwingApplication` contains.) Here's the code that initializes the button:

```
JButton button = new JButton("I'm a Swing button!");
button.setMnemonic(KeyEvent.VK_I);
button.addActionListener(...create an action listener...);
```

The first line creates the button. The second sets the I key as the mnemonic that the user can use to simulate a click of the button. For example, in the Java look and feel, typing Alt-i results in a button click. The third line registers an event handler for the button click. You'll see the event-handling code for this program in Handling Events.

Here's the code that initializes and manipulates the label:

```
...//where instance variables are declared:
private static String labelPrefix = "Number of button clicks: ";
private int numClicks = 0;

...//in GUI initialization code:
final JLabel label = new JLabel(labelPrefix + "0    ");
...
label.setLabelFor(button);
```

```
...//in the event handler for button clicks:
label.setText(labelPrefix + numClicks);
```

The preceding code is pretty straightforward, except for the line that invokes the `setLabelFor` method. That code exists solely to hint to assistive technologies that the label describes the button. For more information, see Supporting Assistive Technologies.

For more information about Swing components such as buttons and labels, see Using Swing Components◆.

Adding Components to Containers

`SwingApplication` groups the label and button in a container (a `JPanel`) before adding the components to the frame. Here's the code that initializes the panel:

```
JPanel pane = new JPanel();
pane.setBorder(BorderFactory.createEmptyBorder(30, 30, 10, 30));
pane.setLayout(new GridLayout(0, 1));
pane.add(button);
pane.add(label);
```

The first line of code creates the panel. The second line adds a border to it. We'll discuss the border later.

The third line of code creates a layout manager that forces the panel's contents to be displayed in a single column. The last lines add the button and label to the panel. Adding the button and label to the panel means they are controlled by the panel's layout manager. Specifically, a container's layout manager determines the size and position of each component that's been added to the container.

Layout management concepts are discussed in Layout Management◆. To learn how to use individual layout managers, see Laying Out Components Within a Container◆.

Adding Borders Around Components

Here, again, is the code that adds a border to the panel:

```
pane.setBorder(BorderFactory.createEmptyBorder(
                                30, //top
                                30, //left
                                10, //bottom
                                30) //right
                                );
```

This border simply provides some empty space around the panel's contents -- 30 extra pixels on the top, left, and right, and 10 extra pixels on the bottom. Borders are a feature that `JPanel` inherits from the `JComponent` class.

Border concepts are discussed in Layout Management◆ and Painting◆. See How to Use Borders ◆ for information about using the border API.

Handling Events

The `SwingApplication` example contains two event handlers. One handles button clicks (action events); the other handles window closing (window events). Here is the event-handling code from `SwingApplication`:

```
button.addActionListener(new ActionListener() {
    public void actionPerformed(ActionEvent e) {
        numClicks++;
        label.setText(labelPrefix + numClicks);
    }
});
...
frame.addWindowListener(new WindowAdapter() {
    public void windowClosing(WindowEvent e) {
        System.exit(0);
    }
});
```

You can read about Swing event handling in Event Handling◆ and Writing Event Listeners◆.

Dealing with Thread Issues

The `SwingApplication` program is thread safe. Once its GUI is visible, its only GUI manipulation (updating the label) occurs in an event handler. Because the event handler runs in the same thread that performs all event handling and painting for the application, there's no possibility that two threads will try to manipulate the GUI at once.

However, it can be all too easy to introduce thread problems into a program. See Threads and Swing◆ for information about thread safety in Swing.

Supporting Assistive Technologies

Support for assistive technologies -- devices such as screen readers that provide alternate ways of accessing information in a GUI -- is already included in every Swing component. The only code in `SwingApplication` that exists solely to support assistive technologies is this:

```
label.setLabelFor(button);
```

Assistive technologies can get plenty of information from Swing components, without any special code from you. For example, assistive technologies can automatically get the text information set by the following lines of code:

```
JButton button = new JButton("I'm a Swing button!");
label = new JLabel(labelPrefix + "0    ");
label.setText(labelPrefix + numClicks);
JFrame frame = new JFrame("SwingApplication");
```

See How to Support Assistive Technologies◆ for more information about how you can ensure that your programs work well with tools that use the Accessibility API to query components.

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```java
import javax.swing.JInternalFrame;
import javax.swing.JDesktopPane;
import javax.swing.JMenu;
import javax.swing.JMenuItem;
import javax.swing.JMenuBar;
import javax.swing.JFrame;

import java.awt.event.*;
import java.awt.*;

public class InternalFrameDemo extends JFrame {
    JDesktopPane desktop;

    public InternalFrameDemo() {
        super("InternalFrameDemo");

        //Make the big window be indented 50 pixels from each edge
        //of the screen.
        int inset = 50;
        Dimension screenSize = Toolkit.getDefaultToolkit().getScreenSize();
        setBounds(inset, inset,
                  screenSize.width - inset*2,
                  screenSize.height-inset*2);

        //Quit this app when the big window closes.
        addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });

        //Set up the GUI.
        desktop = new JDesktopPane(); //a specialized layered pane
        createFrame(); //Create first window
        setContentPane(desktop);
        setJMenuBar(createMenuBar());

        //Make dragging faster:
        desktop.putClientProperty("JDesktopPane.dragMode", "outline");
    }

    protected JMenuBar createMenuBar() {
        JMenuBar menuBar = new JMenuBar();

        JMenu menu = new JMenu("Document");
        menu.setMnemonic(KeyEvent.VK_D);
        JMenuItem menuItem = new JMenuItem("New");
        menuItem.setMnemonic(KeyEvent.VK_N);
        menuItem.addActionListener(new ActionListener() {
            public void actionPerformed(ActionEvent e) {
                createFrame();
            }
        });
        menu.add(menuItem);
        menuBar.add(menu);

        return menuBar;
    }

    protected void createFrame() {
        MyInternalFrame frame = new MyInternalFrame();
        frame.setVisible(true); //necessary as of kestrel
        desktop.add(frame);
        try {
            frame.setSelected(true);
        } catch (java.beans.PropertyVetoException e) {}
    }

    public static void main(String[] args) {
        InternalFrameDemo frame = new InternalFrameDemo();
        frame.setVisible(true);
    }
}
```

```java
import javax.swing.JInternalFrame;

import java.awt.event.*;
import java.awt.*;

public class MyInternalFrame extends JInternalFrame {
    static int openFrameCount = 0;
    static final int xOffset = 30, yOffset = 30;

    public MyInternalFrame() {
        super("Document #" + (++openFrameCount),
              true, //resizable
              true, //closable
              true, //maximizable
              true);//iconifiable

        //...Create the GUI and put it in the window...

        //...Then set the window size or call pack...
        setSize(300,300);

        //Set the window's location.
        setLocation(xOffset*openFrameCount, yOffset*openFrameCount);
    }
}
```

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Trail: Creating a GUI with JFC/Swing
Lesson: Using Swing Components

Using Top-Level Containers

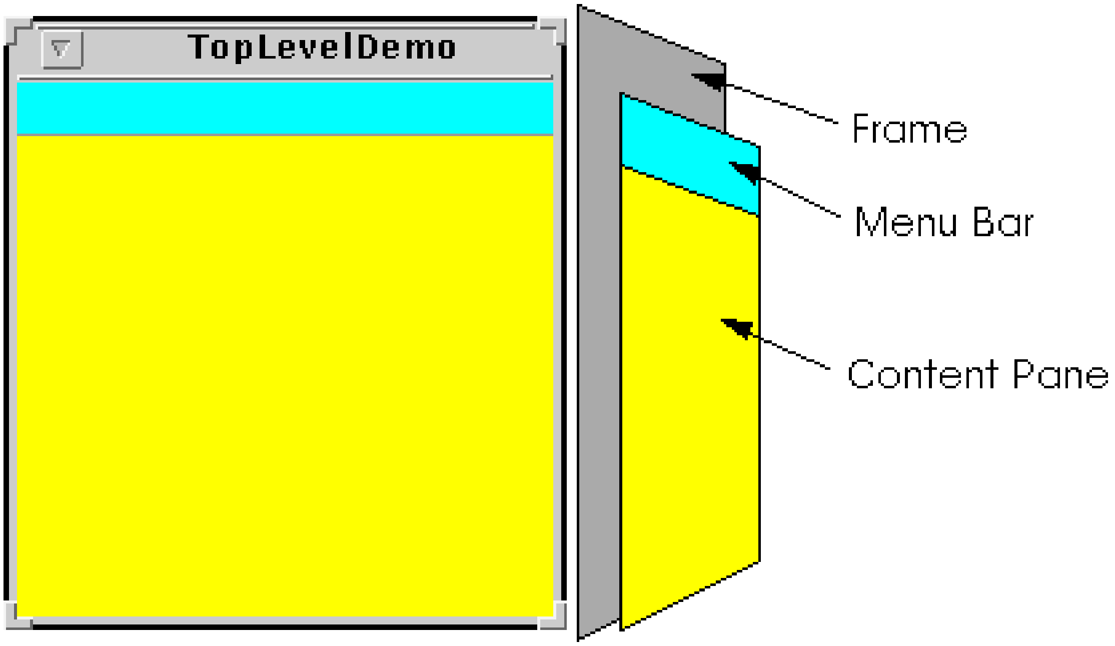
Before you try to use a top-level container, you should read and understand Swing Components and the Containment Hierarchy◆. In particular, you should know these facts:

- Swing provides three generally useful top-level container classes: `JFrame`, `JDialog`, and `JApplet`.

> **Note:** Swing contains a fourth top-level container, `JWindow`, which we don't cover because it isn't generally useful. `JWindow` is the Swing version of the AWT `Window` class, which provides a window with no controls or title that is always on top of every other window.
>
> Swing also provides an intermediate container, `JInternalFrame`, that mimics a frame. However, internal frames aren't actually top-level containers.

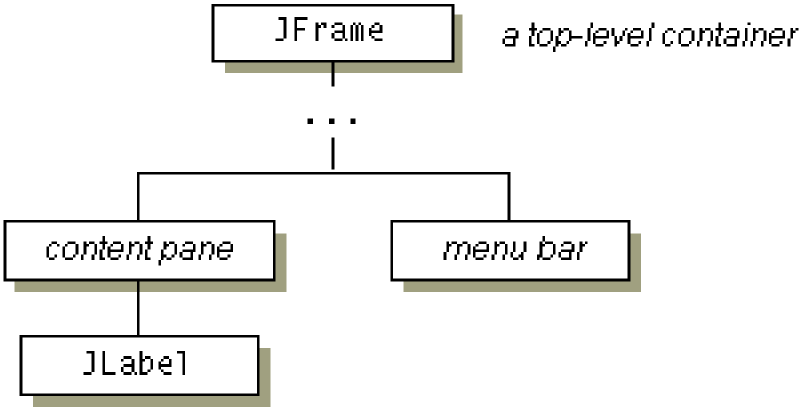
- To appear onscreen, every GUI component must be part of a containment hierarchy. Each containment hierarchy has a top-level container as its root.
- Each top-level container has a content pane that, generally speaking, contains the visible components in that top-level container's GUI.
- You can optionally add a menu bar to a top-level container. The menu bar is positioned within the top-level container, but outside the content pane.

Here's a picture of a frame created by an application. The frame contains an empty cyan menu bar and, in the frame's content pane, a large yellow label.



You can find the entire source for this example in `TopLevelDemo.java`. Although the example uses a `JFrame` in a standalone application, the same concepts apply to `JApplet`s and `JDialog`s.

Here's the containment hierarchy for this example's GUI:



As the ellipses imply, we left some details out of this diagram. We reveal the missing details a bit later. Here are the topics this section discusses:

- Top-Level Containers and Containment Hierarchies
- Adding Components to the Content Pane
- Adding a Menu Bar
- The Root Pane (a.k.a. The Missing Details)

Top-Level Containers and Containment Hierarchies

Each program that uses Swing components has at least one top-level container. This top-level container is the root of a containment hierarchy -- the hierarchy that contains all of the Swing components that appear inside the top-level container.

As a rule, a standalone application with a Swing-based GUI has at least one containment hierarchy with a `JFrame` as its root. For example, if an application has one main window and two dialogs, then the application has three containment hierarchies, and thus three top-level containers. One containment hierarchy has a `JFrame` as its root, and each of the other two has a `JDialog` object as its root.

A Swing-based applet has at least one containment hierarchy, exactly one of which is rooted by a `JApplet` object. For example, an applet that brings up a dialog has two containment hierarchies. The components in the browser window are in a containment hierarchy rooted by a `JApplet` object. The dialog has a containment hierarchy rooted by a `JDialog` object.

Adding Components to the Content Pane

Here's the code that the preceding example uses to get a frame's content pane and add the yellow label to it:

```
frame.getContentPane().add(yellowLabel, BorderLayout.CENTER);
```

As the code shows, you find the content pane of a top-level container by calling the `getContentPane` method. The default content pane is a simple intermediate container that inherits from `JComponent`, and that uses a `BorderLayout` as its layout manager.

It's easy to customize the content pane -- setting the layout manager or adding a border, for example. However, there is one tiny gotcha. The `getContentPane` method returns a `Container` object, not a `JComponent` object. This means that if you want to take advantage of the content pane's `JComponent` features, you need to either typecast the return value or create your own component to be the content pane. Our examples generally take the second approach, since it's a little cleaner. Another approach we sometimes take is to simply add a customized component to the content pane, covering the content pane completely.

If you create your own content pane, make sure it's opaque. A `JPanel` object makes a good content pane because it's simple and it's opaque, by default. Note that the default layout manager for `JPanel` is `FlowLayout`; you'll probably want to change it. To make a component the content pane, use the top-level container's `setContentPane` method. For example:

```
JPanel contentPane = new JPanel();
contentPane.setLayout(new BorderLayout());
contentPane.setBorder(someBorder);
contentPane.add(someComponent, BorderLayout.CENTER);
contentPane.add(anotherComponent, BorderLayout.SOUTH);
topLevelContainer.setContentPane(contentPane);
```

Note: Don't use non-opaque containers such as `JScrollPane`, `JSplitPane`, and `JTabbedPane` as content panes. A non-opaque content pane results in messy repaints. Although you can make any Swing component opaque by invoking `setOpaque(true)` on it, some components don't look right when they're completely opaque. For example, tabbed panes generally let part of the underlying container show through, so that the tabs look non-rectangular. So an opaque tabbed pane just tends to look bad.

Adding a Menu Bar

All top-level containers can, in theory, have a menu bar. In practice, however, menu bars usually appear only in frames and perhaps in applets. To add a menu bar to a frame or applet, you create a `JMenuBar` object, populate it with menus, and then call `setJMenuBar`. The `TopLevelDemo` adds a menu bar to its frame with this code:

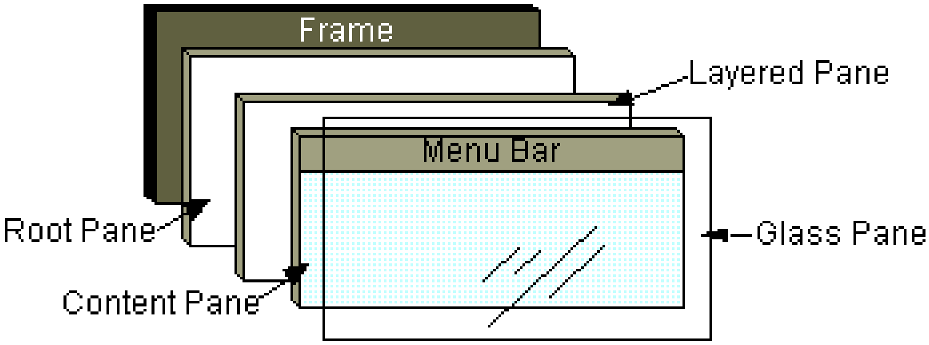
```
frame.setJMenuBar(cyanMenuBar);
```

For more information about implementing menus and menu bars, see How to Use Menus.

The Root Pane

Each top-level container relies on a reclusive intermediate container called the *root pane*. The root pane manages the content pane and the menu bar, along with a couple of other containers. You generally don't need to know about root panes to use Swing components. However, if you ever need to intercept mouse clicks or paint over multiple components, you should get acquainted with root panes.

Here's a glimpse at the components that a root pane provides to a frame (and to every other top-level container):



We've already told you about the content pane and the optional menu bar. The two other components that a root pane adds are a layered pane and a glass pane. The layered pane directly contains the menu bar and content pane, and enables Z-ordering of other components you might add. The glass pane is often used to intercept input events occuring over the top-level container, and can also be used to paint over multiple components.

For more information about the intricacies of root panes, see How to Use Root Panes.

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

public class FrameDemo {
    public static void main(String s[]) {
        JFrame frame = new JFrame("FrameDemo");

        frame.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });

        JLabel emptyLabel = new JLabel("");
        emptyLabel.setPreferredSize(new Dimension(175, 100));
        frame.getContentPane().add(emptyLabel, BorderLayout.CENTER);

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

Trail: Creating a GUI with JFC/Swing
Lesson: Swing Features and Concepts

Threads and Swing

If your program creates and refers to its GUI the right way, you might not need to worry about threads. For example, if your program is an applet, it's safe to construct its GUI in the `init` method. And if your program is an application with the following common pattern, you're also safe:

```
//Thread-safe example
public class MyApplication {
    public static void main(String[] args) {
        JFrame f = new JFrame(...);
        ...//Add components to the frame here...
        f.pack();
        f.setVisible(true);
        //Don't do any more GUI work here.
    }

    ...
    //All manipulation of the GUI -- setText, getText, etc. --
    //is performed in event handlers such as actionPerformed().
    ...
}
```

However, if your program creates threads to perform tasks that affect the GUI, or if it manipulates the already-visible GUI in response to anything but a standard event, then read on! If you aren't familiar with threads, you might first want to read Threads: Doing Two or More Tasks At Once◆ -- just for concepts. Don't bother with the details of coding threads, since we give you information about that in How to Use Threads◆.

The Single-Thread Rule
: Swing components can be accessed by only one thread at a time, generally, the event-dispatching thread.

Exceptions to the Rule
: A few operations are guaranteed to be thread safe.

How to Execute Code in the Event-Dispatching Thread
: If you need access to the UI from outside event-handling or painting code, you can use

the `SwingUtilities` `invokeLater` or `invokeAndWait` method.

The Single-Thread Rule

The single-thread rule is as follows:

Rule: Once a Swing component has been realized, all code that might affect or depend on the state of that component should be executed in the event-dispatching thread.

This rule might sound scary, but for many simple programs, you don't have to worry about threads. Before we go into detail about how to write Swing code, let's define the term *realized*.

Realized means that the component has been painted on-screen, or that it is ready to be painted. A Swing component that's a top-level window is realized by having one of these methods invoked on it: `setVisible(true)`, `show`, or `pack`. Once a window is realized, all the components that it contains are realized. Another way to realize a component is to add it to a container that's already realized. You'll see examples of realizing components later.

Note: The `show` method does the same thing as `setVisible(true)`.

Exceptions to the Rule

There are a few exceptions to the rule that all code that might affect a realized Swing component must run in the event-dispatching thread.

A few methods are thread safe.

In the Swing API documentation, thread-safe methods are marked with this text:

This method is thread safe, although most Swing methods are not.

An application's GUI can often be constructed and shown in the main thread.

As long as no components (Swing or otherwise) have been realized in the current runtime environment, it's fine to construct and show a GUI in the main thread of an application. To help you see why, here's an analysis of the thread safety of the thread-safe example. To refresh your memory, here are the important lines from the example:

```
public static void main(String[] args) {
    JFrame f = new JFrame(...);
    ...//Add components to the frame here...
    f.pack();
    f.setVisible(true);
    //Don't do any more GUI work here.
}
```

1. The example constructs the GUI in the main thread. In general, you can construct (but not show) a GUI in any thread, as long as you don't make any calls that refer to or affect already-realized components.
2. The components in the GUI are realized by the `pack` call.
3. Immediately afterward, the components in the GUI are shown with the `setVisible` (or `show`) call. Technically, the `setVisible` call is unsafe because the components have already been realized by the `pack` call. However, because the program doesn't already have a visible GUI, it's exceedingly unlikely that a paint request will occur before `setVisible` returns.
4. The main thread executes no GUI code after the `setVisible` call. This means that all GUI work moves from the main thread to the event-dispatching thread, and the example is, in practice, thread safe.

An applet's GUI can be constructed and shown in the `init` method.

Existing browsers don't paint an applet until after its `init` and `start` methods have been called. Thus, constructing the GUI in the applet's `init` method is safe, as long as you never call `show()` or `setVisible(true)` on the actual applet object.

Two `JComponent` methods are safe to call from any thread: `repaint` and `revalidate`.

These methods queue requests to be executed on the event-dispatching thread.

Listener lists can be modified from any thread.

It's always safe to call the add*ListenerType*Listener and remove*ListenerType*Listener methods. The add/remove operations have no effect on an event dispatch that's under way.

How to Execute Code in the Event-Dispatching Thread

Most post-initialization GUI work naturally occurs in the event-dispatching thread. Once the GUI is visible, most programs are driven by events such as button actions or mouse clicks, which are always handled in the event-dispatching thread.

However, some programs need to perform non-event-driven GUI work after the GUI is visible. Here are two examples:

Programs that must perform a lengthy initialization operation before they can be used

This kind of program should generally show some GUI while the initialization is occurring, and then update or change the GUI. The initialization should *not* occur in the event-dispatching thread; otherwise, repainting and event dispatch would stop. However, after initialization the GUI update/change *should* occur in the event-dispatching thread, for thread-safety reasons.

Programs whose GUI must be updated as the result of nonstandard events

For example, suppose a server program can get requests from other programs that might be running on different machines. These requests can come at any time, and they result in one of the server's methods being invoked in some possibly unknown thread. How can that method update the GUI? By executing the GUI-update code in the event-dispatching thread.

The `SwingUtilities`◆ class provides two methods to help you run code in the event-dispatching thread:

`invokeLater`

Requests that some code be executed in the event-dispatching thread. This method returns immediately, without waiting for the code to execute.

`invokeAndWait`

Acts like `invokeLater`, except that this method waits for the code to execute. As a rule, you should use `invokeLater` rather than this method.

For information on using `invokeLater` and `invokeAndWait`, and for other tips on writing multithreaded programs, see How to Use Threads◆.

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

public class SliderDemo extends JFrame
                        implements ActionListener {
    //Set up animation parameters.
    static final int FPS_INIT = 15;    //initial frames per second
    int frameNumber = 0;
    int delay;
    Timer timer;
    boolean frozen = false;

    //This label uses ImageIcon to show the doggy pictures.
    JLabel picture;

    public SliderDemo(String windowTitle) {
        super(windowTitle);
        delay = 1000 / FPS_INIT;

        //Create the slider and its label
        JLabel sliderLabel = new JLabel("Frames Per Second", JLabel.CENTER);
        sliderLabel.setAlignmentX(Component.CENTER_ALIGNMENT);

        JSlider framesPerSecond = new JSlider(JSlider.HORIZONTAL,
                                              0, 30, FPS_INIT);
        framesPerSecond.addChangeListener(new SliderListener());

        //Turn on labels at major tick marks.
        framesPerSecond.setMajorTickSpacing(10);
        framesPerSecond.setMinorTickSpacing(1);
        framesPerSecond.setPaintTicks(true);
        framesPerSecond.setPaintLabels(true);
        framesPerSecond.setBorder(
                BorderFactory.createEmptyBorder(0,0,10,0));

        //Create the label for the animation.
        picture = new JLabel(new ImageIcon("images/doggy/T"
                                        + frameNumber
                                        + ".gif"),
                             JLabel.CENTER);
        picture.setAlignmentX(Component.CENTER_ALIGNMENT);
        picture.setBorder(BorderFactory.createCompoundBorder(
                BorderFactory.createLoweredBevelBorder(),
                BorderFactory.createEmptyBorder(10,10,10,10)));

        //Put everything in the content pane.
        JPanel contentPane = new JPanel();
        contentPane.setLayout(new BoxLayout(contentPane, BoxLayout.Y_AXIS));
        contentPane.add(sliderLabel);
        contentPane.add(framesPerSecond);
        contentPane.add(picture);
        contentPane.setBorder(BorderFactory.createEmptyBorder(10,10,10,10));
        setContentPane(contentPane);

        //Set up a timer that calls this object's action handler.
        timer = new Timer(delay, this);
        timer.setInitialDelay(delay * 10); //pauses animation after frames
                                         //0 and 6 by restarting the timer
        timer.setCoalesce(true);
        //Add a listener for window events
        addWindowListener(new WindowAdapter() {
            public void windowIconified(WindowEvent e) {
                stopAnimation();
            }
            public void windowDeiconified(WindowEvent e) {
                startAnimation();
            }
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });

    }

    /** Listens to the slider. */
    class SliderListener implements ChangeListener {
        public void stateChanged(ChangeEvent e) {
            JSlider source = (JSlider)e.getSource();
            if (!source.getValueIsAdjusting()) {
                int fps = (int)source.getValue();
                if (fps == 0) {
                    if (!frozen) stopAnimation();
                } else {
                    delay = 1000 / fps;
                    timer.setDelay(delay);
                    timer.setInitialDelay(delay * 10);
                    if (frozen) startAnimation();
                }
            }
        }
    }

    public void startAnimation() {
        //Start (or restart) animating!
        timer.start();
        frozen = false;
    }

    public void stopAnimation() {
        //Stop the animating thread.
        timer.stop();
        frozen = true;
    }

    //Called when the Timer fires
    public void actionPerformed(ActionEvent e) {
        //Advance the animation frame.
        if (frameNumber==13) {
            frameNumber = 0;
        } else {
            frameNumber++;
        }
        //XXX no caching?
        picture.setIcon(new ImageIcon("images/doggy/T"
                                      + frameNumber
                                      + ".gif"));
        if (frameNumber==0 || frameNumber==6) {
            timer.restart();
        }
    }
    public static void main(String[] args) {
        SliderDemo animator = new SliderDemo("SliderDemo");
        animator.pack();
        animator.setVisible(true);
        animator.startAnimation();
    }
}
```

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

public class SliderDemo2 extends JFrame
                         implements ActionListener {
    //Set up animation parameters.
    static final int FPS_INIT = 15;    //initial frames per second
    int frameNumber = 0;
    int delay;
    Timer timer;
    boolean frozen = false;

    //This label uses ImageIcon to show the doggy pictures.
    JLabel picture;

    public SliderDemo2(String windowTitle) {
        super(windowTitle);
        delay = 1000 / FPS_INIT;

        //Create the slider.
        JSlider framesPerSecond = new JSlider(JSlider.VERTICAL,
                                              0, 30, FPS_INIT);
        framesPerSecond.addChangeListener(new SliderListener());
        framesPerSecond.setMajorTickSpacing(10);
        framesPerSecond.setPaintTicks(true);

        //Create the label table.
        Hashtable labelTable = new Hashtable();
        //PENDING: could use images, but we don't have any good ones.
        labelTable.put(new Integer( 0 ),
                       new JLabel("Stop") );
                     //new JLabel(new ImageIcon("images/stop.gif")) );
        labelTable.put(new Integer( 3 ),
                       new JLabel("Slow") );
                     //new JLabel(new ImageIcon("images/slow.gif")) );
        labelTable.put(new Integer( 30 ),
                       new JLabel("Fast") );
                     //new JLabel(new ImageIcon("images/fast.gif")) );
        framesPerSecond.setLabelTable(labelTable);

        framesPerSecond.setPaintLabels(true);
        framesPerSecond.setBorder(
                BorderFactory.createEmptyBorder(0,0,0,10));

        //Create the label for the animation.
        picture = new JLabel(new ImageIcon("images/doggy/T"
                                         + frameNumber
                                         + ".gif"),
                             JLabel.CENTER);
        picture.setAlignmentX(Component.CENTER_ALIGNMENT);
        picture.setBorder(BorderFactory.createCompoundBorder(
                BorderFactory.createLoweredBevelBorder(),
                BorderFactory.createEmptyBorder(10,10,10,10)));

        //Put everything in the content pane.
        JPanel contentPane = new JPanel();
        contentPane.setLayout(new BorderLayout());
        contentPane.add(framesPerSecond, BorderLayout.WEST);
        contentPane.add(picture, BorderLayout.CENTER);
        contentPane.setBorder(BorderFactory.createEmptyBorder(10,10,10,10));
        setContentPane(contentPane);

        //Set up a timer that calls this object's action handler.
        timer = new Timer(delay, this);
        timer.setInitialDelay(delay * 10); //pauses animation after frames
                                          //0 and 6 by restarting the timer
        timer.setCoalesce(true);

        //Add a listener for window events
        addWindowListener(new WindowAdapter() {
            public void windowIconified(WindowEvent e) {
                stopAnimation();
            }
            public void windowDeiconified(WindowEvent e) {
                startAnimation();
            }
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });

    }

    /** Listens to the slider. */
    class SliderListener implements ChangeListener {
        public void stateChanged(ChangeEvent e) {
            JSlider source = (JSlider)e.getSource();
            if (!source.getValueIsAdjusting()) {
                int fps = (int)source.getValue();
                if (fps == 0) {
                    if (!frozen) stopAnimation();
                } else {
                    delay = 1000 / fps;
                    timer.setDelay(delay);
                    timer.setInitialDelay(delay * 10);
                    if (frozen) startAnimation();
                }
            }
        }
    }

    public void startAnimation() {
        //Start (or restart) animating!
        timer.start();
        frozen = false;
    }

    public void stopAnimation() {
        //Stop the animating thread.
        timer.stop();
        frozen = true;
    }

    //Called when the Timer fires
    public void actionPerformed(ActionEvent e) {
        //Advance the animation frame.
        if (frameNumber==13) {
            frameNumber = 0;
        } else {
            frameNumber++;
        }
        //XXX no caching?
        picture.setIcon(new ImageIcon("images/doggy/T"
                                      + frameNumber
                                      + ".gif"));
        if (frameNumber==0 || frameNumber==6) {
            timer.restart();
        }
    }

    public static void main(String[] args) {
        SliderDemo2 animator = new SliderDemo2("SliderDemo2");
        animator.pack();
        animator.setVisible(true);
        animator.startAnimation();
    }
}
```

```
<APPLET CODE="MouseEventDemo.class"
        ARCHIVE="example-swing/intro.jar"
        WIDTH="450" HEIGHT="200"
        ALT="Your browser understands the applet tag but isn't displaying any applet.">

Since you can't run the applet,
here's a picture of it:

#usemacro UI_FIGURE (
    NAME MouseEventDemo.gif
    W 450
    H 200
    ALT A snapshot of MouseEventDemo, which demonstrates the events that are fired when the clicks
or drags the mouse.

)

</APPLET>
```

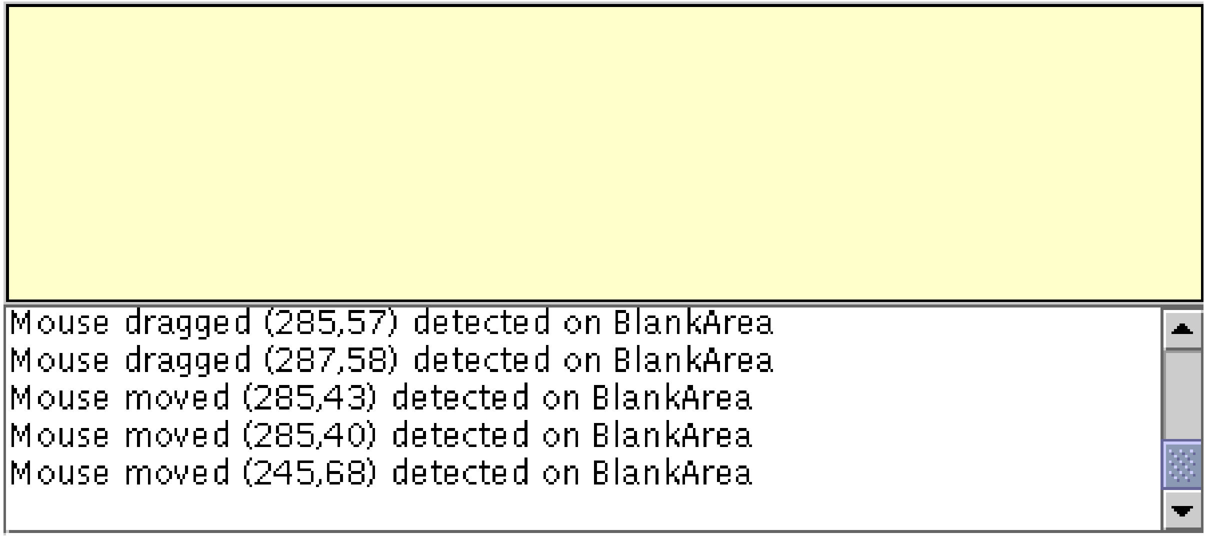
```java
/*
 * Swing version
 */

import javax.swing.*;

import java.awt.Color;
import java.awt.Dimension;
import java.awt.Insets;
import java.awt.GridBagLayout;
import java.awt.GridBagConstraints;

import java.awt.event.MouseMotionListener;
import java.awt.event.MouseEvent;

public class MouseMotionEventDemo extends JApplet
                                  implements MouseMotionListener {
    BlankArea blankArea;
    JTextArea textArea;
    static final String newline = "\n";

    public void init() {
        JPanel contentPane = new JPanel();

        GridBagLayout gridbag = new GridBagLayout();
        GridBagConstraints c = new GridBagConstraints();
        contentPane.setLayout(gridbag);

        c.fill = GridBagConstraints.BOTH;
        c.gridwidth = GridBagConstraints.REMAINDER;
        c.weightx = 1.0;
        c.weighty = 1.0;

        c.insets = new Insets(1, 1, 1, 1);
        blankArea = new BlankArea(new Color(0.98f, 0.97f, 0.85f));
        gridbag.setConstraints(blankArea, c);
        contentPane.add(blankArea);

        c.insets = new Insets(0, 0, 0, 0);
        textArea = new JTextArea();
        textArea.setEditable(false);
        JScrollPane scrollPane = new JScrollPane(textArea,
                JScrollPane.VERTICAL_SCROLLBAR_ALWAYS,
                JScrollPane.HORIZONTAL_SCROLLBAR_AS_NEEDED);
        scrollPane.setPreferredSize(new Dimension(200, 75));
        gridbag.setConstraints(scrollPane, c);
        contentPane.add(scrollPane);

        //Register for mouse events on blankArea and applet.
        blankArea.addMouseMotionListener(this);
        addMouseMotionListener(this);

        setContentPane(contentPane);
    }

    public void mouseMoved(MouseEvent e) {
       saySomething("Mouse moved", e);
    }

    public void mouseDragged(MouseEvent e) {
       saySomething("Mouse dragged", e);
    }
    void saySomething(String eventDescription, MouseEvent e) {
        textArea.append(eventDescription
                        + " (" + e.getX() + "," + e.getY() + ")"
                        + " detected on "
                        + e.getComponent().getClass().getName()
                        + newline);
    }
}
```

The Java^{TM} Tutorial

Trail: Creating a GUI with JFC/Swing
Lesson: Writing Event Listeners

Run MouseMotionEventDemo

Since you can't run the applet, here's a picture of it:



```
Mouse dragged (285,57) detected on BlankArea
Mouse dragged (287,58) detected on BlankArea
Mouse moved (285,43) detected on BlankArea
Mouse moved (285,40) detected on BlankArea
Mouse moved (245,68) detected on BlankArea
```

Note: Because the preceding applet uses the Swing 1.1 API, it requires Java Plug-in 1.1.2 or Java Plug-in 1.2. It won't work with Java Plug-in 1.1.1 or uncustomized 1.1 browsers. For more information about running applets in the tutorial, refer to About Our Examples. That page includes a section about Downloading Java Plug-in.

```java
import java.awt.*;
import java.awt.event.*;
import javax.swing.JMenu;
import javax.swing.JMenuItem;
import javax.swing.JCheckBoxMenuItem;
import javax.swing.JRadioButtonMenuItem;
import javax.swing.ButtonGroup;
import javax.swing.JMenuBar;
import javax.swing.KeyStroke;
import javax.swing.ImageIcon;

import javax.swing.JTextArea;
import javax.swing.JScrollPane;
import javax.swing.JFrame;

/*
 * This class exists solely to show you what menus look like.
 * It has no menu-related event handling.
 */
public class MenuLookDemo extends JFrame {
    JTextArea output;
    JScrollPane scrollPane;

    public MenuLookDemo() {
        JMenuBar menuBar;
        JMenu menu, submenu;
        JMenuItem menuItem;
        JCheckBoxMenuItem cbMenuItem;
        JRadioButtonMenuItem rbMenuItem;

        addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });

        //Add regular components to the window, using the default BorderLayout.
        Container contentPane = getContentPane();
        output = new JTextArea(5, 30);
        output.setEditable(false);
        scrollPane = new JScrollPane(output);
        contentPane.add(scrollPane, BorderLayout.CENTER);

        //Create the menu bar.
        menuBar = new JMenuBar();
        setJMenuBar(menuBar);

        //Build the first menu.
        menu = new JMenu("A Menu");
        menu.setMnemonic(KeyEvent.VK_A);
        menu.getAccessibleContext().setAccessibleDescription(
                "The only menu in this program that has menu items");
        menuBar.add(menu);

        //a group of JMenuItems
        menuItem = new JMenuItem("A text-only menu item",
                                 KeyEvent.VK_T);
        //menuItem.setMnemonic(KeyEvent.VK_T); //used constructor instead
        menuItem.setAccelerator(KeyStroke.getKeyStroke(
                KeyEvent.VK_1, ActionEvent.ALT_MASK));
        menuItem.getAccessibleContext().setAccessibleDescription(
                "This doesn't really do anything");
        menu.add(menuItem);

        menuItem = new JMenuItem("Both text and icon",
                                 new ImageIcon("images/middle.gif"));
        menuItem.setMnemonic(KeyEvent.VK_B);
        menu.add(menuItem);

        menuItem = new JMenuItem(new ImageIcon("images/middle.gif"));
        menuItem.setMnemonic(KeyEvent.VK_D);
        menu.add(menuItem);

        //a group of radio button menu items
        menu.addSeparator();
        ButtonGroup group = new ButtonGroup();

        rbMenuItem = new JRadioButtonMenuItem("A radio button menu item");
        rbMenuItem.setSelected(true);
        rbMenuItem.setMnemonic(KeyEvent.VK_R);
        group.add(rbMenuItem);
        menu.add(rbMenuItem);

        rbMenuItem = new JRadioButtonMenuItem("Another one");
        rbMenuItem.setMnemonic(KeyEvent.VK_O);
        group.add(rbMenuItem);
        menu.add(rbMenuItem);

        //a group of check box menu items
        menu.addSeparator();
        cbMenuItem = new JCheckBoxMenuItem("A check box menu item");
        cbMenuItem.setMnemonic(KeyEvent.VK_C);
        menu.add(cbMenuItem);

        cbMenuItem = new JCheckBoxMenuItem("Another one");
        cbMenuItem.setMnemonic(KeyEvent.VK_H);
        menu.add(cbMenuItem);

        //a submenu
        menu.addSeparator();
        submenu = new JMenu("A submenu");
        submenu.setMnemonic(KeyEvent.VK_S);

        menuItem = new JMenuItem("An item in the submenu");
        menuItem.setAccelerator(KeyStroke.getKeyStroke(
                KeyEvent.VK_2, ActionEvent.ALT_MASK));
        submenu.add(menuItem);

        menuItem = new JMenuItem("Another item");
        submenu.add(menuItem);
        menu.add(submenu);

        //Build second menu in the menu bar.
        menu = new JMenu("Another Menu");
        menu.setMnemonic(KeyEvent.VK_N);
        menu.getAccessibleContext().setAccessibleDescription(
                "This menu does nothing");
        menuBar.add(menu);
    }

    public static void main(String[] args) {
        MenuLookDemo window = new MenuLookDemo();

        window.setTitle("MenuLookDemo");
        window.setSize(450, 260);
        window.setVisible(true);
    }
}
```

Trail: Creating a GUI with JFC/Swing
Lesson: Using Other Swing Features

How to Support Assistive Technologies

You might be wondering what exactly assistive technologies are, and why you should care. Primarily, assistive technologies exist to enable people with permanent or temporary disabilities to use the computer. For example, if you get carpal tunnel syndrome, you can use assistive technologies to accomplish your work without using your hands.

Assistive technologies -- voice interfaces, screen readers, alternate input devices, and so on -- are useful not only for people with disabilities, but also for people using computers in non-office environments. For example, if you're stuck in a traffic jam, you might use assistive technologies to check your e-mail, using only voice input and output. The information that enables assistive technologies can be used for other tools, as well, such as automated GUI testers and input devices such as touchscreens. Assistive technologies get information from components using the Accessibility API, which is defined in the `javax.accessibility`◆ package.

Because support for the Accessibility API is built into the Swing components, your Swing program will probably work just fine with assistive technologies, even if you do nothing special. For example, assistive technologies can automatically get the text information that is set by the following lines of code:

```
JButton button = new JButton("I'm a Swing button!");
label = new JLabel(labelPrefix + "0    ");
label.setText(labelPrefix + numClicks);
JFrame frame = new JFrame("SwingApplication");
```

Assistive technologies can also grab the tool tip text (if any) associated with a component and use it to describe the component to the user.

With very little extra effort, however, you can make your program function even more smoothly with assistive technologies. Besides helping individual users, this will also make your product more attractive to government, education, and large corporate markets.

The rest of this section covers these topics:

- Rules for Supporting Accessibility
- Setting Accessible Names and Descriptions on Components
- Concepts: How Accessibility Works
- Making Custom Components Accessible
- Testing for Accessibility

- The Accessibility API
- Examples that Use the Accessibility API

Rules for Supporting Accessibility

Here are a few things you can do to make your program work as well as possible with assistive technologies:

- If a component doesn't display a short string (which serves as its default name), specify a name with the `setAccessibleName` method. You might want to do this for image-only buttons, panels that provide logical groupings, text areas, and so on.

- Set tool tip◆ text for components whenever it makes sense to do so. For example:

  ```
  aJComponent.setToolTipText("Clicking this component " +
                             "causes XYZ to happen.");
  ```

- If you don't want to provide a tool tip for a component, use the `setAccessibleDescription` method to provide a description that assistive technologies can give the user. For example:

  ```
  aJComponent.getAccessibleContext().
      setAccessibleDescription(
      "Clicking this component causes XYZ to happen.");
  ```

- Specify keyboard alternatives wherever possible. Make sure you can use your program with only the keyboard. Try hiding your mouse!

  Buttons◆ support keyboard alternatives with the `setMnemonic` method. Menus inherit the button mnemonic support and also support accelerators, as described in Enabling Keyboard Operation◆. Mnemonics and accelerators are special cases of keyboard-generated actions, which are described in The JComponent Class◆.

- Use the `setDescription` method to provide a text description for all `ImageIcon` objects in your program.

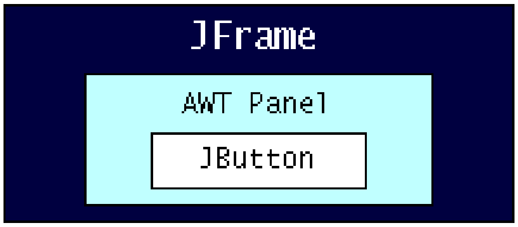
- If a bunch of components form a logical group, try to put them into one container. For example, use a `JPanel`◆ to contain all the radio buttons in a radio button group.

- Whenever you have a label◆ that describes another component, use the `setLabelFor` method so that assistive technologies can find the component that the label is associated with. This is especially important when the label displays a mnemonic for another component (such as a text field),

- If you create a custom component, make sure it supports accessibility. In particular, be aware that subclasses of `JComponent` are not automatically accessible. Custom components that are descendants of other Swing components should override inherited accessibility information as necessary. For more information, see Concepts: How Accessibility Works and Making Custom Components Accessible.

- Use the examples provided with the accessibility utilities to test your program. Although the primary purpose of these examples is to show programmers how to use the Accessibility API when implementing assistive technologies, these examples are also quite useful for testing application programs for accessibility. Testing for Accessibility shows `ScrollDemo` running with Monkey -- one of the accessibility utilities examples. Monkey shows the tree of accessible components in a program and lets you interact with those components.

- Finally, don't break what you get for free! If your GUI has an inaccessible container -- for example, an AWT `Panel` or any other container that doesn't implement the `Accessible` interface -- any components inside that container become inaccessible. For example, if you put a `JButton` inside a `Panel`, then the `JButton` becomes inaccessible.

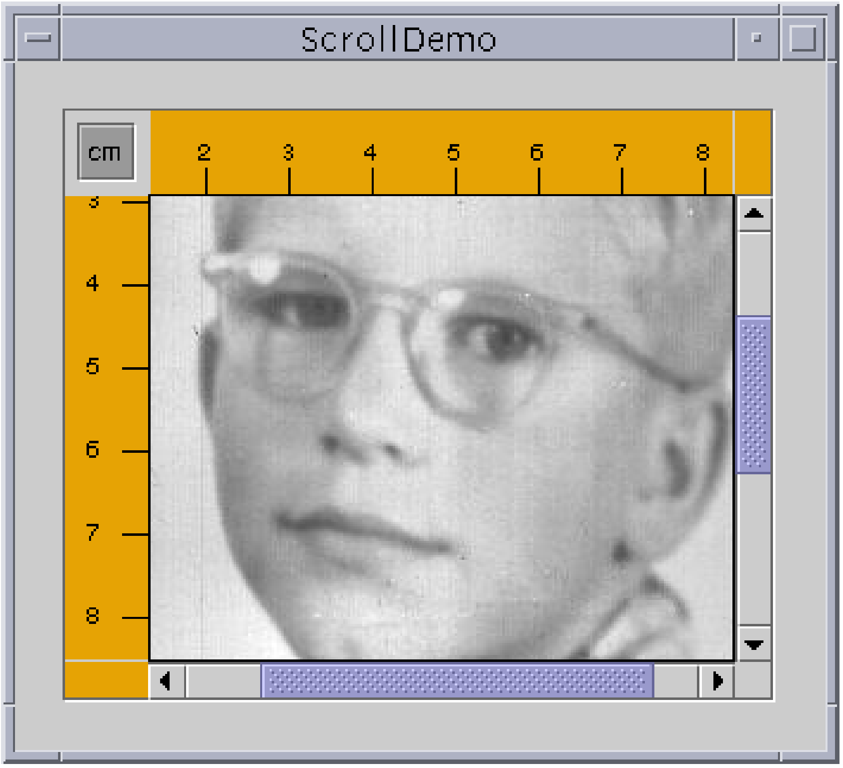


Don't do this!
The JButton becomes inaccessible.

We've always recommended against mixing lightweight and heavyweight components anyway. Its impact on accessibility is just another reason to avoid this practice.

Setting Accessible Names and Descriptions on Components

Here's a picture of one of our demo programs, called `ScrollDemo`.



You can find all of the files necessary to compile and run the program in How to Use Scroll Panes◆. Let's compare the original version of `ScrollDemo` to a version of the program to which the rules for supporting accessibility have been applied.

Try this:

1. Compile and run the accessible version of the application. The main source file is `AccessibleScrollDemo.java`◆. You also need a few other source files and an image file. See the examples index for links to all the files required by this example.
   See Getting Started with Swing if you need help compiling or running this application.
2. Run the accessible version along-side the original and compare. The only noticeable difference is that the **cm** toggle button and the photograph have tool tips in the accessible version.
3. Now run the two versions under Monkey as described in Testing for Accessibility. You can see detailed information for the various components. The custom components (rules and corners) that weren't accessible in the original version are accessible in the modified version. This can make quite a difference to assistive technologies.

Following is a complete listing of `AccessibleScrollDemo`'s constructor, which creates the scroll pane and the custom components it uses. The bold statements give components names and descriptions that assistive technologies can use.

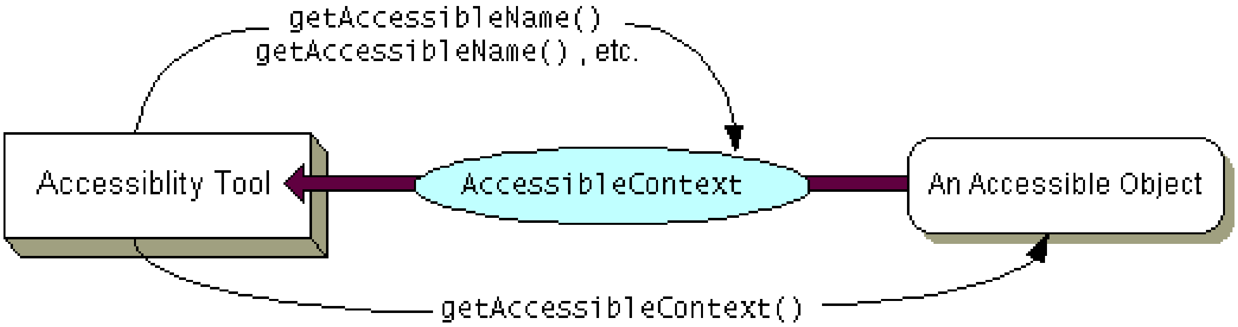
```
public AccessibleScrollDemo() {

    //Load the photograph into an image icon.
    ImageIcon david = new ImageIcon("images/youngdad.jpeg");
    david.setDescription("Photograph of David McNabb in his youth.");

    //Create the row and column headers
    columnView = new Rule(Rule.HORIZONTAL, true);
    columnView.setPreferredWidth(david.getIconWidth());
    columnView.getAccessibleContext().
        setAccessibleName("Column Header");
    columnView.getAccessibleContext().
        setAccessibleDescription("Displays horizontal ruler for " +
                                 "measuring scroll pane client.");
    rowView = new Rule(Rule.VERTICAL, true);
    rowView.setPreferredHeight(david.getIconHeight());
    rowView.getAccessibleContext().
        setAccessibleName("Row Header");
    rowView.getAccessibleContext().
        setAccessibleDescription("Displays vertical ruler for " +
                                 "measuring scroll pane client.");

    //Create the corners
    JPanel buttonCorner = new JPanel();
    isMetric = new JToggleButton("cm", true);
    isMetric.setFont(new Font("SansSerif", Font.PLAIN, 11));
    isMetric.setMargin(new Insets(2,2,2,2));
    isMetric.addItemListener(new UnitsListener());
    isMetric.setToolTipText("Toggles rulers' unit of measure " +
                            "between inches and centimeters.");
    buttonCorner.add(isMetric); //Use the default FlowLayout
    buttonCorner.getAccessibleContext().
                 setAccessibleName("Upper Left Corner");

    String desc = "Fills the corner of a scroll pane " +
                  "with color for aesthetic reasons.";
    Corner lowerLeft = new Corner();
    lowerLeft.getAccessibleContext().
              setAccessibleName("Lower Left Corner");
    lowerLeft.getAccessibleContext().setAccessibleDescription(desc);

    Corner upperRight = new Corner();
    upperRight.getAccessibleContext().
               setAccessibleName("Upper Right Corner");
    upperRight.getAccessibleContext().setAccessibleDescription(desc);

    //Set up the scroll pane
    picture = new ScrollablePicture(david, columnView.getIncrement());
    picture.setToolTipText(david.getDescription());
```

```
        picture.getAccessibleContext().
            setAccessibleName("Scroll pane client");

        JScrollPane pictureScrollPane = new JScrollPane(picture);
        pictureScrollPane.setPreferredSize(new Dimension(300, 250));
        pictureScrollPane.setViewportBorder(
            BorderFactory.createLineBorder(Color.black));

        pictureScrollPane.setColumnHeaderView(columnView);
        pictureScrollPane.setRowHeaderView(rowView);

        pictureScrollPane.setCorner(JScrollPane.UPPER_LEFT_CORNER,
                                    buttonCorner);
        pictureScrollPane.setCorner(JScrollPane.LOWER_LEFT_CORNER,
                                    lowerLeft);
        pictureScrollPane.setCorner(JScrollPane.UPPER_RIGHT_CORNER,
                                    upperRight);

        setLayout(new BoxLayout(this, BoxLayout.X_AXIS));
        add(pictureScrollPane);
        setBorder(BorderFactory.createEmptyBorder(20,20,20,20));
    }
```

Often, the program sets a component's name and description directly through the component's accessible context. Other times, the program sets an accessible description indirectly with tool tips. In the case of the **cm** toggle button, the program gives the component an accessible name as a side effect of creating it.

Concepts: How Accessibility Works

An object is accessible if it implements the `Accessible` interface. The `Accessible` interface defines just one method, `getAccessibleContext`, which returns an `AccessibleContext` object. The `AccessibleContext` object is an intermediary that contains the accessible information for an accessible object. The following figure shows how assistive technologies get the accessible context from an accessible object and query it for information:



`AccessibleContext` is an abstract class that defines the minimum set of information an accessible object must provide about itself. The minimum set includes name, description, role, state set, and so on. To identify its accessible object as having particular capabilities, an accessible context can implement one or more of the following interfaces:

- `AccessibleAction` -- Indicates that the object can perform actions. By implementing this interface, the accessible context can give information about what actions the accessible object can perform and can tell the accessible object to perform them.
- `AccessibleComponent` -- Indicates that the accessible object has an onscreen presence. Through this interface, an accessible object can provide information about its size, position, visibility and so on. The accessible contexts for all standard Swing components implement this interface. The accessible contexts for your custom components should do the same.
- `AccessibleHypertext` -- Indicates that the accessible object contains hyperlinks. Through this interface, an accessible object can provide information about its links and allow them to be traversed.
- `AccessibleSelection` -- Indicates that the accessible object is selectable. Accessible contexts that implement this interface can report information about the current selection and can modify the selection.
- `AccessibleText` -- Indicates that the accessible object displays text. This interface provides methods for returning all or part of the text, attributes applied to it, and other information about the text such as its length.
- `AccessibleValue` -- Indicates that the object has a numeric value. Through this interface an accessible object provides information about the current value and its minimum and maximum.

The `JComponent` class itself does not implement the `Accessible` interface. So instances of its direct subclasses are not accessible. If you write a custom component that inherits directly from `JComponent`, you need to explicitly make it implement the `Accessible` interface. `JComponent` does have an accessible context, called `AccessibleJComponent`, that implements the `AccessibleComponent` interface and provides a minimal amount of accessible information. You can provide an accessible context for your custom components by creating a subclass of `AccessibleJComponent` and overriding important methods. Making Custom Components Accessible shows two examples of doing this.

All of the other standard Swing components implement the `Accessible` interface and have an accessible context that implements one or more of the preceding interfaces as appropriate. The accessible contexts for Swing components are implemented as inner classes and have names of this style:

> `*Component*.Accessible*Component*`

If you create a subclass of a standard Swing component and your subclass is substantially different from its superclass, then you should provide a custom accessible context for it. The easiest way is to create a subclass of the superclass's accessible context class and override methods as necessary. For example, if you create a `JLabel` subclass substantially different from `JLabel`, then your `JLabel` subclass should contain an inner class that extends `AccessibleJLabel`. The next section shows how to do so, using examples in which `JComponent` subclasses extend `AccessibleJComponent`.

Making Custom Components Accessible

The scroll demo program uses three custom component classes. `ScrollablePicture` is a subclass of `JLabel`, and `Corner` and `Rule` are both subclasses of `JComponent`.

The `ScrollablePicture` class relies completely on accessibility inherited from `JLabel` through `JLabel.AccessibleJLabel`. The code that creates an instance of `ScrollablePicture` sets the tool tip text for the scrollable picture. The tool tip text is used by the context as the component's accessible description. This behavior is provided by `AccessibleJLabel`.

The accessible version of the `Corner` class contains just enough code to make its instances accessible. We implemented accessibility support by adding the code shown in bold to the original version of `Corner`.

```
public class Corner extends JComponent implements Accessible {

    public void paintComponent(Graphics g) {
        //fill me with dirty brown/orange
        g.setColor(new Color(230, 163, 4));
        g.fillRect(0, 0, getWidth(), getHeight());
    }

    public AccessibleContext getAccessibleContext() {
        if (accessibleContext == null) {
            accessibleContext = new AccessibleCorner();
        }
        return accessibleContext;
    }

    protected class AccessibleCorner extends AccessibleJComponent {
        //Inherit everything, override nothing.
    }
}
```

All of the accessibility provided by this class is inherited from `AccessibleJComponent`. This approach is fine for `Corner` because `AccessibleJComponent` provides a reasonable amount of default accessibility information and because corners are uninteresting -- they exist only to take up a little bit of space onscreen. Other classes, such as `Rule`, need to provide customized information.

`Rule` provides an accessible context for itself in the same manner as `Corner`, but the context overrides two methods to provide details about the component's role and state:

```
protected class AccessibleRuler extends AccessibleJComponent {

    public AccessibleRole getAccessibleRole() {
        return AccessibleRuleRole.RULER;
    }

    public AccessibleStateSet getAccessibleStateSet() {
        AccessibleStateSet states =
            super.getAccessibleStateSet();
        if (orientation == VERTICAL) {
            states.add(AccessibleState.VERTICAL);
        } else {
            states.add(AccessibleState.HORIZONTAL);
        }
        if (isMetric) {
            states.add(AccessibleRulerState.CENTIMETERS);
        } else {
            states.add(AccessibleRulerState.INCHES);
        }
        return states;
    }
}
```

`AccessibleRole`◆ is an enumeration of objects that identify roles that Swing components can play. It contains predefined roles such as label, button, and so on. The rulers in our example don't fit well into any of the predefined roles, so the program invents a new one in a subclass of `AccessibleRole`:

```
class AccessibleRuleRole extends AccessibleRole {
    public static final AccessibleRuleRole RULER
        = new AccessibleRuleRole("ruler");

    protected AccessibleRuleRole(String key) {
        super(key);
    }

    //Should really provide localizable versions of these names
    public String toDisplayString(String resourceBundleName,
                                  Locale locale) {
        return key;
    }
}
```

Any component that has state can provide state information to assistive technologies by overriding the `getAccessibleStateSet` method. A rule has two sets of states: its orientation can be either vertical or horizontal, and its units of measure can be either centimeters or inches. `AccessibleState`◆ is an enumeration of predefined states. This program uses its predefined states for vertical and horizontal orientation. Because `AccessibleState` contains nothing for centimeters and inches, the program makes a subclass to provide appropriate states:

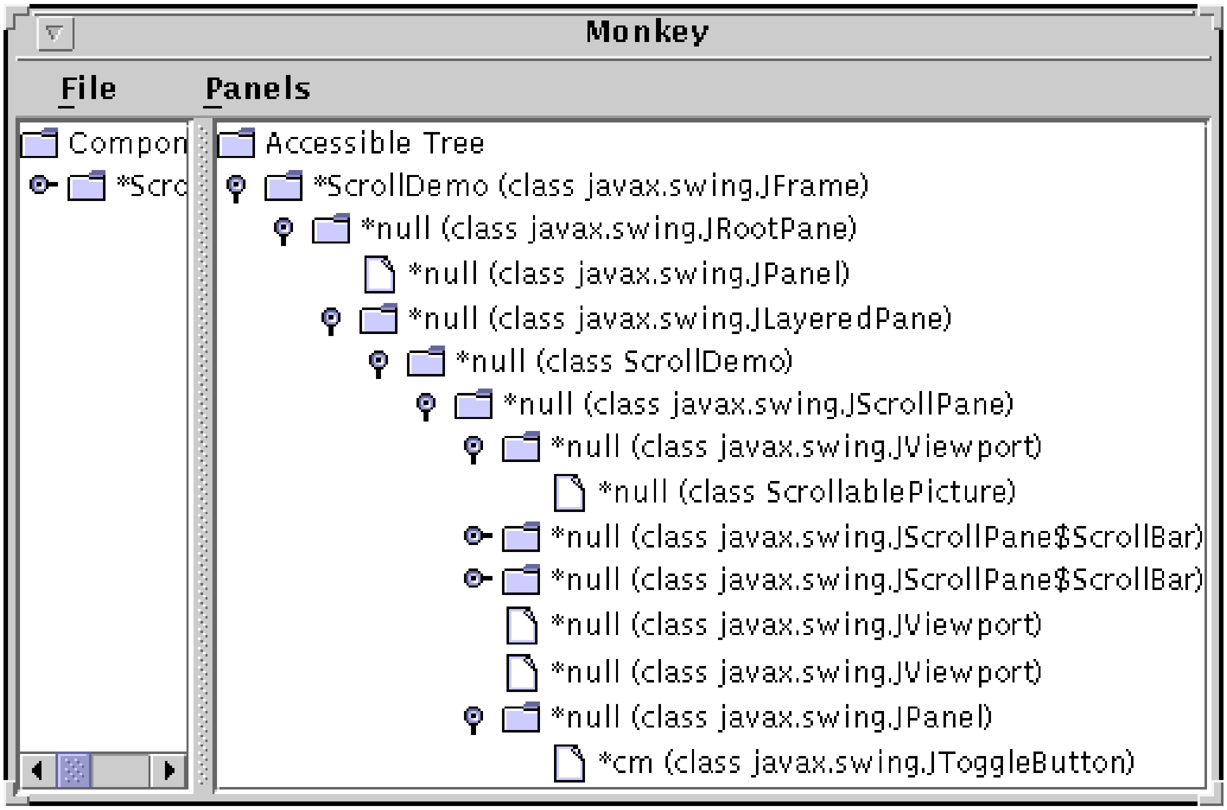
```
class AccessibleRulerState extends AccessibleState {
    public static final AccessibleRulerState INCHES
        = new AccessibleRulerState("inches");
    public static final AccessibleRulerState CENTIMETERS
        = new AccessibleRulerState("centimeters");

    protected AccessibleRulerState(String key) {
        super(key);
    }

    //Should really provide localizable versions of these names
    public String toDisplayString(String resourceBundleName,
                                  Locale locale) {
        return key;
    }
}
```

You've seen how to implement accessibility for two simple components, which exist only to paint themselves onscreen. Components that do more, such as responding to mouse or keyboard events, need to provide more elaborate accessible contexts. You can find examples of implementing accessible contexts by delving in the source code for the Swing components.

Testing for Accessibility

The examples that come with the accessibility utilities can give you an idea of how accessible your program is. You can download the accessibility utilities and the examples for free from http://java.sun.com/products/jfc/#download-access. Follow the instructions in the accessibility utilities documentation for setting up the Java Virtual Machine to run one or more of the utilities automatically.

For example, to get an idea of the benefit gained by rewriting `ScrollDemo`, you can run Monkey on the original program and its accessible cousin, `AccessibleScrollDemo`. Here's a snapshot of Monkey running on `ScrollDemo`:



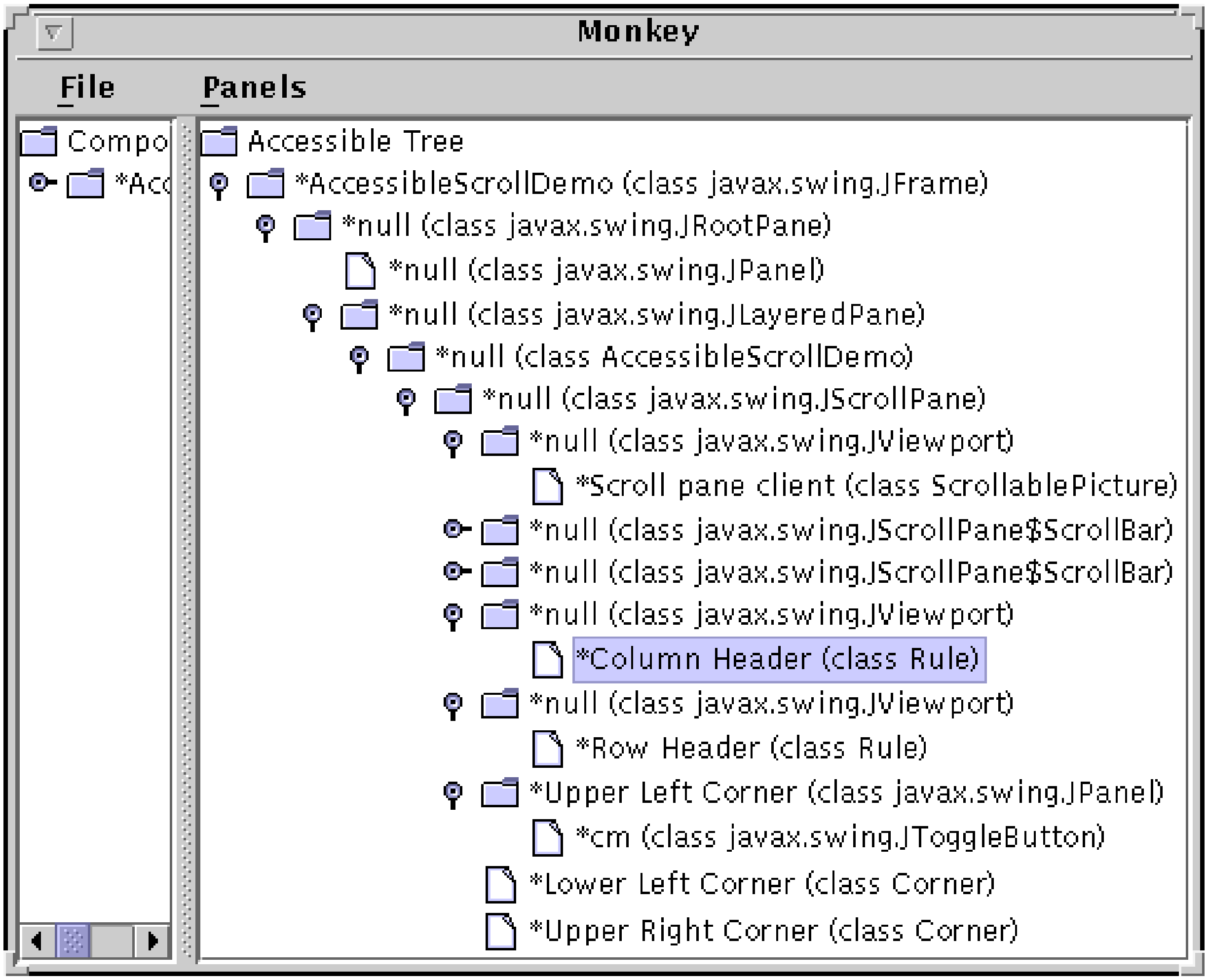
```
Accessible Tree
  *ScrollDemo (class javax.swing.JFrame)
    *null (class javax.swing.JRootPane)
      *null (class javax.swing.JPanel)
      *null (class javax.swing.JLayeredPane)
        *null (class ScrollDemo)
          *null (class javax.swing.JScrollPane)
            *null (class javax.swing.JViewport)
              *null (class ScrollablePicture)
            *null (class javax.swing.JScrollPane$ScrollBar)
            *null (class javax.swing.JScrollPane$ScrollBar)
            *null (class javax.swing.JViewport)
            *null (class javax.swing.JViewport)
            *null (class javax.swing.JPanel)
              *cm (class javax.swing.JToggleButton)
```

The left side of the split pane shows the actual component hierarchy for the program. The right side shows the accessible components in the hierarchy, which is what interests us.

The first thing to notice is that, even with no explicit support in `ScrollDemo`, Monkey is able to discover a lot of information about the various components in the program. Most of the components and their children appear in the tree. However, the names for most of the components are empty (null), which is rather unhelpful. The descriptions are also empty.

Further trouble comes with the program's custom components. The two rulers are inaccessible, so they are not included in the accessible tree. The viewports that contain the rulers are displayed as leaf nodes because they have no accessible children. The custom corners are also missing from the accessible tree.

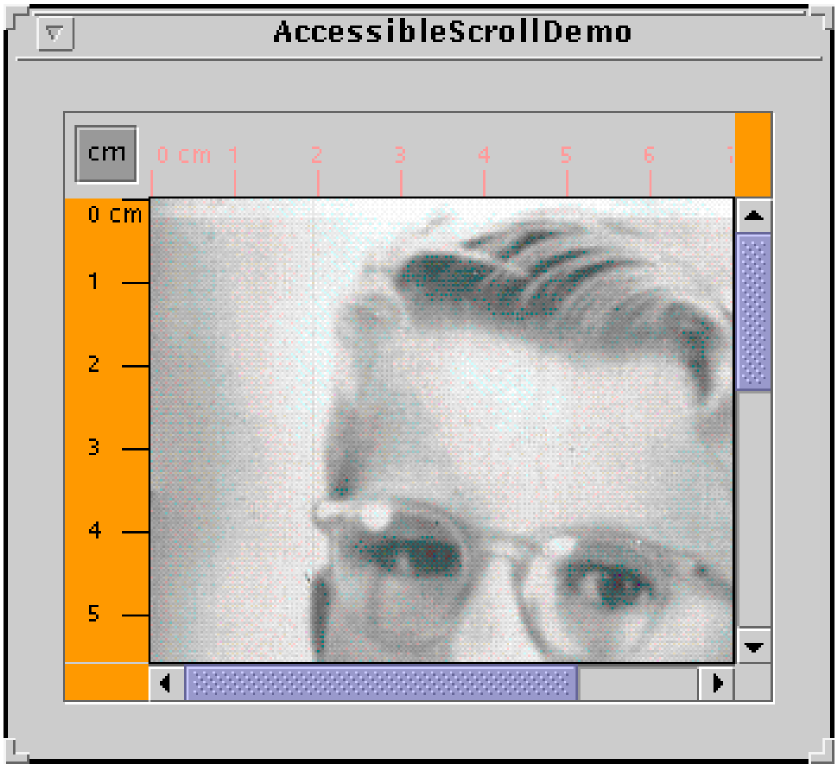
Now here's a picture of the Monkey window for `AccessibleScrollDemo`:



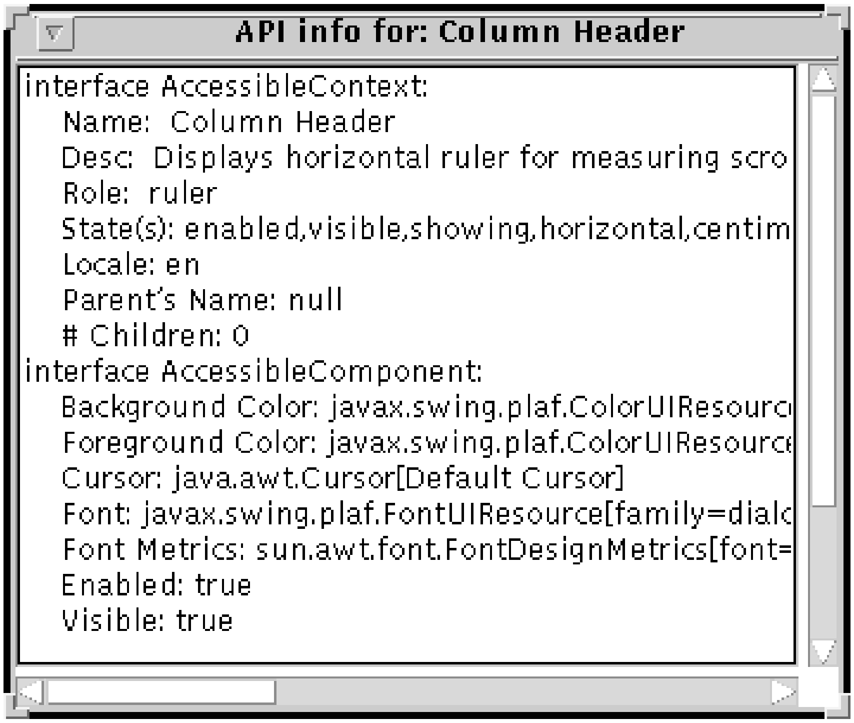
```
Accessible Tree
*AccessibleScrollDemo (class javax.swing.JFrame)
    *null (class javax.swing.JRootPane)
        *null (class javax.swing.JPanel)
        *null (class javax.swing.JLayeredPane)
            *null (class AccessibleScrollDemo)
                *null (class javax.swing.JScrollPane)
                    *null (class javax.swing.JViewport)
                        *Scroll pane client (class ScrollablePicture)
                    *null (class javax.swing.JScrollPane$ScrollBar)
                    *null (class javax.swing.JScrollPane$ScrollBar)
                    *null (class javax.swing.JViewport)
                        *Column Header (class Rule)
                    *null (class javax.swing.JViewport)
                        *Row Header (class Rule)
                    *Upper Left Corner (class javax.swing.JPanel)
                        *cm (class javax.swing.JToggleButton)
                    *Lower Left Corner (class Corner)
                    *Upper Right Corner (class Corner)
```

The rules are now listed as children of the viewports, and the corners are listed as children of the scroll pane. Furthermore, many of the components now have non-null names.

In the previous snapshot of Monkey, the Column Header item is selected. Monkey highlights the corresponding component in `ScrollDemo` program.



When an item is selected, you can use Monkey's **Panels** menu to bring up one of four different panels that let you interact with the selected component. Choosing **Panels > Accessibility API panel** brings up a panel like the one shown in the following figure. This panel displays information available through methods defined in the `AccessibleContext` base class and the `AccessibleComponent` interface.


API info for: Column Header

```
interface AccessibleContext:
   Name:  Column Header
   Desc:  Displays horizontal ruler for measuring scro
   Role:  ruler
   State(s): enabled,visible,showing,horizontal,centim
   Locale: en
   Parent's Name: null
   # Children: 0
interface AccessibleComponent:
   Background Color: javax.swing.plaf.ColorUIResourc
   Foreground Color: javax.swing.plaf.ColorUIResourc
   Cursor: java.awt.Cursor[Default Cursor]
   Font: javax.swing.plaf.FontUIResource[family=dialc
   Font Metrics: sun.awt.font.FontDesignMetrics[font=
   Enabled: true
   Visible: true
```

Monkey has three other panels:

- **AccessibleAction** -- Shows the actions supported by an accessible component and lets you

invoke the action. Works only with an accessible component whose context implements the `AccessibleAction` interface.
- **AccessibleSelection** -- Shows the current selection of an accessible component and lets you manipulate the selection. Works only with accessible component whose context implements the `AccessibleSelection` interface.
- **AccessibleHypertext** -- Shows any hyperlinks contained within an accessible component and lets you traverse them. Works only with accessible component whose context implements the `AccessibleHypertext` interface.

The accessibility utilities examples are handy as testing tools and can give you an idea of how accessible the components in your program are. However, even if your components behave well in Monkey or the other examples, they still might not be completely accessible because Monkey and the other examples exercise only certain portions of the Accessibility API. The only true test of accessibility is to run your programs with real-world assistive technologies.

The Accessibility API

The tables in this section cover just part of the accessibility API. For more information about the accessibility API, see the API documentation for the classes and packages in the accessibility package◆. Also, refer to the API documentation for the accessible contexts for individual Swing components.

The API for supporting accessibility falls into the following categories:

- Naming and Linking Components
- Making a Custom Component Accessible

Naming and Linking Components

Method	**Purpose**

`getAccessibleContext().setAccessibleName(String)`
`getAccessibleContext().setAccessibleDescription(String)`
(on a `JComponent` or `Accessible` object)
	Provide a name or description for an accessible object.

`void setToolTipText(String)` (*in* *`JComponent`*)	Set a component's tool tip. If you don't set the description, than many accessible contexts use the tool-tip text as the accessible description.
`void setLabelFor(Component)` (*in* *`JLabel`*)	Associates a label with a component. This tells assistive technologies that a label describes another component.
`void setDescription(String)` (*in* *`ImageIcon`*)	Provides a description for an image icon.

Making a Custom Component Accessible

Method, Interface, or Class	**Purpose**

Accessible (*an interface*)	Components that implement this interface are accessible. Subclasses of JComponent must implement this explicitly.
AccessibleContext getAccessibleContext() (*in* *Accessible*)	Get the accessible context for an accessible object. Custom components should implement this method to return a custom accessible context.
AccessibleContext *Component*.Accessible*Component* (*an abstract class and its subclasses*)	The base class defines the minimal set of information required of accessible objects. The accessible context for each Swing component is a subclass of this and named as shown. To provide custom accessible contexts, custom components should contain an inner class that is a subclass of AccessibleContext. Typically, the accessible context for a custom component is a subclass of one of the Swing component's accessible context classes.
AccessibleAction AccessibleComponent AccessibleHypertext AccessibleSelection AccessibleText AccessibleValue (*interfaces*)	Interfaces that accessible contexts can implement to identify particular behaviors.
AccessibleRole AccessibleStateSet (*classes*)	Define the objects returned by an AccessibleContext object's getAccessibleRole and getAccessibleStateSet methods respectively.

Examples that Use the Accessibility API

The following table lists some of our examples that have good support for assistive technologies.

Example	**Where Described**	**Notes**
AccessibleScrollDemo	This section	Contains two custom components that implement the Accessible interface. To see a less accessible version of this program see How to Use Scroll Panes.
ButtonDemo	How to Use the Common Button API◆	Uses three buttons. Supports accessibility through button text, mnemonics, and tool tips.

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```
import java.awt.*;
import java.awt.event.*;
import javax.swing.JMenu;
import javax.swing.JMenuItem;
import javax.swing.JCheckBoxMenuItem;
import javax.swing.JRadioButtonMenuItem;
import javax.swing.ButtonGroup;
import javax.swing.JMenuBar;
import javax.swing.KeyStroke;
import javax.swing.ImageIcon;

import javax.swing.JTextArea;
import javax.swing.JScrollPane;
import javax.swing.JFrame;

/*
 * This class adds event handling to MenuLookDemo.
 */
public class MenuDemo extends JFrame
                      implements ActionListener, ItemListener {
    JTextArea output;
    JScrollPane scrollPane;
    String newline = "\n";

    public MenuDemo() {
        JMenuBar menuBar;
        JMenu menu, submenu;
        JMenuItem menuItem;
        JRadioButtonMenuItem rbMenuItem;
        JCheckBoxMenuItem cbMenuItem;

        addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });

        //Add regular components to the window, using the default BorderLayout.
        Container contentPane = getContentPane();
        output = new JTextArea(5, 30);
        output.setEditable(false);
        scrollPane = new JScrollPane(output);
        contentPane.add(scrollPane, BorderLayout.CENTER);

        //Create the menu bar.
        menuBar = new JMenuBar();
        setJMenuBar(menuBar);

        //Build the first menu.
        menu = new JMenu("A Menu");
        menu.setMnemonic(KeyEvent.VK_A);
        menu.getAccessibleContext().setAccessibleDescription(
                "The only menu in this program that has menu items");
        menuBar.add(menu);

        //a group of JMenuItems
        menuItem = new JMenuItem("A text-only menu item",
                                 KeyEvent.VK_T);
        //menuItem.setMnemonic(KeyEvent.VK_T); //used constructor instead
        menuItem.setAccelerator(KeyStroke.getKeyStroke(
                KeyEvent.VK_1, ActionEvent.ALT_MASK));
        menuItem.getAccessibleContext().setAccessibleDescription(
                "This doesn't really do anything");
        menuItem.addActionListener(this);
        menu.add(menuItem);

        menuItem = new JMenuItem("Both text and icon",
                                 new ImageIcon("images/middle.gif"));
        menuItem.setMnemonic(KeyEvent.VK_B);
        menuItem.addActionListener(this);
        menu.add(menuItem);

        menuItem = new JMenuItem(new ImageIcon("images/middle.gif"));
        menuItem.setMnemonic(KeyEvent.VK_D);
        menuItem.addActionListener(this);
        menu.add(menuItem);

        //a group of radio button menu items
        menu.addSeparator();
        ButtonGroup group = new ButtonGroup();
        rbMenuItem = new JRadioButtonMenuItem("A radio button menu item");
        rbMenuItem.setSelected(true);
        rbMenuItem.setMnemonic(KeyEvent.VK_R);
        group.add(rbMenuItem);
        rbMenuItem.addActionListener(this);
        menu.add(rbMenuItem);
        rbMenuItem = new JRadioButtonMenuItem("Another one");
        rbMenuItem.setMnemonic(KeyEvent.VK_O);
        group.add(rbMenuItem);
        rbMenuItem.addActionListener(this);
        menu.add(rbMenuItem);

        //a group of check box menu items
        menu.addSeparator();
        cbMenuItem = new JCheckBoxMenuItem("A check box menu item");
        cbMenuItem.setMnemonic(KeyEvent.VK_C);
        cbMenuItem.addItemListener(this);
        menu.add(cbMenuItem);
        cbMenuItem = new JCheckBoxMenuItem("Another one");
        cbMenuItem.setMnemonic(KeyEvent.VK_H);
        cbMenuItem.addItemListener(this);
        menu.add(cbMenuItem);

        //a submenu
        menu.addSeparator();
        submenu = new JMenu("A submenu");
        submenu.setMnemonic(KeyEvent.VK_S);

        menuItem = new JMenuItem("An item in the submenu");
        menuItem.setAccelerator(KeyStroke.getKeyStroke(
                KeyEvent.VK_2, ActionEvent.ALT_MASK));
        menuItem.addActionListener(this);
        submenu.add(menuItem);

        menuItem = new JMenuItem("Another item");
        menuItem.addActionListener(this);
        submenu.add(menuItem);
        menu.add(submenu);

        //Build second menu in the menu bar.
        menu = new JMenu("Another Menu");
        menu.setMnemonic(KeyEvent.VK_N);
        menu.getAccessibleContext().setAccessibleDescription(
                "This menu does nothing");
        menuBar.add(menu);
    }

    public void actionPerformed(ActionEvent e) {
        JMenuItem source = (JMenuItem)(e.getSource());
        String s = "Action event detected."
                   + newline
                   + "    Event source: " + source.getText()
                   + " (an instance of " + getClassName(source) + ")";
        output.append(s + newline);
    }

    public void itemStateChanged(ItemEvent e) {
        JMenuItem source = (JMenuItem)(e.getSource());
        String s = "Item event detected."
                   + newline
                   + "    Event source: " + source.getText()
                   + " (an instance of " + getClassName(source) + ")"
                   + newline
                   + "    New state: "
                   + ((e.getStateChange() == ItemEvent.SELECTED) ?
                     "selected":"unselected");
        output.append(s + newline);
    }

    // Returns just the class name -- no package info.
    protected String getClassName(Object o) {
        String classString = o.getClass().getName();
        int dotIndex = classString.lastIndexOf(".");
        return classString.substring(dotIndex+1);
    }

    public static void main(String[] args) {
        MenuDemo window = new MenuDemo();

        window.setTitle("MenuDemo");
        window.setSize(450, 260);
        window.setVisible(true);
    }
}
```

```
import java.awt.*;
import java.awt.event.*;
import javax.swing.JPopupMenu;
import javax.swing.JMenu;
import javax.swing.JMenuItem;
import javax.swing.JCheckBoxMenuItem;
import javax.swing.JRadioButtonMenuItem;
import javax.swing.ButtonGroup;
import javax.swing.JMenuBar;
import javax.swing.KeyStroke;
import javax.swing.ImageIcon;

import javax.swing.JTextArea;
import javax.swing.JScrollPane;
import javax.swing.JFrame;

/*
 * This class adds popup menus to MenuDemo.
 */
public class PopupMenuDemo extends JFrame
                           implements ActionListener, ItemListener {
    JTextArea output;
    JScrollPane scrollPane;
    String newline = "\n";
    JPopupMenu popup;

    public PopupMenuDemo() {
        JMenuBar menuBar;
        JMenu menu, submenu;
        JMenuItem menuItem;
        JRadioButtonMenuItem rbMenuItem;
        JCheckBoxMenuItem cbMenuItem;

        addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });

        //Add regular components to the window, using the default BorderLayout.
        Container contentPane = getContentPane();
        output = new JTextArea(5, 30);
        output.setEditable(false);
        scrollPane = new JScrollPane(output);
        contentPane.add(scrollPane, BorderLayout.CENTER);

        //Create the menu bar.
        menuBar = new JMenuBar();
        setJMenuBar(menuBar);

        //Build the first menu.
        menu = new JMenu("A Menu");
        menu.setMnemonic(KeyEvent.VK_A);
        menu.getAccessibleContext().setAccessibleDescription(
                "The only menu in this program that has menu items");
        menuBar.add(menu);

        //a group of JMenuItems
        menuItem = new JMenuItem("A text-only menu item",
                                 KeyEvent.VK_T);
        //menuItem.setMnemonic(KeyEvent.VK_T); //used constructor instead
        menuItem.setAccelerator(KeyStroke.getKeyStroke(
                KeyEvent.VK_1, ActionEvent.ALT_MASK));
        menuItem.getAccessibleContext().setAccessibleDescription(
                "This doesn't really do anything");
        menuItem.addActionListener(this);
        menu.add(menuItem);
        menuItem = new JMenuItem("Both text and icon",
                                 new ImageIcon("images/middle.gif"));
        menuItem.setMnemonic(KeyEvent.VK_B);
        menuItem.addActionListener(this);
        menu.add(menuItem);
        menuItem = new JMenuItem(new ImageIcon("images/middle.gif"));
        menuItem.setMnemonic(KeyEvent.VK_D);
        menuItem.addActionListener(this);
        menu.add(menuItem);

        //a group of radio button menu items
        menu.addSeparator();
        ButtonGroup group = new ButtonGroup();
        rbMenuItem = new JRadioButtonMenuItem("A radio button menu item");
        rbMenuItem.setSelected(true);
        rbMenuItem.setMnemonic(KeyEvent.VK_R);
        group.add(rbMenuItem);
        rbMenuItem.addActionListener(this);
        menu.add(rbMenuItem);
        rbMenuItem = new JRadioButtonMenuItem("Another one");
        rbMenuItem.setMnemonic(KeyEvent.VK_O);
        group.add(rbMenuItem);
        rbMenuItem.addActionListener(this);
        menu.add(rbMenuItem);

        //a group of check box menu items
        menu.addSeparator();
        cbMenuItem = new JCheckBoxMenuItem("A check box menu item");
        cbMenuItem.setMnemonic(KeyEvent.VK_C);
        cbMenuItem.addItemListener(this);
        menu.add(cbMenuItem);
        cbMenuItem = new JCheckBoxMenuItem("Another one");
        cbMenuItem.setMnemonic(KeyEvent.VK_H);
        cbMenuItem.addItemListener(this);
        menu.add(cbMenuItem);

        //a submenu
        menu.addSeparator();
        submenu = new JMenu("A submenu");
        submenu.setMnemonic(KeyEvent.VK_S);

        menuItem = new JMenuItem("An item in the submenu");
        menuItem.setAccelerator(KeyStroke.getKeyStroke(
                KeyEvent.VK_2, ActionEvent.ALT_MASK));
        menuItem.addActionListener(this);
        submenu.add(menuItem);

        menuItem = new JMenuItem("Another item");
        menuItem.addActionListener(this);
        submenu.add(menuItem);
        menu.add(submenu);

        //Build second menu in the menu bar.
        menu = new JMenu("Another Menu");
        menu.setMnemonic(KeyEvent.VK_N);
        menu.getAccessibleContext().setAccessibleDescription(
                "This menu does nothing");
        menuBar.add(menu);

        //Create the popup menu.
        popup = new JPopupMenu();
        menuItem = new JMenuItem("A popup menu item");
        menuItem.addActionListener(this);
        popup.add(menuItem);
        menuItem = new JMenuItem("Another popup menu item");
        menuItem.addActionListener(this);
        popup.add(menuItem);

        //Add listener to components that can bring up popup menus.
        MouseListener popupListener = new PopupListener();
        output.addMouseListener(popupListener);
        scrollPane.addMouseListener(popupListener);
        menuBar.addMouseListener(popupListener);
    }

    public void actionPerformed(ActionEvent e) {
        JMenuItem source = (JMenuItem)(e.getSource());
        String s = "Action event detected."
                   + newline
                   + "    Event source: " + source.getText()
                   + " (an instance of " + getClassName(source) + ")";
        output.append(s + newline);
    }

    public void itemStateChanged(ItemEvent e) {
        JMenuItem source = (JMenuItem)(e.getSource());
        String s = "Item event detected."
                   + newline
                   + "    Event source: " + source.getText()
                   + " (an instance of " + getClassName(source) + ")"
                   + newline
                   + "    New state: "
                   + ((e.getStateChange() == ItemEvent.SELECTED) ?
                     "selected":"unselected");
        output.append(s + newline);
    }

    // Returns just the class name -- no package info.
    protected String getClassName(Object o) {
        String classString = o.getClass().getName();
        int dotIndex = classString.lastIndexOf(".");
        return classString.substring(dotIndex+1);
    }

    public static void main(String[] args) {
        PopupMenuDemo window = new PopupMenuDemo();

        window.setTitle("PopupMenuDemo");
        window.setSize(450, 260);
        window.setVisible(true);
    }

    class PopupListener extends MouseAdapter {
        public void mousePressed(MouseEvent e) {
            maybeShowPopup(e);
        }

        public void mouseReleased(MouseEvent e) {
            maybeShowPopup(e);
        }

        private void maybeShowPopup(MouseEvent e) {
            if (e.isPopupTrigger()) {
                popup.show(e.getComponent(),
                           e.getX(), e.getY());
            }
        }
    }
}
```

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

/**
 * @author ges
 * @author kwalrath
 */
public class MenuGlueDemo extends JFrame {
    protected JMenuBar menuBar;

    public MenuGlueDemo() {
        super("MenuGlueDemo");
        menuBar = new JMenuBar();
        setJMenuBar(menuBar);
        addNewMenu("Menu 1");
        addNewMenu("Menu 2");
        menuBar.add(Box.createHorizontalGlue());
        addNewMenu("Menu 3");

        addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });
    }

    public void addNewMenu(String title) {
        JMenu m = (JMenu)menuBar.add(new JMenu(title));
        m.add("Menu item");
        m.add("Menu item");
        m.add("Menu item");
    }

    public static void main(String args[]) {
        MenuGlueDemo f = new MenuGlueDemo();
        f.setSize(300, 50);
        f.setVisible(true);
    }
}
```

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

/** @author ges */

public class MenuLayoutDemo extends JFrame {
    protected JMenuBar menuBar;

    public MenuLayoutDemo() {
        super("MenuLayoutDemo");
        menuBar = new JMenuBar();
        menuBar.setLayout(new BoxLayout(menuBar, BoxLayout.Y_AXIS));
        addNewMenu("Menu 1");
        addNewMenu("Menu 2");
        addNewMenu("Menu 3");
        getContentPane().add(menuBar, BorderLayout.WEST);

        addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });
    }

    public void addNewMenu(String title) {
        JMenu m = (JMenu)menuBar.add(new HorizontalMenu(title));
        m.add("Menu item");
        m.add("Menu item");
        m.add("Menu item");
        JMenu m1 = (JMenu)m.add(new HorizontalMenu("Submenu"));
        m1.add("Submenu item");
        m1.add("Submenu item");
    }

    public static void main(String args[]) {
        MenuLayoutDemo f = new MenuLayoutDemo();
        f.pack();
        f.setVisible(true);
    }

    class HorizontalMenu extends JMenu {
        HorizontalMenu(String label) {
            super(label);
            JPopupMenu pm = getPopupMenu();
            pm.setLayout(new BoxLayout(pm, BoxLayout.X_AXIS));
            setMinimumSize(getPreferredSize());
        }

        public void setPopupMenuVisible(boolean b) {
            boolean isVisible = isPopupMenuVisible();
            if (b != isVisible) {
                if ((b==true) && isShowing()) {
                    // Set location of popupMenu (pulldown or pullright)
                    // Perhaps this should be dictated by L&F
                    int x = 0;
                    int y = 0;
                    Container parent = getParent();
                    if (parent instanceof JPopupMenu) {
                        x = 0;
                        y = getHeight();
                    } else {
                        x = getWidth();
                        y = 0;
                    }
                    getPopupMenu().show(this, x, y);
                } else {
                    getPopupMenu().setVisible(false);
                }
            }
        }
    }
}
```

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

public class GlassPaneDemo {
    static private MyGlassPane myGlassPane;

    public static void main(String[] args) {
        JFrame frame = new JFrame("GlassPaneDemo");
        frame.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });

        JCheckBox changeButton =
                new JCheckBox("Glass pane \"visible\"");
        changeButton.setSelected(false);
        changeButton.addItemListener(new ItemListener() {
            public void itemStateChanged(ItemEvent e) {
                myGlassPane.setVisible(e.getStateChange()
                                       == ItemEvent.SELECTED);
            }
        });

        //Set up the content pane, where the "main GUI" lives.
        Container contentPane = frame.getContentPane();
        contentPane.setLayout(new FlowLayout());
        contentPane.add(changeButton);
        contentPane.add(new JButton("Button 1"));
        contentPane.add(new JButton("Button 2"));

        //Set up the menu bar, which appears above the content pane.
        JMenuBar menuBar = new JMenuBar();
        JMenu menu = new JMenu("Menu");
        menu.add(new JMenuItem("Do nothing"));
        menuBar.add(menu);
        frame.setJMenuBar(menuBar);

        //Set up the glass pane, which appears over both menu bar
        //and content pane.
        myGlassPane = new MyGlassPane(changeButton, menuBar,
                                      frame.getContentPane());
        frame.setGlassPane(myGlassPane);

        frame.pack();
        frame.setVisible(true);
    }
}

/**
 * We have to provide our own glass pane so that it can paint.
 */
class MyGlassPane extends JComponent {
    Point point;

    public void paint(Graphics g) {
        if (point != null) {
            g.setColor(Color.red);
            g.fillOval(point.x - 10, point.y - 10, 20, 20);
        }
    }

    public void setPoint(Point p) {
        point = p;
    }

    public MyGlassPane(AbstractButton aButton,
                       JMenuBar menuBar,
                       Container contentPane) {
        CBListener listener = new CBListener(aButton, menuBar,
                                             this, contentPane);
        addMouseListener(listener);
        addMouseMotionListener(listener);
    }
}

/**
 * Listen for all events that our check box is likely to be
 * interested in.  Redispatch them to the check box.
 */
class CBListener extends MouseInputAdapter {
    Toolkit toolkit;
    Component liveButton;
    JMenuBar menuBar;
    MyGlassPane glassPane;
    Container contentPane;
    boolean inDrag = false;

    public CBListener(Component liveButton, JMenuBar menuBar,
                      MyGlassPane glassPane, Container contentPane) {
        toolkit = Toolkit.getDefaultToolkit();
        this.liveButton = liveButton;
        this.menuBar = menuBar;
        this.glassPane = glassPane;
        this.contentPane = contentPane;
    }

    public void mouseMoved(MouseEvent e) {
        redispatchMouseEvent(e, false);
    }

    /*
     * We must forward at least the mouse drags that started
     * with mouse presses over the check box.  Otherwise,
     * when the user presses the check box then drags off,
     * the check box isn't disarmed -- it keeps its dark
     * gray background or whatever its L&F uses to indicate
     * that the button is currently being pressed.
     */
    public void mouseDragged(MouseEvent e) {
        redispatchMouseEvent(e, false);
    }

    public void mouseClicked(MouseEvent e) {
        redispatchMouseEvent(e, false);
    }

    public void mouseEntered(MouseEvent e) {
        redispatchMouseEvent(e, false);
    }

    public void mouseExited(MouseEvent e) {
        redispatchMouseEvent(e, false);
    }

    public void mousePressed(MouseEvent e) {
        redispatchMouseEvent(e, false);
    }

    public void mouseReleased(MouseEvent e) {
        redispatchMouseEvent(e, true);
        inDrag = false;
    }

    private void redispatchMouseEvent(MouseEvent e,
                                      boolean repaint) {
        boolean inButton = false;
        boolean inMenuBar = false;
        Point glassPanePoint = e.getPoint();
        Component component = null;
        Container container = contentPane;
        Point containerPoint = SwingUtilities.convertPoint(
                                        glassPane,
                                        glassPanePoint,
                                        contentPane);
        int eventID = e.getID();

        if (containerPoint.y < 0) {
            inMenuBar = true;
            container = menuBar;
            containerPoint = SwingUtilities.convertPoint(
                                        glassPane,
                                        glassPanePoint,
                                        menuBar);
            testForDrag(eventID);
        }

        //XXX: If the event is from a component in a popped-up menu,
        //XXX: then the container should probably be the menu's
        //XXX: JPopupMenu, and containerPoint should be adjusted
        //XXX: accordingly.
        component = SwingUtilities.getDeepestComponentAt(
                                        container,
                                        containerPoint.x,
                                        containerPoint.y);

        if (component == null) {
            return;
        }

        if (component.equals(liveButton)) {
            inButton = true;
            testForDrag(eventID);
        }

        if (inMenuBar || inButton || inDrag) {
            Point componentPoint = SwingUtilities.convertPoint(
                                        glassPane,
                                        glassPanePoint,
                                        component);
            component.dispatchEvent(new MouseEvent(component,
                                                 eventID,
                                                 e.getWhen(),
                                                 e.getModifiers(),
                                                      componentPoint.x,
                                                      componentPoint.y,
                                                      e.getClickCount(),
                                                      e.isPopupTrigger()));
        }

        if (repaint) {
            toolkit.beep();
            glassPane.setPoint(glassPanePoint);
            glassPane.repaint();
        }
    }

    private void testForDrag(int eventID) {
        if (eventID == MouseEvent.MOUSE_PRESSED) {
            inDrag = true;
        }
    }
}
```

```
import javax.swing.*;
import javax.swing.border.*;
import javax.accessibility.*;

import java.awt.*;
import java.awt.event.*;

public class LayeredPaneDemo extends JFrame {
    private String[] layerStrings = { "Yellow (0)", "Magenta (1)",
                                      "Cyan (2)", "Red (3)",
                                      "Green (4)" };
    private Color[] layerColors = { Color.yellow, Color.magenta,
                                    Color.cyan, Color.red,
                                    Color.green };

    private JLayeredPane layeredPane;
    private JLabel dukeLabel;

    public LayeredPaneDemo()    {
        super("LayeredPaneDemo");

        //Create and load the duke icon.
        final ImageIcon icon = new ImageIcon("images/dukeWaveRed.gif");

        //Create and set up the layered pane.
        layeredPane = new JLayeredPane();
        layeredPane.setPreferredSize(new Dimension(300, 310));
        layeredPane.setBorder(BorderFactory.createTitledBorder(
                                    "Move the Mouse to Move Duke"));
        layeredPane.addMouseMotionListener(new MouseMotionAdapter() {
            final int XFUDGE = 40;
            final int YFUDGE = 57;
            public void mouseEntered(MouseEvent e) {
                dukeLabel.setLocation(e.getX()-XFUDGE, e.getY()-YFUDGE);
            }
            public void mouseMoved(MouseEvent e) {
                dukeLabel.setLocation(e.getX()-XFUDGE, e.getY()-YFUDGE);
            }
        });

        //This is the origin of the first label added.
        Point origin = new Point(10, 20);

        //This is the offset for computing the origin for the next label.
        int offset = 35;

        //Add several overlapping, colored labels to the layered pane
        //using absolute positioning/sizing.
        for (int i = 0; i < layerStrings.length; i++) {
            JLabel label = createColoredLabel(layerStrings[i],
                                              layerColors[i], origin);
            layeredPane.add(label, new Integer(i));
            origin.x += offset;
            origin.y += offset;
        }

        //Create and add the Duke label to the layered pane.
        dukeLabel = new JLabel(icon);
        dukeLabel.setBounds(15, 225,
                            icon.getIconWidth(),
                            icon.getIconHeight());
        layeredPane.add(dukeLabel, new Integer(2), 0);
        //Add control pane and layered pane to frame.
        Container contentPane = getContentPane();
        contentPane.setLayout(new BoxLayout(contentPane,
                                            BoxLayout.Y_AXIS));
        contentPane.add(Box.createRigidArea(new Dimension(0, 10)));
        contentPane.add(createControlPanel());
        contentPane.add(Box.createRigidArea(new Dimension(0, 10)));
        contentPane.add(layeredPane);
    }

    //Create and set up a colored label.
    private JLabel createColoredLabel(String text,
                                      Color color,
                                      Point origin) {
        JLabel label = new JLabel(text);
        label.setVerticalAlignment(JLabel.TOP);
        label.setHorizontalAlignment(JLabel.CENTER);
        label.setOpaque(true);
        label.setBackground(color);
        label.setForeground(Color.black);
        label.setBorder(BorderFactory.createLineBorder(Color.black));
        label.setBounds(origin.x, origin.y, 140, 140);
        return label;
    }

    //Create the control pane for the top of the frame.
    private JPanel createControlPanel() {
        final JCheckBox onTop = new JCheckBox("Top Position in Layer");
        onTop.setSelected(true);
        onTop.addActionListener(new ActionListener() {
            public void actionPerformed(ActionEvent e) {
                if (onTop.isSelected())
                    layeredPane.moveToFront(dukeLabel);
                else
                    layeredPane.moveToBack(dukeLabel);
            }
        });

        final JComboBox layerList = new JComboBox(layerStrings);
        layerList.setSelectedIndex(2);    //Cyan layer
        layerList.addActionListener(new ActionListener () {
            public void actionPerformed(ActionEvent e) {
                int position = onTop.isSelected() ? 0 : 1;
                layeredPane.setLayer(dukeLabel,
                                     layerList.getSelectedIndex(),
                                     position);
            }
        });

        JPanel controls = new JPanel();
        controls.add(layerList);
        controls.add(onTop);
        controls.setBorder(BorderFactory.createTitledBorder(
                                 "Choose Duke's Layer and Position"));
        return controls;
    }

    public static void main(String[] args) {
        JFrame frame = new LayeredPaneDemo();

        frame.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });

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

```
<APPLET CODE="MouseMotionEventDemo.class"
        ARCHIVE="example-swing/mousemotion.jar"
        WIDTH="450" HEIGHT="200"
        ALT="Your browser understands the applet tag but isn't displaying any applet.">

Since you can't run the applet,
here's a picture of it:

#usemacro UI_FIGURE (
    NAME MouseMotionEventDemo.gif
    W 450
    H 200
    ALT A snapshot of MouseMotionEventDemo, which demonstrates events that are fired when the user
moves the mouse.
)

</APPLET>
```

```
import javax.swing.*;
import javax.swing.border.*;
import javax.accessibility.*;

import java.awt.*;
import java.awt.event.*;

public class LayeredPaneDemo2 extends JFrame {
    private String[] layerStrings = { "Yellow (0)", "Magenta (1)",
                                      "Cyan (2)", "Red (3)",
                                      "Green (4)", "Blue (5)" };
    private Color[] layerColors = { Color.yellow, Color.magenta,
                                    Color.cyan, Color.red,
                                    Color.green, Color.blue };

    private JLayeredPane layeredPane;
    private JLabel dukeLabel;

    public LayeredPaneDemo2()    {
        super("LayeredPaneDemo2");

        //Create and load the duke icon
        final ImageIcon icon = new ImageIcon("images/dukeWaveRed.gif");

        //Create and set up the layered pane
        layeredPane = new JLayeredPane();
        layeredPane.setPreferredSize(new Dimension(300, 310));
        layeredPane.setBorder(BorderFactory.createTitledBorder(
                                    "Move the Mouse to Move Duke"));
        layeredPane.addMouseMotionListener(new MouseMotionAdapter() {
            final int XFUDGE = 40;
            final int YFUDGE = 57;
            public void mouseEntered(MouseEvent e) {
                dukeLabel.setLocation(e.getX()-XFUDGE, e.getY()-YFUDGE);
            }
            public void mouseMoved(MouseEvent e) {
                dukeLabel.setLocation(e.getX()-XFUDGE, e.getY()-YFUDGE);
            }
        });

        layeredPane.setLayout(new GridLayout(2,3));

        //Add several overlapping, colored labels to the layered pane
        //using absolute positioning/sizing.
        for (int i = 0; i < layerStrings.length; i++) {
            JLabel label = createColoredLabel(layerStrings[i],
                                              layerColors[i]);
            layeredPane.add(label, new Integer(i));
        }

        //Create and add the Duke label to the layered pane
        dukeLabel = new JLabel(icon);
        dukeLabel.setBounds(15, 225,
                            icon.getIconWidth(),
                            icon.getIconHeight());
        layeredPane.add(dukeLabel, new Integer(2), 0);

        //Add control pane and layered pane to frame
        Container contentPane = getContentPane();
        contentPane.setLayout(new BoxLayout(contentPane,
                                            BoxLayout.Y_AXIS));
        contentPane.add(Box.createRigidArea(new Dimension(0, 10)));
        contentPane.add(createControlPanel());
        contentPane.add(Box.createRigidArea(new Dimension(0, 10)));
        contentPane.add(layeredPane);
    }

    //Create and set up a colored label
    private JLabel createColoredLabel(String text, Color color) {
        JLabel label = new JLabel(text);
        label.setVerticalAlignment(JLabel.TOP);
        label.setHorizontalAlignment(JLabel.CENTER);
        label.setOpaque(true);
        label.setBackground(color);
        label.setForeground(Color.black);
        label.setBorder(BorderFactory.createLineBorder(Color.black));
        label.setPreferredSize(new Dimension(140, 140));
        return label;
    }

    //Create the control pane for the top of the frame.
    private JPanel createControlPanel() {

        final JCheckBox onTop = new JCheckBox("Top Position in Layer");
        onTop.setSelected(true);
        onTop.addActionListener(new ActionListener() {
            public void actionPerformed(ActionEvent e) {
                if (onTop.isSelected())
                    layeredPane.moveToFront(dukeLabel);
                else
                    layeredPane.moveToBack(dukeLabel);
            }
        });

        final JComboBox layerList = new JComboBox(layerStrings);
        layerList.setSelectedIndex(2);    //cyan layer
        layerList.addActionListener(new ActionListener () {
            public void actionPerformed(ActionEvent e) {
                int position = onTop.isSelected() ? 0 : 1;
                layeredPane.setLayer(dukeLabel,
                                     layerList.getSelectedIndex(),
                                     position);
            }
        });

        JPanel controls = new JPanel();
        controls.add(layerList);
        controls.add(onTop);
        controls.setBorder(BorderFactory.createTitledBorder(
                                 "Choose Duke's Layer and Position"));
        return controls;
    }

    public static void main(String[] args) {
        JFrame frame = new LayeredPaneDemo2();

        frame.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });

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

```
<APPLET CODE="MultiListener.class"
        ARCHIVE="example-swing/intro.jar"
        WIDTH="400" HEIGHT="300"
        ALT="Your browser understands the applet tag but isn't displaying any applet.">

Since you can't run the applet,
here's a picture of it:

#usemacro UI_FIGURE (
    NAME MultiListener.gif
    W 400
    H 300
    ALT A snapshot of Demo, which demonstrates listening to multiple events.

)

</APPLET>
```

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

public class TreeExpandEventDemo extends JApplet {
    DemoArea demoArea;
    JTextArea textArea;
    final static String newline = "\n";

    public void init() {
        GridBagLayout gridbag = new GridBagLayout();
        GridBagConstraints c = new GridBagConstraints();
        JPanel contentPane = new JPanel();
        contentPane.setLayout(gridbag);

        c.fill = GridBagConstraints.BOTH;
        c.gridwidth = GridBagConstraints.REMAINDER;
        c.weightx = 1.0;
        c.weighty = 1.0;

        c.insets = new Insets(1, 1, 1, 1);
        demoArea = new DemoArea();
        gridbag.setConstraints(demoArea, c);
        contentPane.add(demoArea);

        c.insets = new Insets(0, 0, 0, 0);
        textArea = new JTextArea();
        textArea.setEditable(false);
        JScrollPane scrollPane = new JScrollPane(textArea);
        scrollPane.setVerticalScrollBarPolicy(
            JScrollPane.VERTICAL_SCROLLBAR_ALWAYS);
        scrollPane.setPreferredSize(new Dimension(200, 75));
        gridbag.setConstraints(scrollPane, c);
        contentPane.add(scrollPane);

        setContentPane(contentPane);
    }

    void saySomething(String eventDescription, TreeExpansionEvent e) {
        textArea.append(eventDescription + "; "
                        + "path = " + e.getPath()
                        + newline);
    }

    class DemoArea extends JScrollPane
                   implements TreeExpansionListener {
        Dimension minSize = new Dimension(100, 100);
        JTree tree;

        public DemoArea() {
            TreeNode rootNode = createNodes();
            tree = new JTree(rootNode);
            tree.addTreeExpansionListener(this);

            setViewportView(tree);
        }

        private TreeNode createNodes() {
            DefaultMutableTreeNode root;
            DefaultMutableTreeNode grandparent;
            DefaultMutableTreeNode parent;
            DefaultMutableTreeNode child;

            root = new DefaultMutableTreeNode("San Francisco");

            grandparent = new DefaultMutableTreeNode("Potrero Hill");
            root.add(grandparent);
            //
            parent = new DefaultMutableTreeNode("Restaurants");
            grandparent.add(parent);
            child = new DefaultMutableTreeNode("Thai Barbeque");
            parent.add(child);
            child = new DefaultMutableTreeNode("Goat Hill Pizza");
            parent.add(child);
            //
            parent = new DefaultMutableTreeNode("Grocery Stores");
            grandparent.add(parent);
            child = new DefaultMutableTreeNode("Good Life Grocery");
            parent.add(child);
            child = new DefaultMutableTreeNode("Safeway");
            parent.add(child);

            grandparent = new DefaultMutableTreeNode("Noe Valley");
            root.add(grandparent);
            //
            parent = new DefaultMutableTreeNode("Restaurants");
            grandparent.add(parent);
            child = new DefaultMutableTreeNode("Hamano Sushi");
            parent.add(child);
            child = new DefaultMutableTreeNode("Hahn's Hibachi");
            parent.add(child);
            //
            parent = new DefaultMutableTreeNode("Grocery Stores");
            grandparent.add(parent);
            child = new DefaultMutableTreeNode("Real Foods");
            parent.add(child);
            child = new DefaultMutableTreeNode("Bell Market");
            parent.add(child);

            return root;
        }

        public Dimension getMinimumSize() {
            return minSize;
        }

        public Dimension getPreferredSize() {
            return minSize;
        }

        // Required by TreeExpansionListener interface.
        public void treeExpanded(TreeExpansionEvent e) {
            saySomething("Tree-expanded event detected", e);
        }

        // Required by TreeExpansionListener interface.
        public void treeCollapsed(TreeExpansionEvent e) {
            saySomething("Tree-collapsed event detected", e);
        }
    }
}
```

Run TreeExpandEventDemo

Note: Because the preceding applet uses the Swing 1.1 API, it requires Java Plug-in 1.1.2 or Java Plug-in 1.2. It won't work with Java Plug-in 1.1.1 or uncustomized 1.1 browsers. For more information about running applets in the tutorial, refer to About Our Examples. That page includes a section about Downloading Java Plug-in.

```
<APPLET CODE="TreeExpandEventDemo.class"
        ARCHIVE="example-swing/treeexpand.jar"
        WIDTH="450" HEIGHT="200"
        ALT="Your browser understands the applet tag but isn't displaying any applet.">
</APPLET>
```

```
/*
 * This code is based on an example provided by Richard Stanford,
 * a tutorial reader.
 */

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

public class DynamicTree extends JPanel {
    protected DefaultMutableTreeNode rootNode;
    protected DefaultTreeModel treeModel;
    protected JTree tree;
    private Toolkit toolkit = Toolkit.getDefaultToolkit();

    public DynamicTree() {
        rootNode = new DefaultMutableTreeNode("Root Node");
        treeModel = new DefaultTreeModel(rootNode);
        treeModel.addTreeModelListener(new MyTreeModelListener());

        tree = new JTree(treeModel);
        tree.setEditable(true);
        tree.getSelectionModel().setSelectionMode
                (TreeSelectionModel.SINGLE_TREE_SELECTION);
        tree.setShowsRootHandles(true);

        JScrollPane scrollPane = new JScrollPane(tree);
        setLayout(new GridLayout(1,0));
        add(scrollPane);
    }

    /** Remove all nodes except the root node. */
    public void clear() {
        rootNode.removeAllChildren();
        treeModel.reload();
    }

    /** Remove the currently selected node. */
    public void removeCurrentNode() {
        TreePath currentSelection = tree.getSelectionPath();
        if (currentSelection != null) {
            DefaultMutableTreeNode currentNode = (DefaultMutableTreeNode)
                         (currentSelection.getLastPathComponent());
            MutableTreeNode parent = (MutableTreeNode)(currentNode.getParent());
            if (parent != null) {
                treeModel.removeNodeFromParent(currentNode);
                return;
            }
        }

        // Either there was no selection, or the root was selected.
        toolkit.beep();
    }

    /** Add child to the currently selected node. */
    public DefaultMutableTreeNode addObject(Object child) {
        DefaultMutableTreeNode parentNode = null;
        TreePath parentPath = tree.getSelectionPath();

        if (parentPath == null) {
            parentNode = rootNode;
        } else {
            parentNode = (DefaultMutableTreeNode)
                         (parentPath.getLastPathComponent());
        }

        return addObject(parentNode, child, true);
    }

    public DefaultMutableTreeNode addObject(DefaultMutableTreeNode parent,
                                            Object child) {
        return addObject(parent, child, false);
    }

    public DefaultMutableTreeNode addObject(DefaultMutableTreeNode parent,
                                            Object child,
                                            boolean shouldBeVisible) {
        DefaultMutableTreeNode childNode =
                new DefaultMutableTreeNode(child);

        if (parent == null) {
            parent = rootNode;
        }

        treeModel.insertNodeInto(childNode, parent,
                                 parent.getChildCount());

        // Make sure the user can see the lovely new node.
        if (shouldBeVisible) {
            tree.scrollPathToVisible(new TreePath(childNode.getPath()));
        }
        return childNode;
    }

    class MyTreeModelListener implements TreeModelListener {
        public void treeNodesChanged(TreeModelEvent e) {
            DefaultMutableTreeNode node;
            node = (DefaultMutableTreeNode)
                     (e.getTreePath().getLastPathComponent());

            /*
             * If the event lists children, then the changed
             * node is the child of the node we've already
             * gotten.  Otherwise, the changed node and the
             * specified node are the same.
             */
            try {
                int index = e.getChildIndices()[0];
                node = (DefaultMutableTreeNode)
                       (node.getChildAt(index));
            } catch (NullPointerException exc) {}

            System.out.println("The user has finished editing the node.");
            System.out.println("New value: " + node.getUserObject());
        }
        public void treeNodesInserted(TreeModelEvent e) {
        }
        public void treeNodesRemoved(TreeModelEvent e) {
        }
        public void treeStructureChanged(TreeModelEvent e) {
        }
    }
}
```

```
/*
 * This code is based on an example provided by Richard Stanford,
 * a tutorial reader.
 */

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

public class DynamicTreeDemo extends JPanel {
    private int newNodeSuffix = 1;

    public DynamicTreeDemo(JFrame frame) {
        //create the components
        final DynamicTree treePanel = new DynamicTree();
        populateTree(treePanel);

        JButton addButton = new JButton("Add");
        addButton.addActionListener(new ActionListener() {
            public void actionPerformed(ActionEvent e) {
                treePanel.addObject("New Node " + newNodeSuffix++);
            }
        });

        JButton removeButton = new JButton("Remove");
        removeButton.addActionListener(new ActionListener() {
            public void actionPerformed(ActionEvent e) {
                treePanel.removeCurrentNode();
            }
        });

        JButton clearButton = new JButton("Clear");
        clearButton.addActionListener(new ActionListener() {
            public void actionPerformed(ActionEvent e) {
                treePanel.clear();
            }
        });

        //Lay everything out.
        setLayout(new BorderLayout());
        treePanel.setPreferredSize(new Dimension(300, 150));
        add(treePanel, BorderLayout.CENTER);

        JPanel panel = new JPanel();
        panel.setLayout(new GridLayout(0,1));
        panel.add(addButton);
        panel.add(removeButton);
        panel.add(clearButton);
        add(panel, BorderLayout.EAST);
    }

    public void populateTree(DynamicTree treePanel) {
        String p1Name = new String("Parent 1");
        String p2Name = new String("Parent 2");
        String c1Name = new String("Child 1");
        String c2Name = new String("Child 2");

        DefaultMutableTreeNode p1, p2;

        p1 = treePanel.addObject(null, p1Name);
        p2 = treePanel.addObject(null, p2Name);
        treePanel.addObject(p1, c1Name);
        treePanel.addObject(p1, c2Name);

        treePanel.addObject(p2, c1Name);
        treePanel.addObject(p2, c2Name);
    }

    public static void main(String[] args) {
        JFrame frame = new JFrame("DynamicTreeDemo");

        Container contentPane = frame.getContentPane();
        contentPane.setLayout(new GridLayout(1,1));
        contentPane.add(new DynamicTreeDemo(frame));

        frame.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });

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

```
import javax.swing.JTree;
import javax.swing.tree.DefaultMutableTreeNode;
import javax.swing.event.TreeSelectionListener;
import javax.swing.event.TreeSelectionEvent;
import javax.swing.tree.TreeSelectionModel;
import java.net.URL;
import java.io.IOException;
import javax.swing.JEditorPane;
import javax.swing.JScrollPane;
import javax.swing.JSplitPane;
import javax.swing.JFrame;
import java.awt.*;
import java.awt.event.*;

public class TreeDemo extends JFrame {
    private JEditorPane htmlPane;
    private static boolean DEBUG = false;
    private URL helpURL;

    //Optionally play with line styles.  Possible values are
    //"Angled", "Horizontal", and "None" (the default).
    private boolean playWithLineStyle = false;
    private String lineStyle = "Angled";

    public TreeDemo() {
        super("TreeDemo");

        //Create the nodes.
        DefaultMutableTreeNode top = new DefaultMutableTreeNode("The Java Series");
        createNodes(top);

        //Create a tree that allows one selection at a time.
        final JTree tree = new JTree(top);
        tree.getSelectionModel().setSelectionMode
                (TreeSelectionModel.SINGLE_TREE_SELECTION);

        //Listen for when the selection changes.
        tree.addTreeSelectionListener(new TreeSelectionListener() {
            public void valueChanged(TreeSelectionEvent e) {
                DefaultMutableTreeNode node = (DefaultMutableTreeNode)
                                   tree.getLastSelectedPathComponent();

                if (node == null) return;

                Object nodeInfo = node.getUserObject();
                if (node.isLeaf()) {
                    BookInfo book = (BookInfo)nodeInfo;
                    displayURL(book.bookURL);
                    if (DEBUG) {
                        System.out.print(book.bookURL + ":  \n    ");
                    }
                } else {
                    displayURL(helpURL);
                }
                if (DEBUG) {
                    System.out.println(nodeInfo.toString());
                }
            }
        });

        if (playWithLineStyle) {
            tree.putClientProperty("JTree.lineStyle", lineStyle);
        }

        //Create the scroll pane and add the tree to it. 
        JScrollPane treeView = new JScrollPane(tree);

        //Create the HTML viewing pane.
        htmlPane = new JEditorPane();
        htmlPane.setEditable(false);
        initHelp();
        JScrollPane htmlView = new JScrollPane(htmlPane);

        //Add the scroll panes to a split pane.
        JSplitPane splitPane = new JSplitPane(JSplitPane.VERTICAL_SPLIT);
        splitPane.setTopComponent(treeView);
        splitPane.setBottomComponent(htmlView);

        Dimension minimumSize = new Dimension(100, 50);
        htmlView.setMinimumSize(minimumSize);
        treeView.setMinimumSize(minimumSize);
        splitPane.setDividerLocation(100); //XXX: ignored in some releases
                                           //of Swing. bug 4101306
        //workaround for bug 4101306:
        //treeView.setPreferredSize(new Dimension(100, 100)); 

        splitPane.setPreferredSize(new Dimension(500, 300));

        //Add the split pane to this frame.
        getContentPane().add(splitPane, BorderLayout.CENTER);
    }

    private class BookInfo {
        public String bookName;
        public URL bookURL;
        public String prefix = "file:" 
                               + System.getProperty("user.dir")
                               + System.getProperty("file.separator");
        public BookInfo(String book, String filename) {
            bookName = book;
            try {
                bookURL = new URL(prefix + filename);
            } catch (java.net.MalformedURLException exc) {
                System.err.println("Attempted to create a BookInfo "
                                   + "with a bad URL: " + bookURL);
                bookURL = null;
            }
        }

        public String toString() {
            return bookName;
        }
    }

    private void initHelp() {
        String s = null;
        try {
            s = "file:" 
                + System.getProperty("user.dir")
                + System.getProperty("file.separator")
                + "TreeDemoHelp.html";
            if (DEBUG) {
                System.out.println("Help URL is " + s);
            }
            helpURL = new URL(s);
            displayURL(helpURL);
        } catch (Exception e) {
            System.err.println("Couldn't create help URL: " + s);
        }
    }

    private void displayURL(URL url) {
        try {
            htmlPane.setPage(url);
        } catch (IOException e) {
            System.err.println("Attempted to read a bad URL: " + url);
        }
    }

    private void createNodes(DefaultMutableTreeNode top) {
        DefaultMutableTreeNode category = null;
        DefaultMutableTreeNode book = null;

        category = new DefaultMutableTreeNode("Books for Java Programmers");
        top.add(category);

        //original Tutorial
        book = new DefaultMutableTreeNode(new BookInfo
            ("The Java Tutorial: Object-Oriented Programming for the Internet",
            "tutorial.html"));
        category.add(book);

        //Tutorial Continued
        book = new DefaultMutableTreeNode(new BookInfo
            ("The Java Tutorial Continued: The Rest of the JDK",
            "tutorialcont.html"));
        category.add(book);

        //JFC Swing Tutorial
        book = new DefaultMutableTreeNode(new BookInfo
            ("The JFC Swing Tutorial: A Guide to Constructing GUIs",
            "swingtutorial.html"));
        category.add(book);

        //Arnold/Gosling
        book = new DefaultMutableTreeNode(new BookInfo
            ("The Java Programming Language", "arnold.html"));
        category.add(book);

        //FAQ
        book = new DefaultMutableTreeNode(new BookInfo(
            "The Java FAQ", "faq.html"));
        category.add(book);

        //Chan/Lee
        book = new DefaultMutableTreeNode(new BookInfo
            ("The Java Class Libraries: An Annotated Reference",
             "chanlee.html"));
        category.add(book);

        //Threads
        book = new DefaultMutableTreeNode(new BookInfo
            ("Concurrent Programming in Java: Design Principles and Patterns",
             "thread.html"));
        category.add(book);
        category = new DefaultMutableTreeNode("Books for Java Implementers");
        top.add(category);

        //VM
        book = new DefaultMutableTreeNode(new BookInfo
            ("The Java Virtual Machine Specification",
             "vm.html"));
        category.add(book);

        //Language Spec
        book = new DefaultMutableTreeNode(new BookInfo
            ("The Java Language Specification",
             "jls.html"));
        category.add(book);
    }

    public static void main(String[] args) {
        JFrame frame = new TreeDemo();

        frame.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });

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

```
import javax.swing.JTree;
import javax.swing.tree.DefaultMutableTreeNode;
import javax.swing.event.TreeSelectionListener;
import javax.swing.event.TreeSelectionEvent;
import javax.swing.tree.TreeSelectionModel;
import javax.swing.tree.DefaultTreeCellRenderer;
import javax.swing.ImageIcon;
import java.net.URL;
import java.io.IOException;
import javax.swing.JEditorPane;
import javax.swing.JScrollPane;
import javax.swing.JSplitPane;
import javax.swing.JFrame;
import java.awt.*;
import java.awt.event.*;

public class TreeIconDemo extends JFrame {
    private JEditorPane htmlPane;
    private static boolean DEBUG = false;
    private URL helpURL;

    public TreeIconDemo() {
        super("TreeIconDemo");

        //Create the nodes.
        DefaultMutableTreeNode top = new DefaultMutableTreeNode("The Java Series");
        createNodes(top);

        //Create a tree that allows one selection at a time.
        final JTree tree = new JTree(top);
        tree.getSelectionModel().setSelectionMode
                (TreeSelectionModel.SINGLE_TREE_SELECTION);

        /*
         * Set the icon for leaf nodes.
         * Note: In the Swing 1.0.x release, we used
         * swing.plaf.basic.BasicTreeCellRenderer.
         */
        DefaultTreeCellRenderer renderer = new DefaultTreeCellRenderer();
        renderer.setLeafIcon(new ImageIcon("images/middle.gif"));
        tree.setCellRenderer(renderer);

        //Listen for when the selection changes.
        tree.addTreeSelectionListener(new TreeSelectionListener() {
            public void valueChanged(TreeSelectionEvent e) {
                DefaultMutableTreeNode node = (DefaultMutableTreeNode)
                                   tree.getLastSelectedPathComponent();

                if (node == null) return;

                Object nodeInfo = node.getUserObject();
                if (node.isLeaf()) {
                    BookInfo book = (BookInfo)nodeInfo;
                    displayURL(book.bookURL);
                    if (DEBUG) {
                        System.out.print(book.bookURL + ":  \n    ");
                    }
                } else {
                    displayURL(helpURL);
                }
                if (DEBUG) {
                    System.out.println(nodeInfo.toString());
                }
            }
        });

        //Create the scroll pane and add the tree to it.
        JScrollPane treeView = new JScrollPane(tree);

        //Create the HTML viewing pane.
        htmlPane = new JEditorPane();
        htmlPane.setEditable(false);
        initHelp();
        JScrollPane htmlView = new JScrollPane(htmlPane);

        //Add the scroll panes to a split pane.
        JSplitPane splitPane = new JSplitPane(JSplitPane.VERTICAL_SPLIT);
        splitPane.setTopComponent(treeView);
        splitPane.setBottomComponent(htmlView);
        Dimension minimumSize = new Dimension(100, 50);
        htmlView.setMinimumSize(minimumSize);
        treeView.setMinimumSize(minimumSize);
        splitPane.setDividerLocation(100); //XXX: ignored in some releases
                                           //of Swing. bug 4101306
        //workaround for bug 4101306:
        //treeView.setPreferredSize(new Dimension(100, 100));

        splitPane.setPreferredSize(new Dimension(500, 300));

        //Add the split pane to this frame.
        getContentPane().add(splitPane, BorderLayout.CENTER);
    }

    private class BookInfo {
        public String bookName;
        public URL bookURL;
        public String prefix = "file:"
                               + System.getProperty("user.dir")
                               + System.getProperty("file.separator");
        public BookInfo(String book, String filename) {
            bookName = book;
            try {
                bookURL = new URL(prefix + filename);
            } catch (java.net.MalformedURLException exc) {
                System.err.println("Attempted to create a BookInfo "
                                   + "with a bad URL: " + bookURL);
                bookURL = null;
            }
        }

        public String toString() {
            return bookName;
        }
    }

    private void initHelp() {
        String s = null;
        try {
            s = "file:"
                + System.getProperty("user.dir")
                + System.getProperty("file.separator")
                + "TreeDemoHelp.html";
            if (DEBUG) {
                System.out.println("Help URL is " + s);
            }
            helpURL = new URL(s);
            displayURL(helpURL);
        } catch (Exception e) {
            System.err.println("Couldn't create help URL: " + s);
        }
    }

    private void displayURL(URL url) {
        try {
            htmlPane.setPage(url);
        } catch (IOException e) {
            System.err.println("Attempted to read a bad URL: " + url);
        }
    }

    private void createNodes(DefaultMutableTreeNode top) {
        DefaultMutableTreeNode category = null;
        DefaultMutableTreeNode book = null;

        category = new DefaultMutableTreeNode("Books for Java Programmers");
        top.add(category);

        //original Tutorial
        book = new DefaultMutableTreeNode(new BookInfo
            ("The Java Tutorial: Object-Oriented Programming for the Internet",
            "tutorial.html"));
        category.add(book);

        //Tutorial Continued
        book = new DefaultMutableTreeNode(new BookInfo
            ("The Java Tutorial Continued: The Rest of the JDK",
            "tutorialcont.html"));
        category.add(book);

        //JFC Swing Tutorial
        book = new DefaultMutableTreeNode(new BookInfo
            ("The JFC Swing Tutorial: A Guide to Constructing GUIs",
            "swingtutorial.html"));
        category.add(book);

        //Arnold/Gosling
        book = new DefaultMutableTreeNode(new BookInfo
            ("The Java Programming Language", "arnold.html"));
        category.add(book);

        //FAQ
        book = new DefaultMutableTreeNode(new BookInfo(
            "The Java FAQ", "faq.html"));
        category.add(book);

        //Chan/Lee
        book = new DefaultMutableTreeNode(new BookInfo
            ("The Java Class Libraries: An Annotated Reference",
             "chanlee.html"));
        category.add(book);

        //Threads
        book = new DefaultMutableTreeNode(new BookInfo
            ("Concurrent Programming in Java: Design Principles and Patterns",
             "thread.html"));
        category.add(book);
        category = new DefaultMutableTreeNode("Books for Java Implementers");
        top.add(category);

        //VM
        book = new DefaultMutableTreeNode(new BookInfo
            ("The Java Virtual Machine Specification",
             "vm.html"));
        category.add(book);

        //Language Spec
        book = new DefaultMutableTreeNode(new BookInfo
            ("The Java Language Specification",
             "jls.html"));
        category.add(book);
    }

    public static void main(String[] args) {
        JFrame frame = new TreeIconDemo();

        frame.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });

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

```
import javax.swing.JTree;
import javax.swing.tree.DefaultMutableTreeNode;
import javax.swing.event.TreeSelectionListener;
import javax.swing.event.TreeSelectionEvent;
import javax.swing.tree.TreeSelectionModel;
import javax.swing.tree.DefaultTreeCellRenderer;
import javax.swing.ImageIcon;
import javax.swing.ToolTipManager;
import java.net.URL;
import java.io.IOException;
import javax.swing.JEditorPane;
import javax.swing.JScrollPane;
import javax.swing.JSplitPane;
import javax.swing.JFrame;
import java.awt.*;
import java.awt.event.*;

public class TreeIconDemo2 extends JFrame {
    private JEditorPane htmlPane;
    private static boolean DEBUG = false;
    private URL helpURL;

    public TreeIconDemo2() {
        super("TreeIconDemo2");

        //Create the nodes.
        DefaultMutableTreeNode top = new DefaultMutableTreeNode(
                                          "The Java Series");
        createNodes(top);

        //Create a tree that allows one selection at a time.
        final JTree tree = new JTree(top);
        tree.getSelectionModel().setSelectionMode
                (TreeSelectionModel.SINGLE_TREE_SELECTION);

        //Enable tool tips.
        ToolTipManager.sharedInstance().registerComponent(tree);

        /*
         * Set the icon for leaf nodes.
         * Note: In the Swing 1.0.x release, we used
         * swing.plaf.basic.BasicTreeCellRenderer.
         */
        tree.setCellRenderer(new MyRenderer());

        //Listen for when the selection changes.
        tree.addTreeSelectionListener(new TreeSelectionListener() {
            public void valueChanged(TreeSelectionEvent e) {
                DefaultMutableTreeNode node = (DefaultMutableTreeNode)
                                   tree.getLastSelectedPathComponent();

                if (node == null) return;

                Object nodeInfo = node.getUserObject();
                if (node.isLeaf()) {
                    BookInfo book = (BookInfo)nodeInfo;
                    displayURL(book.bookURL);
                    if (DEBUG) {
                        System.out.print(book.bookURL + ":  \n    ");
                    }
                } else {
                    displayURL(helpURL);
                }
                if (DEBUG) {
                    System.out.println(nodeInfo.toString());
                }
            }
        });

        //Create the scroll pane and add the tree to it.
        JScrollPane treeView = new JScrollPane(tree);

        //Create the HTML viewing pane.
        htmlPane = new JEditorPane();
        htmlPane.setEditable(false);
        initHelp();
        JScrollPane htmlView = new JScrollPane(htmlPane);

        //Add the scroll panes to a split pane.
        JSplitPane splitPane = new JSplitPane(JSplitPane.VERTICAL_SPLIT);
        splitPane.setTopComponent(treeView);
        splitPane.setBottomComponent(htmlView);
        Dimension minimumSize = new Dimension(100, 50);
        htmlView.setMinimumSize(minimumSize);
        treeView.setMinimumSize(minimumSize);
        splitPane.setDividerLocation(100); //XXX: ignored in some releases
                                           //of Swing. bug 4101306
        //workaround for bug 4101306:
        //treeView.setPreferredSize(new Dimension(100, 100));

        splitPane.setPreferredSize(new Dimension(500, 300));

        //Add the split pane to this frame.
        getContentPane().add(splitPane, BorderLayout.CENTER);
    }

    private class BookInfo {
        public String bookName;
        public URL bookURL;
        public String prefix = "file:"
                               + System.getProperty("user.dir")
                               + System.getProperty("file.separator");
        public BookInfo(String book, String filename) {
            bookName = book;
            try {
                bookURL = new URL(prefix + filename);
            } catch (java.net.MalformedURLException exc) {
                System.err.println("Attempted to create a BookInfo "
                                   + "with a bad URL: " + bookURL);
                bookURL = null;
            }
        }

        public String toString() {
            return bookName;
        }
    }

    private void initHelp() {
        String s = null;
        try {
            s = "file:"
                + System.getProperty("user.dir")
                + System.getProperty("file.separator")
                + "TreeDemoHelp.html";
            if (DEBUG) {
                System.out.println("Help URL is " + s);
            }
            helpURL = new URL(s);
            displayURL(helpURL);
        } catch (Exception e) {
            System.err.println("Couldn't create help URL: " + s);
        }
    }

    private void displayURL(URL url) {
        try {
            htmlPane.setPage(url);
        } catch (IOException e) {
            System.err.println("Attempted to read a bad URL: " + url);
        }
    }

    private void createNodes(DefaultMutableTreeNode top) {
        DefaultMutableTreeNode category = null;
        DefaultMutableTreeNode book = null;

        category = new DefaultMutableTreeNode("Books for Java Programmers");
        top.add(category);

        //original Tutorial
        book = new DefaultMutableTreeNode(new BookInfo
            ("The Java Tutorial: Object-Oriented Programming for the Internet",
            "tutorial.html"));
        category.add(book);

        //Tutorial Continued
        book = new DefaultMutableTreeNode(new BookInfo
            ("The Java Tutorial Continued: The Rest of the JDK",
            "tutorialcont.html"));
        category.add(book);

        //JFC Swing Tutorial
        book = new DefaultMutableTreeNode(new BookInfo
            ("The JFC Swing Tutorial: A Guide to Constructing GUIs",
            "swingtutorial.html"));
        category.add(book);

        //Arnold/Gosling
        book = new DefaultMutableTreeNode(new BookInfo
            ("The Java Programming Language", "arnold.html"));
        category.add(book);

        //FAQ
        book = new DefaultMutableTreeNode(new BookInfo(
            "The Java FAQ", "faq.html"));
        category.add(book);

        //Chan/Lee
        book = new DefaultMutableTreeNode(new BookInfo
            ("The Java Class Libraries: An Annotated Reference",
             "chanlee.html"));
        category.add(book);

        //Threads
        book = new DefaultMutableTreeNode(new BookInfo
            ("Concurrent Programming in Java: Design Principles and Patterns",
             "thread.html"));
        category.add(book);

        category = new DefaultMutableTreeNode("Books for Java Implementers");
        top.add(category);

        //VM
        book = new DefaultMutableTreeNode(new BookInfo
            ("The Java Virtual Machine Specification",
             "vm.html"));
        category.add(book);

        //Language Spec
        book = new DefaultMutableTreeNode(new BookInfo
            ("The Java Language Specification",
             "jls.html"));
        category.add(book);
    }

    public static void main(String[] args) {
        JFrame frame = new TreeIconDemo2();

        frame.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });

        frame.pack();
        frame.setVisible(true);
    }

    private class MyRenderer extends DefaultTreeCellRenderer {
        ImageIcon tutorialIcon;

        public MyRenderer() {
            tutorialIcon = new ImageIcon("images/middle.gif");
        }

        public Component getTreeCellRendererComponent(
                            JTree tree,
                            Object value,
                            boolean sel,
                            boolean expanded,
                            boolean leaf,
                            int row,
                            boolean hasFocus) {

            super.getTreeCellRendererComponent(
                            tree, value, sel,
                            expanded, leaf, row,
                            hasFocus);
            if (leaf && isTutorialBook(value)) {
                setIcon(tutorialIcon);
                setToolTipText("This book is in the Tutorial series.");
            } else {
                setToolTipText(null);
            }

            return this;
        }
        protected boolean isTutorialBook(Object value) {
            DefaultMutableTreeNode node =
                    (DefaultMutableTreeNode)value;
            BookInfo nodeInfo =
                    (BookInfo)(node.getUserObject());
            String title = nodeInfo.bookName;
            if (title.indexOf("Tutorial") >= 0) {
                return true;
            }

            return false;
        }
    }
}
```

```
import javax.swing.event.*;
import javax.swing.tree.*;
import java.util.Vector;

public class GenealogyModel implements TreeModel {
    private boolean showAncestors;
    private Vector treeModelListeners = new Vector();
    private Person rootPerson;

    public GenealogyModel(Person root) {
        showAncestors = false;
        rootPerson = root;
    }

    /**
     * Used to toggle between show ancestors/show descendant and
     * to change the root of the tree.
     */
    public void showAncestor(boolean b, Object newRoot) {
        showAncestors = b;
        Person oldRoot = rootPerson;
        if (newRoot != null) {
           rootPerson = (Person)newRoot;
        }
        fireTreeStructureChanged(oldRoot);
    }


//////////////// Fire events //////////////////////////////////////////////

    /**
     * The only event raised by this model is TreeStructureChanged with the
     * root as path, i.e. the whole tree has changed.
     */
    protected void fireTreeStructureChanged(Person oldRoot) {
        int len = treeModelListeners.size();
        TreeModelEvent e = new TreeModelEvent(this,
                                              new Object[] {oldRoot});
        for (int i = 0; i < len; i++) {
            ((TreeModelListener)treeModelListeners.elementAt(i)).
                    treeStructureChanged(e);
        }
    }


//////////////// TreeModel interface implementation ///////////////////////


    /**
     * Adds a listener for the TreeModelEvent posted after the tree changes.
     */
    public void addTreeModelListener(TreeModelListener l) {
        treeModelListeners.addElement(l);
    }

    /**
     * Returns the child of parent at index index in the parent's child array.
     */
    public Object getChild(Object parent, int index) {
        Person p = (Person)parent;
        if (showAncestors) {
            if ((index > 0) && (p.getFather() != null)) {
                return p.getMother();
            }
            return p.getFather();
        }
        return p.getChildAt(index);
    }

    /**
     * Returns the number of children of parent.
     */
    public int getChildCount(Object parent) {
        Person p = (Person)parent;
        if (showAncestors) {
            int count = 0;
            if (p.getFather() != null) {
                count++;
            }
            if (p.getMother() != null) {
                count++;
            }
            return count;
        }
        return p.getChildCount();
    }

    /**
     * Returns the index of child in parent.
     */
    public int getIndexOfChild(Object parent, Object child) {
        Person p = (Person)parent;
        if (showAncestors) {
            int count = 0;
            Person father = p.getFather();
            if (father != null) {
                count++;
                if (father == child) {
                    return 0;
                }
            }
            if (p.getMother() != child) {
                return count;
            }
            return -1;
        }
        return p.getIndexOfChild((Person)child);
    }

    /**
     * Returns the root of the tree.
     */
    public Object getRoot() {
        return rootPerson;
    }

    /**
     * Returns true if node is a leaf.
     */
    public boolean isLeaf(Object node) {
        Person p = (Person)node;
        if (showAncestors) {
            return ((p.getFather() == null)
                 && (p.getMother() == null));
        }
        return p.getChildCount() == 0;
    }

    /**
     * Removes a listener previously added with addTreeModelListener().
     */
    public void removeTreeModelListener(TreeModelListener l) {
        treeModelListeners.removeElement(l);
    }

    /**
     * Messaged when the user has altered the value for the item
     * identified by path to newValue.  Not used by this model.
     */
    public void valueForPathChanged(TreePath path, Object newValue) {
        System.out.println("*** valueForPathChanged : "
                           + path + " --> " + newValue);
    }
}
```

```
import javax.swing.*;
import javax.swing.tree.*;

public class GenealogyTree extends JTree {
    GenealogyModel model;

    public GenealogyTree(Person graphNode) {
        super(new GenealogyModel(graphNode));
        getSelectionModel().setSelectionMode(
                TreeSelectionModel.SINGLE_TREE_SELECTION);
        DefaultTreeCellRenderer renderer = new DefaultTreeCellRenderer();
        Icon personIcon = null;
        renderer.setLeafIcon(personIcon);
        renderer.setClosedIcon(personIcon);
        renderer.setOpenIcon(personIcon);
        setCellRenderer(renderer);
    }

    /**
     * Get the selected item in the tree, and call showAncestor with this
     * item on the model.
     */
    public void showAncestor(boolean b) {
        Object newRoot = null;
        TreePath path = getSelectionModel().getSelectionPath();
        if (path != null) {
            newRoot = path.getLastPathComponent();
        }
        ((GenealogyModel)getModel()).showAncestor(b, newRoot);
    }
}
```

```java
import java.util.Vector;

public class Person {
    Person father;
    Person mother;
    Vector children;
    private String name;

    public Person(String name) {
        this.name = name;
        mother = father = null;
        children = new Vector();
    }

    /**
    *   Link together all members of a family.
    *
    *   @param pa the father
    *   @param ma the mother
    *   @param kids the children
    */
    public static void linkFamily(Person pa,
                                  Person ma,
                                  Person[] kids) {
        int len = kids.length;
        Person kid = null;
        for (int i = 0; i < len; i++) {
            kid = kids[i];
            pa.children.addElement(kid);
            ma.children.addElement(kid);
            kid.father = pa;
            kid.mother = ma;
        }
    }

/// getter methods ///////////////////////////////////

    public String toString() { return name; }
    public String getName() { return name; }
    public Person getFather() { return father; }
    public Person getMother() { return mother; }
    public int getChildCount() { return children.size(); }
    public Person getChildAt(int i) {
        return (Person)children.elementAt(i);
    }
    public int getIndexOfChild(Person kid) {
        return children.indexOf(kid);
    }
}
```

```
/*
 * An example provided by tutorial reader Olivier Berlanger.
 */
import javax.swing.*;
import java.awt.*;
import java.awt.event.*;

public class GenealogyExample extends JFrame {
    GenealogyTree tree;

    public GenealogyExample() {
        super("Genealogy tree demo");
        // add window listener
        addWindowListener(new WindowAdapter() {
                public void windowClosing(WindowEvent e) {
                    System.exit(0);
                }
            });
        // construct the panel with the toggle buttons
        JRadioButton showDescendant =
                new JRadioButton("Show descendants", true);
        final JRadioButton showAncestor =
                new JRadioButton("Show ancestors");
        ButtonGroup bGroup = new ButtonGroup();
        bGroup.add(showDescendant);
        bGroup.add(showAncestor);
        ActionListener al = new ActionListener() {
            public void actionPerformed(ActionEvent ae) {
                if (ae.getSource() == showAncestor) {
                    tree.showAncestor(true);
                }
                else {
                    tree.showAncestor(false);
                }
            }
        };
        showDescendant.addActionListener(al);
        showAncestor.addActionListener(al);
        JPanel buttonPanel = new JPanel();
        buttonPanel.add(showDescendant);
        buttonPanel.add(showAncestor);

        // construct the tree
        tree = new GenealogyTree(getGenealogyGraph());
        JScrollPane scrollPane = new JScrollPane(tree);
        scrollPane.setPreferredSize(new Dimension(200, 200));

        // construct the content pane
        JPanel contentPane = new JPanel(new BorderLayout());
        contentPane.add(buttonPanel, BorderLayout.NORTH);
        contentPane.add(scrollPane, BorderLayout.CENTER);
        setContentPane(contentPane);
    }

    /**
     *  Constructs the genealogy graph used by the model.
     */
    public Person getGenealogyGraph() {
        //the greatgrandparent generation
        Person a1 = new Person("Jack (great-granddaddy)");
        Person a2 = new Person("Jean (great-granny)");
        Person a3 = new Person("Albert (great-granddaddy)");
        Person a4 = new Person("Rae (great-granny)");
        Person a5 = new Person("Paul (great-granddaddy)");
        Person a6 = new Person("Josie (great-granny)");

        //the grandparent generation
        Person b1 = new Person("Peter (grandpa)");
        Person b2 = new Person("Zoe (grandma)");
        Person b3 = new Person("Simon (grandpa)");
        Person b4 = new Person("James (grandpa)");
        Person b5 = new Person("Bertha (grandma)");
        Person b6 = new Person("Veronica (grandma)");
        Person b7 = new Person("Anne (grandma)");
        Person b8 = new Person("Renee (grandma)");
        Person b9 = new Person("Joseph (grandpa)");

        //the parent generation
        Person c1 = new Person("Isabelle (mom)");
        Person c2 = new Person("Frank (dad)");
        Person c3 = new Person("Louis (dad)");
        Person c4 = new Person("Laurence (dad)");
        Person c5 = new Person("Valerie (mom)");
        Person c6 = new Person("Marie (mom)");
        Person c7 = new Person("Helen (mom)");
        Person c8 = new Person("Mark (dad)");
        Person c9 = new Person("Oliver (dad)");

        //the youngest generation
        Person d1 = new Person("Clement (boy)");
        Person d2 = new Person("Colin (boy)");

        Person.linkFamily(a1,a2,new Person[] {b1,b2,b3,b4});
        Person.linkFamily(a3,a4,new Person[] {b5,b6,b7});
        Person.linkFamily(a5,a6,new Person[] {b8,b9});
        Person.linkFamily(b3,b6,new Person[] {c1,c2,c3});
        Person.linkFamily(b4,b5,new Person[] {c4,c5,c6});
        Person.linkFamily(b8,b7,new Person[] {c7,c8,c9});
        Person.linkFamily(c4,c7,new Person[] {d1,d2});

        return a1;
    }

    public static void main(String[] args) {
        // create a frame
        JFrame mainFrame = new GenealogyExample();
        mainFrame.pack();
        mainFrame.setVisible(true);
    }
}
```

The Java^{TM} Tutorial

Trail: Creating a GUI with JFC/Swing
Lesson: Writing Event Listeners

Run TreeExpandEventDemo2

Note: Because the preceding applet uses the Swing 1.1 API, it requires Java Plug-in 1.1.2 or Java Plug-in 1.2. It won't work with Java Plug-in 1.1.1 or uncustomized 1.1 browsers. For more information about running applets in the tutorial, refer to About Our Examples. That page includes a section about Downloading Java Plug-in.

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

public class TreeExpandEventDemo2 extends JApplet {
    DemoArea demoArea;
    JTextArea textArea;
    final static String newline = "\n";

    public void init() {
        GridBagLayout gridbag = new GridBagLayout();
        GridBagConstraints c = new GridBagConstraints();
        JPanel contentPane = new JPanel();
        contentPane.setLayout(gridbag);

        c.fill = GridBagConstraints.BOTH;
        c.gridwidth = GridBagConstraints.REMAINDER;
        c.weightx = 1.0;
        c.weighty = 1.0;

        c.insets = new Insets(1, 1, 1, 1);
        demoArea = new DemoArea();
        gridbag.setConstraints(demoArea, c);
        contentPane.add(demoArea);

        c.insets = new Insets(0, 0, 0, 0);
        textArea = new JTextArea();
        textArea.setEditable(false);
        JScrollPane scrollPane = new JScrollPane(textArea);
        scrollPane.setVerticalScrollBarPolicy(
            JScrollPane.VERTICAL_SCROLLBAR_ALWAYS);
        scrollPane.setPreferredSize(new Dimension(200, 75));
        gridbag.setConstraints(scrollPane, c);
        contentPane.add(scrollPane);

        setContentPane(contentPane);
    }

    void saySomething(String eventDescription, TreeExpansionEvent e) {
        textArea.append(eventDescription + "; "
                        + "path = " + e.getPath()
                        + newline);
    }

    class DemoArea extends JScrollPane
                   implements TreeExpansionListener,
                              TreeWillExpandListener {
        Dimension minSize = new Dimension(100, 100);
        JTree tree;
        Object[] willExpandOptions = {"Cancel Expansion", "Expand"};
        String willExpandText = "A branch node is about to be expanded.\n"
                              + "Click \"Cancel Expansion\" to prevent it.";
        String willExpandTitle = "Tree Will Expand";

        public DemoArea() {
            TreeNode rootNode = createNodes();
            tree = new JTree(rootNode);
            tree.addTreeExpansionListener(this);
            tree.addTreeWillExpandListener(this);

            setViewportView(tree);
        }

        private TreeNode createNodes() {
            DefaultMutableTreeNode root;
            DefaultMutableTreeNode grandparent;
            DefaultMutableTreeNode parent;
            DefaultMutableTreeNode child;

            root = new DefaultMutableTreeNode("San Francisco");

            grandparent = new DefaultMutableTreeNode("Potrero Hill");
            root.add(grandparent);
            //
            parent = new DefaultMutableTreeNode("Restaurants");
            grandparent.add(parent);
            child = new DefaultMutableTreeNode("Thai Barbeque");
            parent.add(child);
            child = new DefaultMutableTreeNode("Goat Hill Pizza");
            parent.add(child);
            //
            parent = new DefaultMutableTreeNode("Grocery Stores");
            grandparent.add(parent);
            child = new DefaultMutableTreeNode("Good Life Grocery");
            parent.add(child);
            child = new DefaultMutableTreeNode("Safeway");
            parent.add(child);

            grandparent = new DefaultMutableTreeNode("Noe Valley");
            root.add(grandparent);
            //
            parent = new DefaultMutableTreeNode("Restaurants");
            grandparent.add(parent);
            child = new DefaultMutableTreeNode("Hamano Sushi");
            parent.add(child);
            child = new DefaultMutableTreeNode("Hahn's Hibachi");
            parent.add(child);
            //
            parent = new DefaultMutableTreeNode("Grocery Stores");
            grandparent.add(parent);
            child = new DefaultMutableTreeNode("Real Foods");
            parent.add(child);
            child = new DefaultMutableTreeNode("Bell Market");
            parent.add(child);

            return root;
        }

        public Dimension getMinimumSize() {
            return minSize;
        }

        public Dimension getPreferredSize() {
            return minSize;
        }

        // Required by TreeWillExpandListener interface.
        public void treeWillExpand(TreeExpansionEvent e)
                    throws ExpandVetoException {
            saySomething("Tree-will-expand event detected", e);
            int n = JOptionPane.showOptionDialog(
                this, willExpandText, willExpandTitle,
                JOptionPane.YES_NO_OPTION,
                JOptionPane.QUESTION_MESSAGE,
                null,
                willExpandOptions,
                willExpandOptions[1]);
            if (n == 0) {
                //User said cancel expansion.
                saySomething("Tree expansion cancelled", e);
                throw new ExpandVetoException(e);
            }
        }

        // Required by TreeWillExpandListener interface.
        public void treeWillCollapse(TreeExpansionEvent e) {
            saySomething("Tree-will-collapse event detected", e);
        }

        // Required by TreeExpansionListener interface.
        public void treeExpanded(TreeExpansionEvent e) {
            saySomething("Tree-expanded event detected", e);
        }

        // Required by TreeExpansionListener interface.
        public void treeCollapsed(TreeExpansionEvent e) {
            saySomething("Tree-collapsed event detected", e);
        }
    }
}
```

```
<APPLET CODE="TreeExpandEventDemo2.class"
        ARCHIVE="example-swing/treeexpand2.jar"
        WIDTH="450" HEIGHT="200"
        ALT="Your browser understands the applet tag but isn't displaying any applet.">
</APPLET>
```

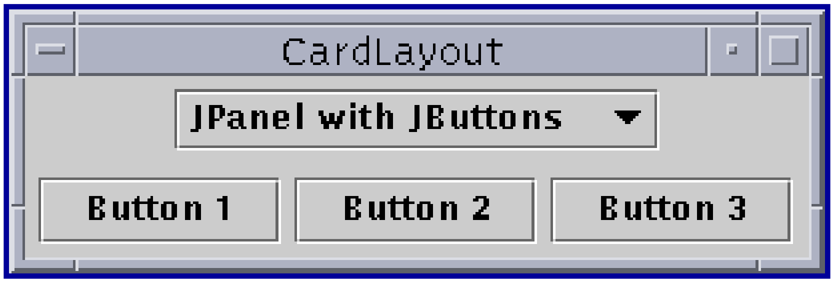
```
<APPLET CODE="WindowEventDemo.class"
        ARCHIVE="example-swing/window.jar"
        WIDTH="400" HEIGHT="200"
        ALT="Your browser understands the applet tag but isn't displaying any applet.">

Since you can't run the applet,
here's a picture of it:

#usemacro UI_FIGURE (
    NAME WindowEventDemo.gif
    W 400
    H 200
    ALT A snapshot of WindowEventDemo, which demonstrates the events that are fired when the
window is resized, hidden, and so on.

)

</APPLET>
```

```
import javax.swing.JOptionPane;
import javax.swing.JDialog;
import javax.swing.JButton;
import javax.swing.JRadioButton;
import javax.swing.ButtonGroup;
import javax.swing.JLabel;
import javax.swing.ImageIcon;
import javax.swing.BoxLayout;
import javax.swing.BorderFactory;
import javax.swing.border.Border;
import javax.swing.JTabbedPane;
import javax.swing.JPanel;
import javax.swing.JFrame;
import java.beans.*; //Property change stuff
import java.awt.*;
import java.awt.event.*;

public class DialogDemo extends JPanel {
    JLabel label;
    ImageIcon icon = new ImageIcon("images/middle.gif");
    JFrame frame;
    String simpleDialogDesc = "Some simple message dialogs";
    String iconDesc = "A JOptionPane has its choice of icons";
    String moreDialogDesc = "Some more dialogs";
    CustomDialog customDialog;

    public DialogDemo(JFrame frame) {
        this.frame = frame;
        customDialog = new CustomDialog(frame, "geisel", this);
        customDialog.pack();

        //create the components
        JPanel frequentPanel = createSimpleDialogBox();
        JPanel featurePanel = createFeatureDialogBox();
        JPanel iconPanel = createIconDialogBox();
        label = new JLabel("Click the \"Show it!\" button"
                           + " to bring up the selected dialog.",
                           JLabel.CENTER);

        //lay them out
        Border padding = BorderFactory.createEmptyBorder(20,20,5,20);
        frequentPanel.setBorder(padding);
        featurePanel.setBorder(padding);
        iconPanel.setBorder(padding);

        JTabbedPane tabbedPane = new JTabbedPane();
        tabbedPane.addTab("Simple Modal Dialogs", null,
                          frequentPanel,
                          simpleDialogDesc); //tooltip text
        tabbedPane.addTab("More Dialogs", null,
                          featurePanel,
                          moreDialogDesc); //tooltip text
        tabbedPane.addTab("Dialog Icons", null,
                          iconPanel,
                          iconDesc); //tooltip text

        setLayout(new BorderLayout());
        add(tabbedPane, BorderLayout.CENTER);
        add(label, BorderLayout.SOUTH);
        label.setBorder(BorderFactory.createEmptyBorder(10,10,10,10));
    }
    void setLabel(String newText) {
        label.setText(newText);
    }

    private JPanel createSimpleDialogBox() {
        final int numButtons = 4;
        JRadioButton[] radioButtons = new JRadioButton[numButtons];
        final ButtonGroup group = new ButtonGroup();

        JButton showItButton = null;

        final String defaultMessageCommand = "default";
        final String yesNoCommand = "yesno";
        final String yeahNahCommand = "yeahnah";
        final String yncCommand = "ync";

        radioButtons[0] = new JRadioButton("OK (in the L&F's words)");
        radioButtons[0].setActionCommand(defaultMessageCommand);

        radioButtons[1] = new JRadioButton("Yes/No (in the L&F's words)");
        radioButtons[1].setActionCommand(yesNoCommand);

        radioButtons[2] = new JRadioButton("Yes/No "
                      + "(in the programmer's words)");
        radioButtons[2].setActionCommand(yeahNahCommand);

        radioButtons[3] = new JRadioButton("Yes/No/Cancel "
                           + "(in the programmer's words)");
        radioButtons[3].setActionCommand(yncCommand);

        for (int i = 0; i < numButtons; i++) {
            group.add(radioButtons[i]);
        }
        radioButtons[0].setSelected(true);

        showItButton = new JButton("Show it!");
        showItButton.addActionListener(new ActionListener() {
            public void actionPerformed(ActionEvent e) {
                String command = group.getSelection().getActionCommand();

                //ok dialog
                if (command == defaultMessageCommand) {
                    JOptionPane.showMessageDialog(frame,
                                "Eggs aren't supposed to be green.");

                //yes/no dialog
                } else if (command == yesNoCommand) {
                    int n = JOptionPane.showConfirmDialog(
                            frame, "Would you like green eggs and ham?",
                            "An Inane Question",
                            JOptionPane.YES_NO_OPTION);
                    if (n == JOptionPane.YES_OPTION) {
                        setLabel("Ewww!");
                    } else if (n == JOptionPane.NO_OPTION) {
                        setLabel("Me neither!");
                    } else {
                        setLabel("Come on -- tell me!");
                    }

                //yes/no (not in those words)
                } else if (command == yeahNahCommand) {
                    Object[] options = {"Yes, please", "No way!"};
                    int n = JOptionPane.showOptionDialog(frame,
                                    "Would you like green eggs and ham?",
                                    "A Silly Question",
                                    JOptionPane.YES_NO_OPTION,
                                    JOptionPane.QUESTION_MESSAGE,
                                    null,
                                    options,
                                    options[0]);
                    if (n == JOptionPane.YES_OPTION) {
                        setLabel("You're kidding!");
                    } else if (n == JOptionPane.NO_OPTION) {
                        setLabel("I don't like them, either.");
                    } else {
                        setLabel("Come on -- 'fess up!");
                    }

                //yes/no/cancel (not in those words)
                } else if (command == yncCommand) {
                    Object[] options = {"Yes, please",
                                        "No, thanks",
                                        "No eggs, no ham!"};
                    int n = JOptionPane.showOptionDialog(frame,
                                    "Would you like some green eggs to go "
                                    + "with that ham?",
                                    "A Silly Question",
                                    JOptionPane.YES_NO_CANCEL_OPTION,
                                    JOptionPane.QUESTION_MESSAGE,
                                    null,
                                    options,
                                    options[2]);
                    if (n == JOptionPane.YES_OPTION) {
                        setLabel("Here you go: green eggs and ham!");
                    } else if (n == JOptionPane.NO_OPTION) {
                        setLabel("OK, just the ham, then.");
                    } else if (n == JOptionPane.CANCEL_OPTION) {
                        setLabel("Well, I'm certainly not going to eat them!");
                    } else {
                        setLabel("Please tell me what you want!");
                    }
                }
                return;
            }
        });

        return createPane(simpleDialogDesc + ":",
                          radioButtons,
                          showItButton);
    }

    //number of buttons *must* be even
    private JPanel create2ColPane(String description,
                                  JRadioButton[] radioButtons,
                                  JButton showButton) {
        JLabel label = new JLabel(description);
        int numPerColumn = radioButtons.length/2;

        JPanel grid = new JPanel();
        grid.setLayout(new GridLayout(0, 2));
        for (int i = 0; i < numPerColumn; i++) {
            grid.add(radioButtons[i]);
            grid.add(radioButtons[i + numPerColumn]);
        }
        JPanel box = new JPanel();
        box.setLayout(new BoxLayout(box, BoxLayout.Y_AXIS));
        box.add(label);
        grid.setAlignmentX(0.0f);
        box.add(grid);

        JPanel pane = new JPanel();
        pane.setLayout(new BorderLayout());
        pane.add(box, BorderLayout.NORTH);
        pane.add(showButton, BorderLayout.SOUTH);

        return pane;
    }

    private JPanel createPane(String description,
                              JRadioButton[] radioButtons,
                              JButton showButton) {

        int numChoices = radioButtons.length;
        JPanel box = new JPanel();
        JLabel label = new JLabel(description);

        box.setLayout(new BoxLayout(box, BoxLayout.Y_AXIS));
        box.add(label);

        for (int i = 0; i < numChoices; i++) {
            box.add(radioButtons[i]);
        }

        JPanel pane = new JPanel();
        pane.setLayout(new BorderLayout());
        pane.add(box, BorderLayout.NORTH);
        pane.add(showButton, BorderLayout.SOUTH);
        return pane;
    }

    /*
     * These dialogs are implemented using showMessageDialog, but
     * you can specify the icon (using similar code) for any other
     * kind of dialog, as well.
     */
    private JPanel createIconDialogBox() {
        JButton showItButton = null;

        final int numButtons = 6;
        JRadioButton[] radioButtons = new JRadioButton[numButtons];
        final ButtonGroup group = new ButtonGroup();

        final String plainCommand = "plain";
        final String infoCommand = "info";
        final String questionCommand = "question";
        final String errorCommand = "error";
        final String warningCommand = "warning";
        final String customCommand = "custom";

        radioButtons[0] = new JRadioButton("Plain (no icon)");
        radioButtons[0].setActionCommand(plainCommand);

        radioButtons[1] = new JRadioButton("Information icon");
        radioButtons[1].setActionCommand(infoCommand);

        radioButtons[2] = new JRadioButton("Question icon");
        radioButtons[2].setActionCommand(questionCommand);

        radioButtons[3] = new JRadioButton("Error icon");
        radioButtons[3].setActionCommand(errorCommand);

        radioButtons[4] = new JRadioButton("Warning icon");
        radioButtons[4].setActionCommand(warningCommand);

        radioButtons[5] = new JRadioButton("Custom icon");
        radioButtons[5].setActionCommand(customCommand);

        for (int i = 0; i < numButtons; i++) {
            group.add(radioButtons[i]);
        }
        radioButtons[0].setSelected(true);

        showItButton = new JButton("Show it!");
        showItButton.addActionListener(new ActionListener() {
            public void actionPerformed(ActionEvent e) {
                String command = group.getSelection().getActionCommand();

                //no icon
                if (command == plainCommand) {
                    JOptionPane.showMessageDialog(frame,
                                    "Eggs aren't supposed to be green.",
                                    "A plain message",
                                    JOptionPane.PLAIN_MESSAGE);
                //information icon
                } else if (command == infoCommand) {
                    JOptionPane.showMessageDialog(frame,
                                    "Eggs aren't supposed to be green.",
                                    "Inane informational dialog",
                                    JOptionPane.INFORMATION_MESSAGE);

            //XXX: It doesn't make sense to make a question with
            //XXX: only one button.
            //XXX: See "Yes/No (but not in those words)" for a better solution.
                //question icon
                } else if (command == questionCommand) {
                    JOptionPane.showMessageDialog(frame,
                                    "You shouldn't use a message dialog "
                                    + "(like this)\n"
                                    + "for a question, OK?",
                                    "Inane question",
                                    JOptionPane.QUESTION_MESSAGE);
                //error icon
                } else if (command == errorCommand) {
                    JOptionPane.showMessageDialog(frame,
                                    "Eggs aren't supposed to be green.",
                                    "Inane error",
                                    JOptionPane.ERROR_MESSAGE);
                //warning icon
                } else if (command == warningCommand) {
                    JOptionPane.showMessageDialog(frame,
                                    "Eggs aren't supposed to be green.",
                                    "Inane warning",
                                    JOptionPane.WARNING_MESSAGE);
                //custom icon
                } else if (command == customCommand) {
                    JOptionPane.showMessageDialog(frame,
                                    "Eggs aren't supposed to be green.",
                                    "Inane custom dialog",
                                JOptionPane.INFORMATION_MESSAGE,
                                icon);
                }
            }
        });

        return create2ColPane(iconDesc + ":",
                              radioButtons,
                              showItButton);
    }

    private JPanel createFeatureDialogBox() {
        final int numButtons = 4;
        JRadioButton[] radioButtons = new JRadioButton[numButtons];
        final ButtonGroup group = new ButtonGroup();

        JButton showItButton = null;

        final String pickOneCommand = "pickone";
        final String nonAutoCommand = "nonautooption";
        final String customOptionCommand = "customoption";
        final String nonModalCommand = "nonmodal";

        radioButtons[0] = new JRadioButton("Pick one of several choices");
        radioButtons[0].setActionCommand(pickOneCommand);

        radioButtons[1] = new JRadioButton("Non-auto-closing dialog");
        radioButtons[1].setActionCommand(nonAutoCommand);

        radioButtons[2] = new JRadioButton("Input-validating dialog "
                                           + "(with custom message area)");
        radioButtons[2].setActionCommand(customOptionCommand);

        radioButtons[3] = new JRadioButton("Non-modal dialog");
        radioButtons[3].setActionCommand(nonModalCommand);

        for (int i = 0; i < numButtons; i++) {
            group.add(radioButtons[i]);
        }
        radioButtons[0].setSelected(true);

        showItButton = new JButton("Show it!");
        showItButton.addActionListener(new ActionListener() {
            public void actionPerformed(ActionEvent e) {
                String command = group.getSelection().getActionCommand();

                //pick one of many
                //XXX: There are some layout problems with this kind
                //XXX: of dialog, partly since this dialog has a two-
                //XXX: line label, and partly since it uses a combo
                //XXX: box that must remain within the window's bounds.
                if (command == pickOneCommand) {
                    Object[] possibilities = {"ham", "spam", "yam"};
                    String s = (String)JOptionPane.showInputDialog(
                                        frame,
                                        "Complete the sentence:\n"
                                        + "\"Green eggs and...\"",
                                        "Customized Dialog",
                                        JOptionPane.PLAIN_MESSAGE,
                                        icon,
                                        possibilities,
                                        "ham");
                    if (s != null) {
                        s = s.trim();
                        if (s.length() > 0) {
                            setLabel("Green eggs and... " + s + "!");
                            return;
                        }
                    }
                    setLabel("Come on, finish the sentence!");

                //non-auto-closing dialog
                } else if (command == nonAutoCommand) {
                    final JOptionPane optionPane = new JOptionPane(
                                    "The only way to close this dialog is by\n"
                                    + "pressing one of the following buttons.\n"
                                    + "Do you understand?",
                                    JOptionPane.QUESTION_MESSAGE,
                                    JOptionPane.YES_NO_OPTION);

                    // You can't use pane.createDialog() because that
                    // method sets up the JDialog with a property change
                    // listener that automatically closes the window
                    // when a button is clicked.
                    final JDialog dialog = new JDialog(frame,
                                                 "Click a button",
                                                 true);
                    dialog.setContentPane(optionPane);
                    dialog.setDefaultCloseOperation(
                        JDialog.DO_NOTHING_ON_CLOSE);
                    dialog.addWindowListener(new WindowAdapter() {
                        public void windowClosing(WindowEvent we) {
                            setLabel("Thwarted user attempt to close window.");
                        }
                    });
                    optionPane.addPropertyChangeListener(
                        new PropertyChangeListener() {
                            public void propertyChange(PropertyChangeEvent e) {
                                String prop = e.getPropertyName();

                                if (dialog.isVisible()
                                 && (e.getSource() == optionPane)
                                 && (prop.equals(JOptionPane.VALUE_PROPERTY) ||
                                     prop.equals(JOptionPane.INPUT_VALUE_PROPERTY))) {
                                    //If you were going to check something
                                    //before closing the window, you'd do
                                    //it here.
                                    dialog.setVisible(false);
                                }
                            }
                        });
                    dialog.pack();
                    dialog.setLocationRelativeTo(frame);
                    dialog.setVisible(true);

                    int value = ((Integer)optionPane.getValue()).intValue();
                    if (value == JOptionPane.YES_OPTION) {
                        setLabel("Good.");
                    } else if (value == JOptionPane.NO_OPTION) {
                        setLabel("Try using the window decorations "
                                 + "to close the non-auto-closing dialog. "
                                 + "You can't!");
                    } else {
                        setLabel("Something's wrong -- this shouldn't happen.");
                    }

                //non-auto-closing dialog with custom message area
                //NOTE: if you don't intend to check the input,
                //then just use showInputDialog instead.
                } else if (command == customOptionCommand) {
                    customDialog.setLocationRelativeTo(frame);
                    customDialog.setVisible(true);

                    String s = customDialog.getValidatedText();
                    if (s != null) {
                        //The text is valid.
                        setLabel("Congratulations!  "
                                 + "You entered \""
                                 + s
                                 + "\".");
                    }

                //non-modal dialog
                } else if (command == nonModalCommand) {
                    //Create the dialog.
                    JDialog dialog = new JDialog(frame, "A Non-Modal Dialog");

                    //Add contents to it.
                    JLabel label = new JLabel("This is a non-modal dialog");
                    label.setHorizontalAlignment(JLabel.CENTER);
                    Container contentPane = dialog.getContentPane();
                    contentPane.add(label, BorderLayout.CENTER);

                    //Show it.
                    dialog.setSize(new Dimension(300, 150));
                    dialog.setLocationRelativeTo(frame);
                    dialog.setVisible(true);
                }
            }
        });

        return createPane(moreDialogDesc + ":",
                          radioButtons,
                          showItButton);
    }

    public static void main(String[] args) {
        JFrame frame = new JFrame("DialogDemo");

        Container contentPane = frame.getContentPane();
        contentPane.setLayout(new GridLayout(1,1));
        contentPane.add(new DialogDemo(frame));

        frame.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });

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

Trail: Creating a GUI with JFC/Swing
Lesson: Laying Out Components Within a Container

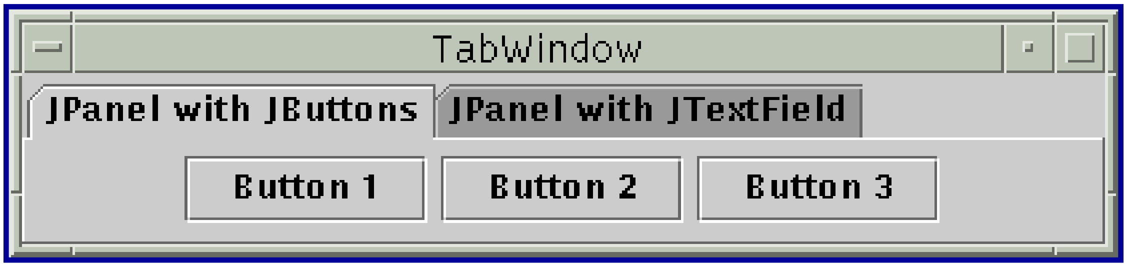
How to Use CardLayout

Here's an applet that shows a `CardLayout` in action.



This is a picture of the applet's GUI. To run the applet, click the picture. The applet will appear in a new browser window.

As the preceding applet shows, the `CardLayout` class helps you manage two or more components (usually `JPanel` instances) that share the same display space. Another way to accomplish the same thing is to use a tabbed pane. Here's the tabbed pane version of the preceding applet:



This is a picture of the applet's GUI. To run the applet, click the picture. The applet will appear in a new browser window.

Because a tabbed pane provides a GUI, using a tabbed pane is simpler than using `CardLayout`. For example, reimplementing the preceding applet to use a tabbed pane results in a program with 12 fewer lines of code. You can see the program's code in `TabWindow.java`. The `CardLayout` version of the program is in `CardWindow.java`.

Conceptually, each component a `CardLayout` manages is like a playing card or trading card in a stack, where only the top card is visible at any time. You can choose the card that's showing in any of the following ways:

- By asking for either the first or last card, in the order it was added to the container.
- By flipping through the deck backwards or forwards.
- By specifying a card with a specific name. This is the scheme the example program uses. Specifically, the user can choose a card (component) by selecting it by name from a pop-up list of choices.

The following code creates the `CardLayout` and the components it manages. The program runs either within an applet, with the help of `AppletButton`, or as an application.)

```
//Where instance variables are declared:
JPanel cards;
final static String BUTTONPANEL = "JPanel with JButtons";
final static String TEXTPANEL = "JPanel with JTextField";

//Where the container is initialized:
cards = new JPanel();
cards.setLayout(new CardLayout());

...//Create a Panel named p1. Put buttons in it.
...//Create a Panel named p2. Put a text field in it.

cards.add(p1, BUTTONPANEL);
cards.add(p2, TEXTPANEL);
```

When you add a component to a container that a `CardLayout` manages, you must specify a string that identifies the component being added. For example, in this example, the first panel has the string `"JPanel with JButtons"`, and the second panel has the string `"JPanel with JTextField"`. In this example, those strings are also used in the combo box.

To choose which component a `CardLayout` shows, you need some additional code. Here's how the example program does this:

```
//Where the container is initialized:
...
    //Put the JComboBox in a JPanel to get a nicer look.
    String comboBoxItems[] = { BUTTONPANEL, TEXTPANEL };
    JPanel cbp = new JPanel();
    JComboBox c = new JComboBox(comboBoxItems);
    c.setEditable(false);
    c.addItemListener(this);
    cbp.add(c);
    contentPane.add(cbp, BorderLayout.NORTH);
...
    contentPane.add(cards, BorderLayout.CENTER);
...

public void itemStateChanged(ItemEvent evt) {
    CardLayout cl = (CardLayout)(cards.getLayout());
    cl.show(cards, (String)evt.getItem());
}
```

This example shows that you can use the `CardLayout` `show` method to set the currently showing component. The first argument to the `show` method is the container the `CardLayout` controls, that is, the container of the components the `CardLayout` manages. The second argument is the string that identifies the component to show. This string is the same as was used when adding the component to the container.

The CardLayout API

The following `CardLayout` methods let you choose a component. For each method, the first argument is the container for which the `CardLayout` is the layout manager (the container of the cards the `CardLayout` controls).

```
void first(Container)
void next(Container)
void previous(Container)
void last(Container)
void show(Container, String)
```

Examples that Use CardLayout

Only one example in this trail uses `CardLayout`: `CardWindow`. Generally, our examples use tabbed panes◆ instead of `CardLayout`, since tabbed panes conveniently provide a nice GUI for the same functionality.

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Trail: Creating a GUI with JFC/Swing
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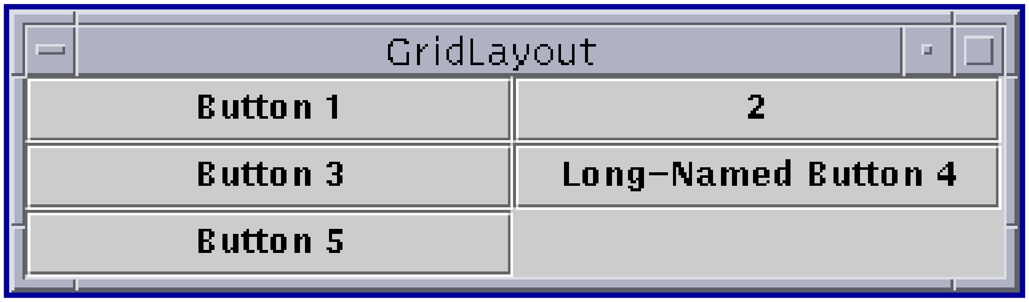
How to Use GridLayout

Here's an applet that shows a GridLayout in action.



This is a picture of the applet's GUI. To run the applet, click the picture. The applet will appear in a new browser window.

A `GridLayout` places components in a grid of cells. Each component takes all the available space within its cell, and each cell is exactly the same size. If you resize the `GridLayout` window, you'll see that the `GridLayout` changes the cell size so that the cells are as large as possible, given the space available to the container.

Below is the code that creates the `GridLayout` and the components it manages. You can find the whole program in GridWindow.java. The program runs either within an applet (with the help of AppletButton) or as an application.

```
Container contentPane = getContentPane();

contentPane.setLayout(new GridLayout(0,2));

contentPane.add(new JButton("Button 1"));
contentPane.add(new JButton("2"));
contentPane.add(new JButton("Button 3"));
contentPane.add(new JButton("Long-Named Button 4"));
contentPane.add(new JButton("Button 5"));
```

The constructor tells the `GridLayout` class to create an instance that has two columns and as many rows as necessary.

The GridLayout API

The `GridLayout` class has two constructors:

```
public GridLayout(int rows, int columns)
public GridLayout(int rows, int columns,
                  int horizontalGap, int verticalGap)
```

At least one of the *`rows`* and *`columns`* arguments must be nonzero. The *`horizontalGap`* and *`verticalGap`* arguments to the second constructor allow you to specify the number of pixels between cells. If you don't specify gaps, their values default to zero. In the applet above, any apparent gaps are the result of the buttons reserving extra space around their apparent display area.

Examples that Use GridLayout

The following table lists some of the examples that use grid layout.

Example	Where Described	Notes
`GridWindow`	This page	Uses a 2-column grid.
`LabelDemo`	How to Use Labels◆	Uses a 3-row grid.
`Converter`	The Anatomy of a Swing-Based Program◆	Uses the 4-argument `GridLayout` constructor.

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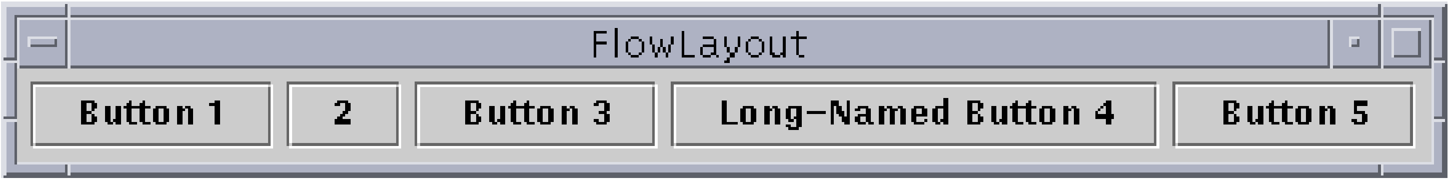
Run FlowLayout Demo

Since you can't run the applet, here's a picture of it:



Note: Because the preceding applet uses the Swing 1.1 API, it requires Java Plug-in 1.1.2 or Java Plug-in 1.2. It won't work with Java Plug-in 1.1.1 or uncustomized 1.1 browsers. For more information about running applets in the tutorial, refer to About Our Examples. That page includes a section about Downloading Java Plug-in.

```java
/*
 * Swing version.
 */

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

public class FlowWindow extends JFrame {
    boolean inAnApplet = true;

    public FlowWindow() {
        Container contentPane = getContentPane();
        contentPane.setLayout(new FlowLayout());

        contentPane.add(new JButton("Button 1"));
        contentPane.add(new JButton("2"));
        contentPane.add(new JButton("Button 3"));
        contentPane.add(new JButton("Long-Named Button 4"));
        contentPane.add(new JButton("Button 5"));

        addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                if (inAnApplet) {
                    dispose();
                } else {
                    System.exit(0);
                }
            }
        });
    }

    public static void main(String args[]) {
        FlowWindow window = new FlowWindow();
        window.inAnApplet = false;

        window.setTitle("FlowLayout");
        window.pack();
        window.setVisible(true);
    }
}
```

```
/*
 * Swing version.
 * XXX: This should probably use a SwingWorker instead of a custom thread.
 */

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

public class AppletButton extends JApplet
                          implements Runnable,
                                     ActionListener {
    int frameNumber = 1;
    String windowClass;
    String buttonText;
    String windowTitle;
    int requestedWidth = 0;
    int requestedHeight = 0;
    JButton button;
    Thread windowThread;
    JLabel label;
    boolean pleaseShow = false;
    boolean shouldInitialize = true;
    Class windowClassObject;

    public void init() {
        //Look up the parameters we need right away.
        windowClass = getParameter("WINDOWCLASS");
        if (windowClass == null) {
            windowClass = "TestWindow";
        }
        buttonText = getParameter("BUTTONTEXT");
        if (buttonText == null) {
            buttonText = "Click here to bring up a " + windowClass;
        }

        //Set up the button and label this applet displays.
        button = new JButton(buttonText);
        button.addActionListener(this);
        label = new JLabel("", JLabel.CENTER);

        //Add the button and label to this applet.
        Container contentPane = getContentPane();
        contentPane.setLayout(new GridLayout(2,0));
        contentPane.add(button);
        contentPane.add(label);
    }

    public void start() {
        if (windowThread == null) {
            windowThread = new Thread(this, "Bringing Up " + windowClass);
            windowThread.start();
        }
    }

    public void stop() {
        windowThread = null;
    }

    public synchronized void run() {
        Object object = null;
        JFrame window = null;
        String name = null;

        if (shouldInitialize) {
            //Look up the rest of the parameters.
            windowTitle = getParameter("WINDOWTITLE");
            if (windowTitle == null) {
                windowTitle = windowClass;
            }
            String windowWidthString = getParameter("WINDOWWIDTH");
            if (windowWidthString != null) {
                try {
                    requestedWidth = Integer.parseInt(windowWidthString);
                } catch (NumberFormatException e) {
                    //Use default width.
                }
            }
            String windowHeightString = getParameter("WINDOWHEIGHT");
            if (windowHeightString != null) {
                try {
                    requestedHeight = Integer.parseInt(windowHeightString);
                } catch (NumberFormatException e) {
                    //Use default height.
                }
            }

            //Make sure the window class exists.
            try {
                windowClassObject = Class.forName(windowClass);
            } catch (Exception e) {
                //The specified class isn't anywhere that we can find.
                label.setText("Bad parameter: Couldn't find class "
                              + windowClass);
                button.setEnabled(false);
                return;
            }

            //Create an invisible instance.
            window = createWindow(windowTitle);
            if (window == null) {
                return;
            }

            shouldInitialize = false;
        }

        Thread currentThread = Thread.currentThread();
        while (currentThread == windowThread) {

            //Wait until we're asked to show a window.
            while (pleaseShow == false) {
                try {
                    wait();
                } catch (InterruptedException e) {
                }
            }

            //We've been asked to bring up a window.
            pleaseShow = false;

            //Create another window if necessary.
            if (window == null) {
                window = createWindow(windowTitle + ": "
                                      + ++frameNumber);
            }

            window.setVisible(true);
            label.setText("");
            window = null;
        } //end thread loop
    }

    private JFrame createWindow(String title) {
        Object object = null;
        JFrame window = null;

        //Instantiate the window class.
        try {
            object = windowClassObject.newInstance();
        } catch (Exception e) {
            label.setText("Bad parameter: Can't instantiate "
                          + windowClassObject);
            button.setEnabled(false);
            return null;
        }

        //Make sure it's a frame.
        try {
            window = (JFrame)object;
        } catch (Exception e) {
            label.setText("Bad parameter: "
                          + windowClassObject +
                          " isn't a JFrame subclass.");
            button.setEnabled(false);
            return null;
        }

        window.setTitle(title);

        //Set its size.
        window.pack();
        if ((requestedWidth > 0)
          | (requestedHeight > 0)) {
            window.setSize(Math.max(requestedWidth,
                                    window.getSize().width),
                           Math.max(requestedHeight,
                                    window.getSize().height));
        }

        return window;
    }

    /* Signal the window thread to build a window. */
    public synchronized void actionPerformed(ActionEvent event) {
        label.setText("Please wait while the window comes up...");
        pleaseShow = true;
        notify();
    }
}

class TestWindow extends JFrame {
    public TestWindow() {
        setDefaultCloseOperation(DISPOSE_ON_CLOSE);
    }
}
```

Trail: Creating a GUI with JFC/Swing
Lesson: Using Swing Components

Using Intermediate Swing Containers

This section describes intermediate containers -- Swing components that, while not top-level containers, exist solely to contain other components. Technically, menu bars are intermediate containers, but we discuss them elsewhere, in the How to Use Menus section. To use intermediate containers, you should understand the concepts presented in Swing Components and the Containment Hierarchy◆. You can see all the intermediate containers in the Visual Index to Swing Components.

Swing provides several general-purpose intermediate containers:

Panel	The most flexible, frequently used intermediate container. Implemented with the `JPanel` class, panels add almost no functionality beyond what all `JComponent` objects have. They are often used to group components, whether because the components are related or just because grouping them makes layout easier. A panel can use any layout manager, and you can easily give it a border. The content panes of top-level containers are often implemented as `JPanel` instances.
Scroll Pane	Provides scroll bars around a large or growable component.
Split Pane	Displays two components in a fixed amount of space, letting the user adjust the amount of space devoted to each component.
Tabbed Pane	Contains multiple components but shows only one at a time. The user can easily switch between components.
Tool Bar	Holds a group of components (usually buttons) in a row or column, optionally allowing the user to drag the tool bar into different locations.

The rest of the Swing intermediate containers are more specialized:

Internal Frame — Looks like a frame and has much the same API, but must appear within another window.

Layered Pane — Provides a third dimension, depth, for positioning components. You specify the position and size of each component. One type of layered pane, a desktop pane, is designed primarily to contain and manage internal frames.

Root Pane — Provides behind-the-scenes support to top-level containers.

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```
/* Uses actions with a tool bar and a menu. */

import javax.swing.AbstractAction;
import javax.swing.Action;

import javax.swing.JToolBar;
import javax.swing.JButton;
import javax.swing.ImageIcon;

import javax.swing.JMenuItem;
import javax.swing.JCheckBoxMenuItem;
import javax.swing.JMenu;
import javax.swing.JMenuBar;

import javax.swing.JFrame;
import javax.swing.JTextArea;
import javax.swing.JScrollPane;
import javax.swing.JPanel;

import java.awt.*;
import java.awt.event.*;

public class ActionDemo extends JFrame {
    protected JTextArea textArea;
    protected String newline = "\n";
    protected Action leftAction;
    protected Action middleAction;
    protected Action rightAction;

    public ActionDemo() {
        //Do frame stuff.
        super("ActionDemo");
        addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });

        //Create the toolbar and menu.
        JToolBar toolBar = new JToolBar();
        JMenu mainMenu = new JMenu("Menu");
        createActionComponents(toolBar, mainMenu);

        //Create the text area used for output.
        textArea = new JTextArea(5, 30);
        JScrollPane scrollPane = new JScrollPane(textArea);

        //Lay out the content pane.
        JPanel contentPane = new JPanel();
        contentPane.setLayout(new BorderLayout());
        contentPane.setPreferredSize(new Dimension(400, 150));
        contentPane.add(toolBar, BorderLayout.SOUTH);
        contentPane.add(scrollPane, BorderLayout.CENTER);
        setContentPane(contentPane);

        //Set up the menu bar.
        JMenuBar mb = new JMenuBar();
        mb.add(mainMenu);
        mb.add(createAbleMenu());
        setJMenuBar(mb);
    }

    protected void createActionComponents(JToolBar toolBar,
                                          JMenu mainMenu) {
        JButton button = null;
        JMenuItem menuItem = null;

        //first button and menu item
        leftAction = new AbstractAction("Go left",
                             new ImageIcon("images/left.gif")) {
            public void actionPerformed(ActionEvent e) {
                displayResult("Action for first button/menu item", e);
            }
        };
        button = toolBar.add(leftAction);
        button.setText(""); //an icon-only button
        button.setToolTipText("This is the left button");
        menuItem = mainMenu.add(leftAction);
        menuItem.setIcon(null); //arbitrarily chose not to use icon in menu

        //second button and menu item
        middleAction = new AbstractAction("Do something",
                             new ImageIcon("images/middle.gif")) {
            public void actionPerformed(ActionEvent e) {
                displayResult("Action for second button/menu item", e);
            }
        };
        button = toolBar.add(middleAction);
        button.setText("");
        button.setToolTipText("This is the middle button");
        menuItem = mainMenu.add(middleAction);
        menuItem.setIcon(null); //arbitrarily chose not to use icon in menu

        //third button and menu item
        rightAction = new AbstractAction("Go right",
                             new ImageIcon("images/right.gif")) {
            public void actionPerformed(ActionEvent e) {
                displayResult("Action for third button/menu item", e);
            }
        };
        button = toolBar.add(rightAction);
        button.setText("");
        button.setToolTipText("This is the right button");
        menuItem = mainMenu.add(rightAction);
        menuItem.setIcon(null); //arbitrarily chose not to use icon in menu
    }

    protected JMenu createAbleMenu() {
        JMenu ableMenu = new JMenu("Action State");
        JCheckBoxMenuItem cbmi = null;

        cbmi = new JCheckBoxMenuItem("First action enabled");
        cbmi.setSelected(true);
        cbmi.addItemListener(new ItemListener() {
            public void itemStateChanged(ItemEvent e) {
                JCheckBoxMenuItem mi = (JCheckBoxMenuItem)(e.getSource());
                boolean selected =
                    (e.getStateChange() == ItemEvent.SELECTED);
                leftAction.setEnabled(selected);
            }
        });
        ableMenu.add(cbmi);

        cbmi = new JCheckBoxMenuItem("Second action enabled");
        cbmi.setSelected(true);
        cbmi.addItemListener(new ItemListener() {
            public void itemStateChanged(ItemEvent e) {
                JCheckBoxMenuItem mi = (JCheckBoxMenuItem)(e.getSource());
                boolean selected =
                    (e.getStateChange() == ItemEvent.SELECTED);
                middleAction.setEnabled(selected);
            }
        });
        ableMenu.add(cbmi);

        cbmi = new JCheckBoxMenuItem("Third action enabled");
        cbmi.setSelected(true);
        cbmi.addItemListener(new ItemListener() {
            public void itemStateChanged(ItemEvent e) {
                JCheckBoxMenuItem mi =
                    (JCheckBoxMenuItem)(e.getSource());
                boolean selected =
                    (e.getStateChange() == ItemEvent.SELECTED);
                rightAction.setEnabled(selected);
            }
        });
        ableMenu.add(cbmi);

        return ableMenu;
    }

    protected void displayResult(String actionDescription,
                                 ActionEvent e) {
        String s = ("Action event detected by: "
                  + actionDescription
                  + newline
                  + "    Event source: " + e.getSource()
                  + newline);
        textArea.append(s);
    }

    public static void main(String[] args) {
        ActionDemo frame = new ActionDemo();
        frame.pack();
        frame.setVisible(true);
    }
}
```

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

public class AccessibleScrollDemo extends JPanel {
    private Rule columnView;
    private Rule rowView;

    private JToggleButton isMetric;
    private ScrollablePicture picture;

    public AccessibleScrollDemo() {
        //Load the photograph into an image icon.
        ImageIcon david = new ImageIcon("images/youngdad.jpeg");
        david.setDescription("Photograph of David McNabb in his youth.");

        //Create the row and column headers
        columnView = new Rule(Rule.HORIZONTAL, true);
        columnView.setPreferredWidth(david.getIconWidth());
        columnView.getAccessibleContext().setAccessibleName("Column Header");
        columnView.getAccessibleContext().
                setAccessibleDescription("Displays horizontal ruler for " +
                                         "measuring scroll pane client.");
        rowView = new Rule(Rule.VERTICAL, true);
        rowView.setPreferredHeight(david.getIconHeight());
        rowView.getAccessibleContext().setAccessibleName("Row Header");
        rowView.getAccessibleContext().
                setAccessibleDescription("Displays vertical ruler for " +
                                         "measuring scroll pane client.");

        //Create the corners
        JPanel buttonCorner = new JPanel();
        isMetric = new JToggleButton("cm", true);
        isMetric.setFont(new Font("SansSerif", Font.PLAIN, 11));
        isMetric.setMargin(new Insets(2,2,2,2));
        isMetric.addItemListener(new UnitsListener());
        isMetric.setToolTipText("Toggles rulers' unit of measure " +
                                "between inches and centimeters.");
        buttonCorner.add(isMetric); //Use the default FlowLayout
        buttonCorner.getAccessibleContext().
                     setAccessibleName("Upper Left Corner");

        String desc = "Fills the corner of a scroll pane " +
                      "with color for aesthetic reasons.";
        Corner lowerLeft = new Corner();
        lowerLeft.getAccessibleContext().
                   setAccessibleName("Lower Left Corner");
        lowerLeft.getAccessibleContext().setAccessibleDescription(desc);

        Corner upperRight = new Corner();
        upperRight.getAccessibleContext().
                    setAccessibleName("Upper Right Corner");
        upperRight.getAccessibleContext().setAccessibleDescription(desc);

        //Set up the scroll pane
        picture = new ScrollablePicture(david,
                                        columnView.getIncrement());
        picture.setToolTipText(david.getDescription());
        picture.getAccessibleContext().setAccessibleName(
                                         "Scroll pane client");
        JScrollPane pictureScrollPane = new JScrollPane(picture);
        pictureScrollPane.setPreferredSize(new Dimension(300, 250));
        pictureScrollPane.setViewportBorder(
                BorderFactory.createLineBorder(Color.black));

        pictureScrollPane.setColumnHeaderView(columnView);
        pictureScrollPane.setRowHeaderView(rowView);

        pictureScrollPane.setCorner(JScrollPane.UPPER_LEFT_CORNER,
                                    buttonCorner);
        pictureScrollPane.setCorner(JScrollPane.LOWER_LEFT_CORNER,
                                    lowerLeft);
        pictureScrollPane.setCorner(JScrollPane.UPPER_RIGHT_CORNER,
                                    upperRight);

        //Put it in this panel
        setLayout(new BoxLayout(this, BoxLayout.X_AXIS));
        add(pictureScrollPane);
        setBorder(BorderFactory.createEmptyBorder(20,20,20,20));
    }

    class UnitsListener implements ItemListener {
        public void itemStateChanged(ItemEvent e) {
            if (e.getStateChange() == ItemEvent.SELECTED) {
                //turn it to metric
                rowView.setIsMetric(true);
                columnView.setIsMetric(true);
            } else {
                //turn it to inches
                rowView.setIsMetric(false);
                columnView.setIsMetric(false);
            }
            picture.setMaxUnitIncrement(rowView.getIncrement());
        }
    }


    public static void main(String s[]) {
        JFrame frame = new JFrame("AccessibleScrollDemo");
        frame.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });

        frame.setContentPane(new AccessibleScrollDemo());
        frame.pack();
        frame.setVisible(true);
    }
}
```

```
import java.awt.*;
import java.awt.event.*;
import javax.swing.BorderFactory;
import javax.swing.border.Border;
import javax.swing.border.TitledBorder;
import javax.swing.ImageIcon;
import javax.swing.JTabbedPane;
import javax.swing.JLabel;
import javax.swing.JPanel;
import javax.swing.JFrame;
import javax.swing.Box;
import javax.swing.BoxLayout;

public class BorderDemo extends JFrame {
    public BorderDemo() {
        super("BorderDemo");
        Border blackline, etched, raisedbevel, loweredbevel, empty;

        //A border that puts 10 extra pixels at the sides and
        //bottom of each pane.
        Border paneEdge = BorderFactory.createEmptyBorder(0,10,10,10);

        blackline = BorderFactory.createLineBorder(Color.black);
        etched = BorderFactory.createEtchedBorder();
        raisedbevel = BorderFactory.createRaisedBevelBorder();
        loweredbevel = BorderFactory.createLoweredBevelBorder();
        empty = BorderFactory.createEmptyBorder();

        //First pane: simple borders
        JPanel simpleBorders = new JPanel();
        simpleBorders.setBorder(paneEdge);
        simpleBorders.setLayout(new BoxLayout(simpleBorders,
                                              BoxLayout.Y_AXIS));

        addCompForBorder(blackline, "line border",
                         simpleBorders);
        addCompForBorder(etched, "etched border",
                         simpleBorders);
        addCompForBorder(raisedbevel, "raised bevel border",
                         simpleBorders);
        addCompForBorder(loweredbevel, "lowered bevel border",
                         simpleBorders);
        addCompForBorder(empty, "empty border",
                         simpleBorders);

        //Second pane: matte borders
        JPanel matteBorders = new JPanel();
        matteBorders.setBorder(paneEdge);
        matteBorders.setLayout(new BoxLayout(matteBorders,
                                              BoxLayout.Y_AXIS));

        //XXX: We *should* size the component so that the
        //XXX: icons tile OK.  Without that, the icons are
        //XXX: likely to be cut off and look bad.
        ImageIcon icon = new ImageIcon("images/left.gif"); //20x22
        Border border = BorderFactory.createMatteBorder(-1, -1, -1, -1, icon);
        addCompForBorder(border,
                         "matte border (-1,-1,-1,-1,icon)",
                         matteBorders);
        border = BorderFactory.createMatteBorder(1, 5, 1, 1, Color.red);
        addCompForBorder(border,
                         "matte border (1,5,1,1,Color.red)",
                         matteBorders);
        border = BorderFactory.createMatteBorder(0, 20, 0, 0, icon);
        addCompForBorder(border,
                         "matte border (0,20,0,0,icon)",
                         matteBorders);

        //Third pane: titled borders
        JPanel titledBorders = new JPanel();
        titledBorders.setBorder(paneEdge);
        titledBorders.setLayout(new BoxLayout(titledBorders,
                                              BoxLayout.Y_AXIS));
        TitledBorder titled;

        titled = BorderFactory.createTitledBorder("title");
        addCompForBorder(titled,
                         "default titled border"
                         + " (default just., default pos.)",
                         titledBorders);

        titled = BorderFactory.createTitledBorder(
                              blackline, "title");
        addCompForTitledBorder(titled,
                               "titled line border"
                                   + " (centered, default pos.)",
                               TitledBorder.CENTER,
                               TitledBorder.DEFAULT_POSITION,
                               titledBorders);

        titled = BorderFactory.createTitledBorder(etched, "title");
        addCompForTitledBorder(titled,
                               "titled etched border"
                                   + " (right just., default pos.)",
                               TitledBorder.RIGHT,
                               TitledBorder.DEFAULT_POSITION,
                               titledBorders);

        titled = BorderFactory.createTitledBorder(
                        loweredbevel, "title");
        addCompForTitledBorder(titled,
                               "titled lowered bevel border"
                                   + " (default just., above top)",
                               TitledBorder.DEFAULT_JUSTIFICATION,
                               TitledBorder.ABOVE_TOP,
                               titledBorders);

        titled = BorderFactory.createTitledBorder(
                        empty, "title");
        addCompForTitledBorder(titled, "titled empty border"
                               + " (default just., bottom)",
                               TitledBorder.DEFAULT_JUSTIFICATION,
                               TitledBorder.BOTTOM,
                               titledBorders);

        //Fourth pane: compound borders
        JPanel compoundBorders = new JPanel();
        compoundBorders.setBorder(paneEdge);
        compoundBorders.setLayout(new BoxLayout(compoundBorders,
                                              BoxLayout.Y_AXIS));
        Border redline = BorderFactory.createLineBorder(Color.red);

        Border compound;
        compound = BorderFactory.createCompoundBorder(
                                  raisedbevel, loweredbevel);
        addCompForBorder(compound, "compound border (two bevels)",
                         compoundBorders);

        compound = BorderFactory.createCompoundBorder(
                                  redline, compound);
        addCompForBorder(compound, "compound border (add a red outline)",
                         compoundBorders);

        titled = BorderFactory.createTitledBorder(
                                  compound, "title",
                                  TitledBorder.CENTER,
                                  TitledBorder.BELOW_BOTTOM);
        addCompForBorder(titled,
                         "titled compound border"
                         + " (centered, below bottom)",
                         compoundBorders);

        JTabbedPane tabbedPane = new JTabbedPane();
        tabbedPane.addTab("Simple", null, simpleBorders, null);
        tabbedPane.addTab("Matte", null, matteBorders, null);
        tabbedPane.addTab("Titled", null, titledBorders, null);
        tabbedPane.addTab("Compound", null, compoundBorders, null);
        tabbedPane.setSelectedIndex(0);

        getContentPane().add(tabbedPane, BorderLayout.CENTER);
    }

    void addCompForTitledBorder(TitledBorder border,
                                String description,
                                int justification,
                                int position,
                                Container container) {
        border.setTitleJustification(justification);
        border.setTitlePosition(position);
        addCompForBorder(border, description,
                         container);
    }

    void addCompForBorder(Border border,
                          String description,
                          Container container) {
        JPanel comp = new JPanel(false);
        JLabel label = new JLabel(description, JLabel.CENTER);
        comp.setLayout(new GridLayout(1, 1));
        comp.add(label);
        comp.setBorder(border);

        container.add(Box.createRigidArea(new Dimension(0, 10)));
        container.add(comp);
    }

    public static void main(String[] args) {
        JFrame frame = new BorderDemo();
        frame.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });

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

Trail: Creating a GUI with JFC/Swing
Lesson: Using Other Swing Features

How to Set the Look and Feel

If you don't care which look and feel your program uses, you can skip this section entirely. For example, most of the programs in this trail don't specify the look and feel, so that you can easily run the programs with your preferred look and feel.

When a program does not set its look and feel, the Swing UI manager must figure out which look and feel to use. It first checks whether the user has specified a preferred look and feel. If so, it attempts to use that. If not, or if the user's choice isn't valid, then the UI manager chooses the Java Look & Feel.

- Setting the Look and Feel
- How the UI Manager Chooses the Look and Feel
- Changing the Look and Feel After Startup

Setting the Look and Feel

To programmatically specify a look and feel, use the `UIManager.setLookAndFeel` method. For example, the bold code in the following snippet makes the program use the Java Look & Feel:

```
public static void main(String[] args) {
    try {
        UIManager.setLookAndFeel(
            UIManager.getCrossPlatformLookAndFeelClassName());
    } catch (Exception e) { }

    new SwingApplication(); //Create and show the GUI.
}
```

The argument to `setLookAndFeel` is the fully qualified name of the appropriate subclass of `LookAndFeel`. To specify the Java Look & Feel, we used the `getCrossPlatformLookAndFeelClassName` method. If you want to specify the native look and feel for whatever platform the user runs the program on, use `getSystemLookAndFeelClassName`, instead. To specify a particular UI, you can use the actual class name. For example, if you design a program to look best with the Windows Look & Feel, you can use this code to set the look and feel:

```
UIManager.setLookAndFeel(
                        "com.sun.java.swing.plaf.windows.WindowsLookAndFeel");
```

Here are some of the arguments you can use for `setLookAndFeel`:

`UIManager.getCrossPlatformLookAndFeelClassName()`
: Returns the string for the one look-and-feel guaranteed to work -- the Java Look & Feel.

`UIManager.getSystemLookAndFeelClassName()`
: Specifies the look and feel for the current platform. On Win32 platforms, this specifies the Windows Look & Feel. On Mac OS platforms, this specifies the Mac OS Look & Feel. On Sun platforms, it specifies the CDE/Motif Look & Feel.

`"javax.swing.plaf.metal.MetalLookAndFeel"`
: Specifies the Java Look & Feel. (The codename for this look and feel was *Metal*.) This string is the value returned by the `getCrossPlatformLookAndFeelClassName` method.

`"com.sun.java.swing.plaf.windows.WindowsLookAndFeel"`
: Specifies the Windows Look & Feel. Currently, you can use this look and feel only on Win32 systems.

`"com.sun.java.swing.plaf.motif.MotifLookAndFeel"`
: Specifies the CDE/Motif Look & Feel. This look and feel can be used on any platform.

`"javax.swing.plaf.mac.MacLookAndFeel"`
: Specifies the Mac OS Look & Feel, which can be used only on Mac OS platforms.

You aren't limited to the preceding arguments. You can specify the name for any look and feel that is in your program's class path.

How the UI Manager Chooses the Look and Feel

Here are the look-and-feel determination steps that occur when the UI manager first initializes itself:

1. If the program sets the look and feel before any components are created, the UI manager tries to create an instance of the specified look-and-feel class. If successful, all components use that look and feel.

2. If the program hasn't successfully specified a look and feel, then before the first component's UI is created, the UI manager tests whether the user specified a look and feel in a file named `swing.properties`. It looks for the file in the `lib` directory of the Java release. For example, if you're using the Java interpreter in *`javaHomeDirectory`*`\bin`, then the `swing.properties` file (if it exists) is in *`javaHomeDirectory`*`\lib`. If the user specified a look and feel, then again the UI manager tries to instantiate the specified class. Here is an example of the contents of a `swing.properties` file:

   ```
   # Swing properties

   swing.defaultlaf=com.sun.java.swing.plaf.motif.MotifLookAndFeel
   ```

3. If neither the program nor the user successfully specifies a look and feel, then the program uses the Java Look & Feel.

Changing the Look and Feel After Startup

You can change the look and feel with `setLookAndFeel` even after the program's GUI is visible. To make existing components reflect the new look and feel, invoke the `SwingUtilities updateComponentTreeUI` method once per top-level container. Then you might wish to resize each top-level container to reflect the new sizes of its contained components. For example:

```
UIManager.setLookAndFeel(lnfName);
SwingUtilities.updateComponentTreeUI(frame);
frame.pack();
```

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Trail: Creating a GUI with JFC/Swing
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Run IconDemoApplet

Note: Because the preceding applet uses the Swing 1.1 API, it requires Java Plug-in 1.1.2 or Java Plug-in 1.2. It won't work with Java Plug-in 1.1.1 or uncustomized 1.1 browsers. For more information about running applets in the tutorial, refer to About Our Examples. That page includes a section about Downloading Java Plug-in.

```
import javax.swing.*;
import java.awt.*;
import java.awt.event.*;
import java.net.URL;
import java.util.Vector;
import java.util.StringTokenizer;

public class IconDemoApplet extends JApplet
                            implements ActionListener {
    Vector pictures;

    JButton previousButton;
    JButton nextButton;
    JLabel photographLabel;
    JLabel captionLabel;
    JLabel numberLabel;

    int current = 0;
    int widthOfWidest = 0;
    int heightOfTallest = 0;

    String imagedir = null;

    public void init() {
        //Parse the applet parameters
        pictures = parseParameters();

        //If the applet tag doesn't provide an "IMAGE0" parameter,
        //display an error message.
        if (pictures.size() == 0) {
            captionLabel = new JLabel("No images listed in applet tag.");
            captionLabel.setHorizontalAlignment(JLabel.CENTER);
            getContentPane().add(captionLabel);
            return;
        }

        //NOW CREATE THE GUI COMPONENTS

        //A label to identify XX of XX.
        numberLabel = new JLabel("Picture " + (current+1) +
                                 " of " + pictures.size());
        numberLabel.setHorizontalAlignment(JLabel.LEFT);
        numberLabel.setBorder(BorderFactory.createEmptyBorder(5, 0, 5, 5));

        //A label for the caption.
        final Photo first = (Photo)pictures.firstElement();
        captionLabel = new JLabel(first.caption);
        captionLabel.setHorizontalAlignment(JLabel.CENTER);
        captionLabel.setBorder(BorderFactory.createEmptyBorder(5, 0, 5, 0));

        //A label for displaying the photographs.
        photographLabel = new JLabel("Loading first image...");
        photographLabel.setHorizontalAlignment(JLabel.CENTER);
        photographLabel.setVerticalAlignment(JLabel.CENTER);
        photographLabel.setVerticalTextPosition(JLabel.CENTER);
        photographLabel.setHorizontalTextPosition(JLabel.CENTER);
        photographLabel.setBorder(BorderFactory.createCompoundBorder(
                        BorderFactory.createLoweredBevelBorder(),
                        BorderFactory.createEmptyBorder(5, 5, 5, 5)
        ));
        photographLabel.setBorder(BorderFactory.createCompoundBorder(
                        BorderFactory.createEmptyBorder(0, 0, 10, 0),
                        photographLabel.getBorder()
        ));

        //Set the preferred size for the picture,
        //with room for the borders.
        Insets i = photographLabel.getInsets();
        photographLabel.setPreferredSize(new Dimension(
                            widthOfWidest+i.left+i.right,
                            heightOfTallest+i.bottom+i.top));

        //Create the next and previous buttons.
        ImageIcon nextIcon = new ImageIcon(
                getURL(imagedir + "right.gif"));
        ImageIcon dimmedNextIcon = new ImageIcon(
                getURL(imagedir + "dimmedRight.gif"));
        ImageIcon previousIcon = new ImageIcon(
                getURL(imagedir + "left.gif"));
        ImageIcon dimmedPreviousIcon = new ImageIcon(
                getURL(imagedir + "dimmedLeft.gif"));

        previousButton = new JButton("Previous Picture",
                                     previousIcon);
        previousButton.setDisabledIcon(dimmedPreviousIcon);
        previousButton.setVerticalTextPosition(AbstractButton.CENTER);
        previousButton.setHorizontalTextPosition(AbstractButton.RIGHT);
        previousButton.setMnemonic(KeyEvent.VK_P);
        previousButton.setActionCommand("previous");
        previousButton.addActionListener(this);
        previousButton.setEnabled(false);

        nextButton = new JButton("Next Picture", nextIcon);
        nextButton.setDisabledIcon(dimmedNextIcon);
        nextButton.setVerticalTextPosition(AbstractButton.CENTER);
        nextButton.setHorizontalTextPosition(AbstractButton.LEFT);
        nextButton.setMnemonic(KeyEvent.VK_N);
        nextButton.setActionCommand("next");
        nextButton.addActionListener(this);

        //Lay out the GUI.
        GridBagLayout layout = new GridBagLayout();
        GridBagConstraints c = new GridBagConstraints();

        Container contentPane = getContentPane();
        contentPane.setLayout(layout);

        c.gridwidth = GridBagConstraints.REMAINDER;
        c.fill = GridBagConstraints.HORIZONTAL;
        layout.setConstraints(numberLabel, c);
        contentPane.add(numberLabel);

        layout.setConstraints(captionLabel, c);
        contentPane.add(captionLabel);

        c.gridwidth = GridBagConstraints.REMAINDER;
        c.fill = GridBagConstraints.BOTH;
        layout.setConstraints(photographLabel, c);
        contentPane.add(photographLabel);

        c.gridwidth = GridBagConstraints.RELATIVE;
        c.fill = GridBagConstraints.HORIZONTAL;
        layout.setConstraints(previousButton, c);
        contentPane.add(previousButton);
        c.gridwidth = GridBagConstraints.REMAINDER;
        layout.setConstraints(nextButton, c);
        contentPane.add(nextButton);

        //Start loading the image for the first photograph now.
        //The loadImage method uses a SwingWorker
        //to load the image in a separate thread.
        loadImage(imagedir + first.filename, current);
    }

    //User clicked either the next or the previous button.
    public void actionPerformed(ActionEvent e) {
        //Show loading message.
        photographLabel.setIcon(null);
        photographLabel.setText("Loading image...");

        //Compute index of photograph to view.
        if (e.getActionCommand().equals("next")) {
            current += 1;
            if (!previousButton.isEnabled())
                previousButton.setEnabled(true);
            if (current == pictures.size() - 1)
                nextButton.setEnabled(false);
        } else {
            current -= 1;
            if (!nextButton.isEnabled())
                nextButton.setEnabled(true);
            if (current == 0)
                previousButton.setEnabled(false);
        }

        //Get the photo object.
        Photo pic = (Photo)pictures.elementAt(current);

        //Update the caption and number labels.
        captionLabel.setText(pic.caption);
        numberLabel.setText("Picture " + (current+1) +
                            " of " + pictures.size());

        //Update the photograph.
        ImageIcon icon = pic.getIcon();
        if (icon == null) {     //haven't viewed this photo before
            loadImage(imagedir + pic.filename, current);
        } else {
            updatePhotograph(current, pic);
        }
    }

    //Must be invoked from the event-dispatching thread.
    private void updatePhotograph(int index, Photo pic) {
        ImageIcon icon = pic.getIcon();

        photographLabel.setToolTipText(pic.filename + ": " +
                                       icon.getIconWidth() + " X " +
                                       icon.getIconHeight());
        photographLabel.setIcon(icon);
        photographLabel.setText("");
    }

    //Load an image in a separate thread.
    private void loadImage(final String imagePath, final int index) {
        final SwingWorker worker = new SwingWorker() {
            ImageIcon icon = null;

            public Object construct() {
                icon = new ImageIcon(getURL(imagePath));
                return icon; //return value not used by this program
            }

            //Runs on the event-dispatching thread.
            public void finished() {
                Photo pic = (Photo)pictures.elementAt(index);
                pic.setIcon(icon);
                if (index == current)
                    updatePhotograph(index, pic);
            }
        };
        worker.start();
    }

    protected URL getURL(String filename) {
        URL codeBase = this.getCodeBase();
        URL url = null;

        try {
            url = new URL(codeBase, filename);
        } catch (java.net.MalformedURLException e) {
            System.out.println("Couldn't create image: "
                             + "badly specified URL");
            return null;
        }

        return url;
    }

    protected Vector parseParameters() {
        Vector pix = new Vector(10);    //start with 10, grows if necessary
        int i = 0;                      //parameters index must start at 0
        String paramName = "IMAGE" + i;
        String paramValue;

        while ((paramValue = getParameter(paramName)) != null) {
            Photo pic = new Photo(paramValue, getCaption(i),
                                  getWidth(i), getHeight(i));
            pix.addElement(pic);
            i++;
            paramName = "IMAGE" + i;
        }

        //Get the name of the directory that contains the image files.
        imagedir = getParameter("IMAGEDIR");
        if (imagedir != null)
            imagedir = imagedir + "/";

        return pix;
    }

    protected String getCaption(int i) {
        return getParameter("CAPTION"+i);
    }

    protected int getWidth(int i) {
        int width = 0;
        String widthString = getParameter("WIDTH"+i);
        if (widthString != null) {
            try {
                width = Integer.parseInt(widthString);
            } catch (NumberFormatException e) {
                width = 0;
            }
        } else {
            width = 0;
        }
        if (width > widthOfWidest)
            widthOfWidest = width;
        return width;
    }

    protected int getHeight(int i) {
        int height = 0;
        String heightString = getParameter("HEIGHT"+i);
        if (heightString != null) {
            try {
                height = Integer.parseInt(heightString);
            } catch (NumberFormatException e) {
                height = 0;
            }
        } else {
            height = 0;
        }
        if (height > heightOfTallest)
            heightOfTallest = height;
        return height;
    }

    public String[][] getParameterInfo() {
        String[][] info = {
            {"IMAGEDIR", "string", "directory containing image files" },
            {"IMAGEN", "string", "filename" },
            {"CAPTIONN", "string", "caption" },
            {"WIDTHN", "integer", "width of image" },
            {"HEIGHTN", "integer", "height of image" },
        };
        return info;
    }
}
```

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

/**
 * @author jag
 * @author mem
 * @author kwalrath
 */

public class TumbleItem extends JApplet
                        implements ActionListener {
    int loopslot = -1;  //the current frame number

    String dir;         //the directory relative to the codebase
                        //from which the images are loaded

    Timer timer;        //the timer animating the images

    int pause;          //the length of the pause between revs

    int offset;         //how much to offset between loops
    int off;            //the current offset
    int speed;          //animation speed
    int nimgs;          //number of images to animate
    int width;          //width of the applet's content pane
    JComponent contentPane; //the applet's content pane

    ImageIcon imgs[];   //the images
    int maxWidth;       //width of widest image
    boolean finishedLoading = false;
    JLabel statusLabel;
    static Color[] labelColor = { Color.black, Color.black,
                                  Color.black, Color.black,
                                  Color.black, Color.white,
                                  Color.white, Color.white,
                                  Color.white, Color.white };

    public void init() {
        //Get the applet parameters.
        String at = getParameter("img");
        dir = (at != null) ? at : "images/tumble";
        at = getParameter("pause");
        pause = (at != null) ? Integer.valueOf(at).intValue() : 1900;
        at = getParameter("offset");
        offset = (at != null) ? Integer.valueOf(at).intValue() : 0;
        at = getParameter("speed");
        speed = (at != null) ? (1000 / Integer.valueOf(at).intValue()) : 100;
        at = getParameter("nimgs");
        nimgs = (at != null) ? Integer.valueOf(at).intValue() : 16;
        at = getParameter("maxwidth");
        maxWidth = (at != null) ? Integer.valueOf(at).intValue() : 0;

        //Animate from right to left if offset is negative.
        width = getSize().width;
        if (offset < 0) {
            off = width - maxWidth;
        }

        //Custom component to draw the current image
        //at a particular offset.
        contentPane = new JPanel() {
            public void paintComponent(Graphics g) {
                super.paintComponent(g);

                if (finishedLoading &&
                    (loopslot > -1) && (loopslot < nimgs)) {
                    imgs[loopslot].paintIcon(this, g, off, 0);
                }
            }
        };
        contentPane.setBackground(Color.white);
        setContentPane(contentPane);

        //Put a "Loading Images..." label in the middle of
        //the content pane.  To center the label's text in
        //the applet, put it in the center part of a
        //BorderLayout-controlled container, and center-align
        //the label's text.
        statusLabel = new JLabel("Loading Images...",
                                 JLabel.CENTER);
        statusLabel.setForeground(labelColor[0]);
        contentPane.setLayout(new BorderLayout());
        contentPane.add(statusLabel, BorderLayout.CENTER);

        //Set up the timer that will perform the animation.
        //Don't start it until all the images are loaded.
        timer = new Timer(speed, this);
        timer.setInitialDelay(pause);
        timer.setCoalesce(false);

        //Loading the images can take quite a while, so to
        //avoid staying in init() (and thus not being able
        //to show the "Loading Images..." label, we'll
        //load the images in a SwingWorker thread.
        imgs = new ImageIcon[nimgs];
        timer.start(); //Start the animation.
        final SwingWorker worker = new SwingWorker() {
            public Object construct() {
                URL baseURL = getCodeBase();
                String prefix = dir + "/T";
                //Images are numbered 1 to nimgs,
                //but fill array from 0 to nimgs-1.
                for (int i = 0; i < nimgs; i++) {
                    imgs[i] = new ImageIcon(getURL(baseURL,
                                     prefix + (i+1) + ".gif"));
                }
                finishedLoading = true;
                return imgs;
            }
            public void finished() {
                //Remove the "Loading images" label.
                contentPane.removeAll();
                contentPane.repaint();
                loopslot = -1;
            }
        };
        worker.start();
    }

    //Update the the loopslot (frame number) and the offset.
    //If it's the last frame, restart the timer to get a long
    //pause between loops.
    public void actionPerformed(ActionEvent e) {
        loopslot++;

        if (!finishedLoading) {
            int colorIndex = loopslot % labelColor.length;
            try {
                statusLabel.setForeground(labelColor[colorIndex]);
            } catch (NullPointerException exc) {}
            return;
        }

        if (loopslot >= nimgs) {
            loopslot = 0;
            off += offset;

            if (off < 0) {
                off = width - maxWidth;
            } else if (off + maxWidth > width) {
                off = 0;
            }
        }

        contentPane.repaint();

        if (loopslot == nimgs - 1) {
            timer.restart();
        }
    }

    public void start() {
        if (finishedLoading && (nimgs > 1)) {
            timer.restart();
        }
    }

    public void stop() {
        timer.stop();
    }

    protected URL getURL(URL codeBase, String filename) {
        URL url = null;

        try {
            url = new URL(codeBase, filename);
        } catch (java.net.MalformedURLException e) {
            System.out.println("Couldn't create image: badly specified URL");
            return null;
        }

        return url;
    }

    public String getAppletInfo() {
        return "Title: TumbleItem v1.2, 23 Jul 1997\n"
               + "Author: James Gosling\n"
               + "A simple Item class to play an image loop.";
    }

    public String[][] getParameterInfo() {
        String[][] info = {
          {"img", "string", "the directory containing the images to loop"},
          {"pause", "int", "pause between complete loops; default is 3900"},
          {"offset", "int", "offset of each image to simulate left (-) or "
                            + "right (+) motion; default is 0 (no motion)"},
          {"speed", "int", "the speed at which the frames are looped; "
                           + "default is 100"},
          {"nimgs", "int", "the number of images to be looped; default is 16"},
          {"maxwidth", "int", "the maximum width of any image in the loop; "
                              + "default is 0"}
        };
        return info;
    }
}
```

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

public class CustomIconDemo extends JPanel
                            implements ActionListener {
    protected JButton b1, b2, b3;

    public CustomIconDemo() {
        Icon leftButtonIcon = new ArrowIcon(SwingConstants.RIGHT);
        Icon middleButtonIcon = new ImageIcon("images/middle.gif");
        Icon rightButtonIcon = new ArrowIcon(SwingConstants.LEFT);

        b1 = new JButton("Disable middle button", leftButtonIcon);
        b1.setVerticalTextPosition(AbstractButton.CENTER);
        b1.setHorizontalTextPosition(AbstractButton.LEFT);
        b1.setMnemonic(KeyEvent.VK_D);
        b1.setActionCommand("disable");

        b2 = new JButton("Middle button", middleButtonIcon);
        b2.setVerticalTextPosition(AbstractButton.BOTTOM);
        b2.setHorizontalTextPosition(AbstractButton.CENTER);
        b2.setMnemonic(KeyEvent.VK_M);

        b3 = new JButton("Enable middle button", rightButtonIcon);
        //Use the default text position of CENTER, RIGHT.
        b3.setMnemonic(KeyEvent.VK_E);
        b3.setActionCommand("enable");
        b3.setEnabled(false);

        //Listen for actions on buttons 1 and 3.
        b1.addActionListener(this);
        b3.addActionListener(this);

        b1.setToolTipText("Click this button to disable the middle button.");
        b2.setToolTipText("This middle button does nothing when you click it.");
        b3.setToolTipText("Click this button to enable the middle button.");

        //Add Components to this container, using the default FlowLayout.
        add(b1);
        add(b2);
        add(b3);
    }

    public void actionPerformed(ActionEvent e) {
        if (e.getActionCommand().equals("disable")) {
            b2.setEnabled(false);
            b1.setEnabled(false);
            b3.setEnabled(true);
        } else {
            b2.setEnabled(true);
            b1.setEnabled(true);
            b3.setEnabled(false);
        }
    }

    public static void main(String[] args) {
        JFrame frame = new JFrame("CustomIconDemo");
        frame.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });

        frame.getContentPane().add(new CustomIconDemo(),
                                   BorderLayout.CENTER);
        frame.pack();
        frame.setVisible(true);
    }
}
```

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

public class ArrowIcon implements Icon, SwingConstants {
    private int width = 9;
    private int height = 18;

    private int[] xPoints = new int[4];
    private int[] yPoints = new int[4];

    public ArrowIcon(int direction) {
        if (direction == LEFT) {
            xPoints[0] = width;
            yPoints[0] = -1;
            xPoints[1] = width;
            yPoints[1] = height;
            xPoints[2] = 0;
            yPoints[2] = height/2;
            xPoints[3] = 0;
            yPoints[3] = height/2 - 1;
        } else /* direction == RIGHT */ {
            xPoints[0] = 0;
            yPoints[0] = -1;
            xPoints[1] = 0;
            yPoints[1] = height;
            xPoints[2] = width;
            yPoints[2] = height/2;
            xPoints[3] = width;
            yPoints[3] = height/2 - 1;
        }
    }

    public int getIconHeight() {
        return height;
    }

    public int getIconWidth() {
        return width;
    }

    public void paintIcon(Component c, Graphics g, int x, int y) {
        int length = xPoints.length;
        int adjustedXPoints[] = new int[length];
        int adjustedYPoints[] = new int[length];

        for (int i = 0; i < length; i++) {
            adjustedXPoints[i] = xPoints[i] + x;
            adjustedYPoints[i] = yPoints[i] + y;
        }

        if (c.isEnabled()) {
            g.setColor(Color.black);
        } else {
            g.setColor(Color.gray);
        }

        g.fillPolygon(adjustedXPoints, adjustedYPoints, length);
    }
}
```

```
# Swing properties

swing.defaultlaf=com.sun.java.swing.plaf.motif.MotifLookAndFeel
```

```
import javax.swing.SwingUtilities;

/**
 * This is the 3rd version of SwingWorker (also known as
 * SwingWorker 3), an abstract class that you subclass to
 * perform GUI-related work in a dedicated thread.  For
 * instructions on using this class, see:
 *
 * http://java.sun.com/docs/books/tutorial/uiswing/misc/threads.html
 *
 * Note that the API changed slightly in the 3rd version:
 * You must now invoke start() on the SwingWorker after
 * creating it.
 */
public abstract class SwingWorker {
    private Object value;  // see getValue(), setValue()
    private Thread thread;

    /**
     * Class to maintain reference to current worker thread
     * under separate synchronization control.
     */
    private static class ThreadVar {
        private Thread thread;
        ThreadVar(Thread t) { thread = t; }
        synchronized Thread get() { return thread; }
        synchronized void clear() { thread = null; }
    }

    private ThreadVar threadVar;

    /**
     * Get the value produced by the worker thread, or null if it
     * hasn't been constructed yet.
     */
    protected synchronized Object getValue() {
        return value;
    }

    /**
     * Set the value produced by worker thread
     */
    private synchronized void setValue(Object x) {
        value = x;
    }

    /**
     * Compute the value to be returned by the <code>get</code> method.
     */
    public abstract Object construct();

    /**
     * Called on the event dispatching thread (not on the worker thread)
     * after the <code>construct</code> method has returned.
     */
    public void finished() {
    }

    /**
     * A new method that interrupts the worker thread.  Call this method
     * to force the worker to stop what it's doing.
     */
    public void interrupt() {
        Thread t = threadVar.get();
        if (t != null) {
            t.interrupt();
        }
        threadVar.clear();
    }

    /**
     * Return the value created by the <code>construct</code> method.
     * Returns null if either the constructing thread or the current
     * thread was interrupted before a value was produced.
     *
     * @return the value created by the <code>construct</code> method
     */
    public Object get() {
        while (true) {
            Thread t = threadVar.get();
            if (t == null) {
                return getValue();
            }
            try {
                t.join();
            }
            catch (InterruptedException e) {
                Thread.currentThread().interrupt(); // propagate
                return null;
            }
        }
    }


    /**
     * Start a thread that will call the <code>construct</code> method
     * and then exit.
     */
    public SwingWorker() {
        final Runnable doFinished = new Runnable() {
           public void run() { finished(); }
        };

        Runnable doConstruct = new Runnable() {
            public void run() {
                try {
                    setValue(construct());
                }
                finally {
                    threadVar.clear();
                }

                SwingUtilities.invokeLater(doFinished);
            }
        };

        Thread t = new Thread(doConstruct);
        threadVar = new ThreadVar(t);
    }

    /**
     * Start the worker thread.
     */
    public void start() {
        Thread t = threadVar.get();
        if (t != null) {
            t.start();
        }
    }
}
```

Trail: Creating a GUI with JFC/Swing
Lesson: Using Other Swing Features

Solving Common Problems Using Other Swing Features

Problem: My applet isn't finding its icons in its JAR file.

- Some versions of Applet Viewer and Java Plug-in can't load icons (or other data files) from JAR files. A workaround is to keep copies of the image files on the server file system, exactly where the files would be if the JAR file were absent. Unfortunately, this workaround doesn't seem to work when the applet is delivered across a firewall. See Specifying the Image Source for more details.

If you don't find your problem in this section, consult Solving Common Component Problems◆.

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

public class ProgressBarDemo extends JFrame {
    public final static int ONE_SECOND = 1000;

    private JProgressBar progressBar;
    private Timer timer;
    private JButton startButton;
    private LongTask task;
    private JTextArea taskOutput;
    private String newline = "\n";

    public ProgressBarDemo() {
        super("ProgressBarDemo");
        task = new LongTask();

        //Create the demo's UI.
        startButton = new JButton("Start");
        startButton.setActionCommand("start");
        startButton.addActionListener(new ButtonListener());

        progressBar = new JProgressBar(0, task.getLengthOfTask());
        progressBar.setValue(0);
        progressBar.setStringPainted(true);

        taskOutput = new JTextArea(5, 20);
        taskOutput.setMargin(new Insets(5,5,5,5));
        taskOutput.setEditable(false);

        JPanel panel = new JPanel();
        panel.add(startButton);
        panel.add(progressBar);

        JPanel contentPane = new JPanel();
        contentPane.setLayout(new BorderLayout());
        contentPane.add(panel, BorderLayout.NORTH);
        contentPane.add(new JScrollPane(taskOutput), BorderLayout.CENTER);
        contentPane.setBorder(BorderFactory.createEmptyBorder(20, 20, 20, 20));
        setContentPane(contentPane);

        //Create a timer.
        timer = new Timer(ONE_SECOND, new ActionListener() {
            public void actionPerformed(ActionEvent evt) {
                progressBar.setValue(task.getCurrent());
                taskOutput.append(task.getMessage() + newline);
                taskOutput.setCaretPosition(
                        taskOutput.getDocument().getLength());
                if (task.done()) {
                    Toolkit.getDefaultToolkit().beep();
                    timer.stop();
                    startButton.setEnabled(true);
                    progressBar.setValue(progressBar.getMinimum());
                }
            }
        });
    }

    /**
     * The actionPerformed method in this class
     * is called when the user presses the start button.
     */
    class ButtonListener implements ActionListener {
        public void actionPerformed(ActionEvent evt) {
            startButton.setEnabled(false);
            task.go();
            timer.start();
        }
    }

    public static void main(String[] args) {
        JFrame frame = new ProgressBarDemo();
        frame.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });

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

Trail: Creating a GUI with JFC/Swing
Lesson: Laying Out Components Within a Container

General Rules for Using Layout Managers

As a rule, the only time you have to think about layout managers is when you create a `JPanel`◆ or add components to a content pane◆. If you don't like the default layout manager that a panel or content pane uses, then you can change it to a different one. When you add components to a panel or content pane, the arguments you specify to the `add` method depend on the layout manager that the panel or content pane is using.

The other Swing containers are more specialized and tend to hide the details of which layout manager (if any) they use. For example, a scroll pane◆ relies on a layout manager named `ScrollPaneLayout`, but you don't need to know that to use a scroll pane. Most Swing containers provide API that you can use instead of the `add` method. For example, instead of adding a component directly to a scroll pane (or, actually, to its viewport), you either specify the component in the `JScrollPane` constructor or use `setViewportView`. For information about how to add components to a specific container, see the how-to page for the container. You can find the how-to pages using A Visual Index to the Swing Components◆.

How to Choose a Layout Manager

Layout managers have different strengths and weaknesses. This section discusses some common layout scenarios and which layout managers might work for each scenario. If none of the layout managers we discuss is right for your situation, feel free to use other layout managers that you write or find.

Scenario: You need to display a component in as much space as it can get.

> Consider using `BorderLayout` or `GridBagLayout`. If you use `BorderLayout`, you'll need to put the space-hungry component in the center. With `GridBagLayout`, you'll need to set the constraints for the component so that `fill=GridBagConstraints.BOTH`. Another possibility is to use `BoxLayout`, making the space-hungry component specify very large preferred and maximum sizes.

Scenario: You need to display a few components in a compact row at their natural size.

Consider using a `JPanel` to group the components and using either the `JPanel`'s default `FlowLayout` manager or the `BoxLayout` manager.

Scenario: You need to display a few components of the same size in rows and columns.
`GridLayout` is perfect for this.

Scenario: You need to display a few components in a row or column, possibly with varying amounts of space between them, custom alignment, or custom component sizes.
`BoxLayout` is perfect for this.

Scenario: You have a complex layout with many components.
Consider either using `GridBagLayout` or grouping the components into one or more `JPanel`s to simplify layout. Each `JPanel` might use a different layout manager.

How to Create a Layout Manager and Associate It with a Container

As mentioned in Layout Management◆, each container either has a layout manager or uses absolute positioning. All `JPanel` objects are initialized to use a `FlowLayout`. Content panes (the main containers in `JApplet`, `JDialog`, and `JFrame` objects) use `BorderLayout`, by default.

If you want to use a container's default layout manager, you don't have to do a thing. The constructor for the container creates a layout manager instance and initializes the container to use it.

To use a layout manager other than the default layout manager, you must create an instance of the desired layout manager class and tell the container to use it. The following statement creates a `BorderLayout` manager and sets it up as the layout manager for a panel.

```
aJPanel.setLayout(new BorderLayout());
```

Here is an example of making a `FlowLayout` object the layout manager for an applet's content pane:

```
//In a JApplet subclass:
Container contentPane = getContentPane();
contentPane.setLayout(new FlowLayout());
```

For examples of creating each layout manager, see the how-to section for the particular layout manager.

When Is a Layout Manager Consulted?

A container's layout manager is automatically consulted each time the container might need to change its appearance. For example, the layout manager is consulted whenever the user adds a component to a container. Most layout managers don't require programs to directly call their methods.

Only a few component methods result in a layout manager actually performing layout: the `JComponent` `revalidate` method, the `Window` `pack` method, and the `Window` `show` and `setVisible` methods. Other methods that result in calls to a container's layout manager (but don't trigger a new layout) include the `Container` `add`, `remove`, `removeAll`, `getAlignmentX`, `getAlignmentY`, `getPreferredSize`, `getMinimumSize`, and `getMaximumSize` methods.

If you change the size of a component, even indirectly by changing its font, for example, the component should automatically resize and repaint itself. If that doesn't happen -- because you made the change to the component's data model instead of the component, for example -- you should invoke the `revalidate` method on the component.

When you invoke `revalidate` on a component, a request is passed up the containment hierarchy until it encounters a container, such as a scroll pane or top-level container, that shouldn't be affected by the component's resizing. (This is determined by calling the container's `isValidateRoot` method.) The container is then laid out, which has the effect of adjusting the revalidated component's size and the size of all affected components.

After calling `revalidate` on a component, you can invoke `repaint` on it to make the change appear onscreen. Both `revalidate` and `repaint` are thread-safe◆ -- you needn't invoke them from the event-dispatching thread.

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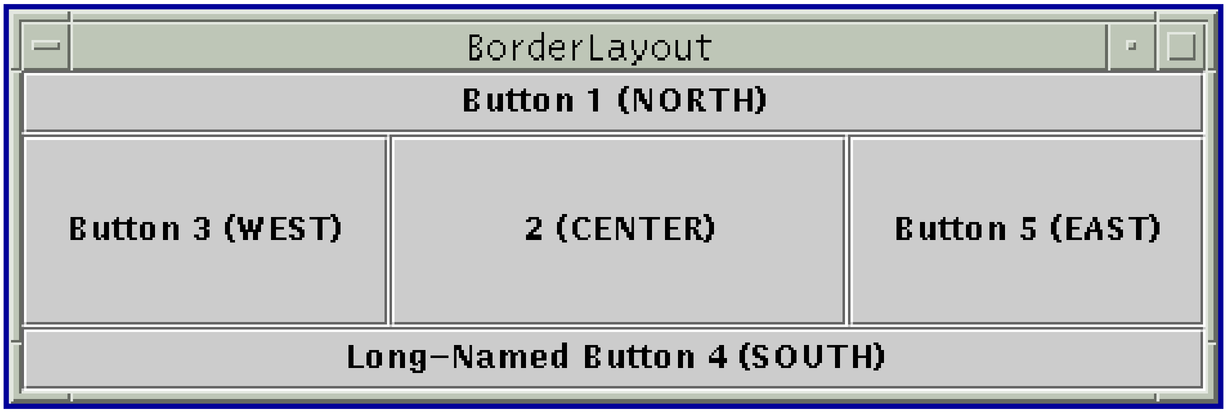
How to Use BorderLayout

Here's an applet that shows a `BorderLayout` in action.



This is a picture of the applet's GUI. To run the applet, click the picture. The applet will appear in a new browser window.

As the preceding applet shows, a `BorderLayout` has five areas: north, south, east, west, and center. If you enlarge the window, the center area gets as much of the available space as possible. The other areas expand only as much as necessary to fill all available space. Often, a container uses only one or two of the areas of the `BorderLayout` -- just the center, or center and south, for example.

The following code creates the `BorderLayout` and the components it manages. You can find the whole program in `BorderWindow.java`. The program runs either within an applet (with the help of `AppletButton`) or as an application.

```
Container contentPane = getContentPane();
//Use the content pane's default BorderLayout.
//contentPane.setLayout(new BorderLayout()); //unnecessary

contentPane.add(new JButton("Button 1 (NORTH)"),
                BorderLayout.NORTH);
contentPane.add(new JButton("2 (CENTER)"),
                BorderLayout.CENTER);
contentPane.add(new JButton("Button 3 (WEST)"),
                BorderLayout.WEST);
contentPane.add(new JButton("Long-Named Button 4 (SOUTH)"),
                BorderLayout.SOUTH);
contentPane.add(new JButton("Button 5 (EAST)"),
                BorderLayout.EAST);
```

Important: When adding a component to a container that uses `BorderLayout`, specify the component's location as one of the arguments to the `add` method. Do not rely on the component being added to the center, by default. If you find that a component is missing from a container controlled by a `BorderLayout`, make sure that you specified the component's location and that you didn't put another component in the same location.

All our examples that use `BorderLayout` specify the component as the first argument to the `add` method. For example:

```
add(component, BorderLayout.CENTER)  //preferred
```

However, you might see code in other programs that specifies the component second. For example, the following are alternate ways of writing the preceding code:

```
add(BorderLayout.CENTER, component)  //valid but old-fashioned
    or
add("Center", component)             //valid but error prone
```

The BorderLayout API

By default, a `BorderLayout` puts no gap between the components it manages. In the preceding applet, any apparent gaps are the result of the buttons reserving extra space around their apparent display area. You can specify gaps (in pixels) using the following constructor:

```
BorderLayout(int horizontalGap, int verticalGap)
```

You can also use the following methods to set the horizontal and vertical gaps, respectively:

```
void setHgap(int)
void setVgap(int)
```

Examples that Use BorderLayout

The following table lists some of the many examples that use `BorderLayout`.

Example	Where Described	Notes
`BorderWindow`	This page	Puts a component in each of the five possible locations.
`TabbedPaneDemo`	How to Use Tabbed Panes◆	One of many examples that puts a single component in the center of a content pane, so that the component is as large as possible.
`CheckBoxDemo`	How to Use Check Boxes◆	Creates a `JPanel` that uses a `BorderLayout`. Puts components into the west and center locations.

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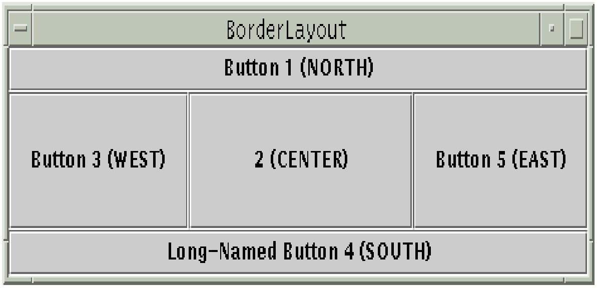
Run BorderLayout Demo

Since you can't run the applet, here's a picture of it:



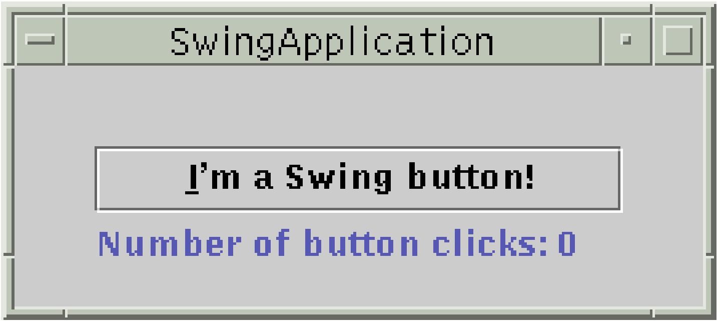
Note: Because the preceding applet uses the Swing 1.1 API, it requires Java Plug-in 1.1.2 or Java Plug-in 1.2. It won't work with Java Plug-in 1.1.1 or uncustomized 1.1 browsers. For more information about running applets in the tutorial, refer to About Our Examples. That page includes a section about Downloading Java Plug-in.

```java
/*
 * Swing version.
 */

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

public class BorderWindow extends JFrame {
    boolean inAnApplet = true;

    public BorderWindow() {
        Container contentPane = getContentPane();
        //Use the content pane's default BorderLayout.
        //contentPane.setLayout(new BorderLayout()); //unnecessary

        contentPane.add(new JButton("Button 1 (NORTH)"),
                        BorderLayout.NORTH);
        contentPane.add(new JButton("2 (CENTER)"),
                        BorderLayout.CENTER);
        contentPane.add(new JButton("Button 3 (WEST)"),
                        BorderLayout.WEST);
        contentPane.add(new JButton("Long-Named Button 4 (SOUTH)"),
                        BorderLayout.SOUTH);
        contentPane.add(new JButton("Button 5 (EAST)"),
                        BorderLayout.EAST);

        addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                if (inAnApplet) {
                    dispose();
                } else {
                    System.exit(0);
                }
            }
        });
    }

    public static void main(String args[]) {
        BorderWindow window = new BorderWindow();
        window.inAnApplet = false;

        window.setTitle("BorderLayout");
        window.pack();
        window.setVisible(true);
    }
}
```

Trail: Creating a GUI with JFC/Swing
Lesson: Swing Features and Concepts

Swing Components and the Containment Hierarchy

Here, again, is a picture of the `SwingApplication` program presented in A Quick Tour of a Swing Application's Code◆:



We use this program to introduce some commonly used Swing components and to show how the components in a GUI fit together into a containment hierarchy.

SwingApplication creates four commonly used Swing components:

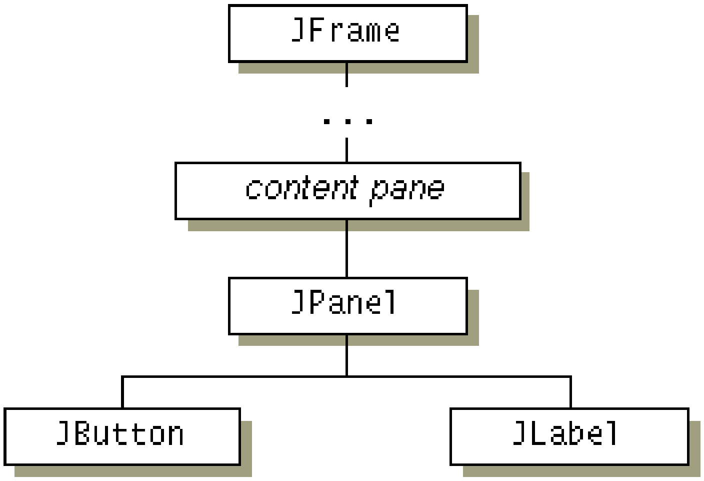
- a *frame*, or main window (`JFrame`)
- a *panel*, sometimes called a *pane* (`JPanel`)
- a button (`JButton`)
- a label (`JLabel`)

The frame is a *top-level container*. It exists mainly to provide a place for other Swing components to paint themselves. The other commonly used top-level containers are dialogs (`JDialog`) and applets (`JApplet`).

The panel is an *intermediate container*. Its only purpose is to simplify the positioning of the button and label. Other intermediate Swing containers, such as scroll panes (`JScrollPane`) and tabbed panes (`JTabbedPane`), typically play a more visible, interactive role in a program's GUI.

The button and label are *atomic components* -- components that exist not to hold random Swing components, but as self-sufficient entities that present bits of information to the user. Often, atomic components also get input from the user. The Swing API provides many atomic components, including combo boxes (`JComboBox`), text fields (`JTextField`), and tables (`JTable`).

Here is a diagram of the *containment hierarchy* for the window shown by `SwingApplication`. This diagram shows each container created or used by the program, along with the components it contains. Note that if we add a window -- a dialog, for instance -- the new window has its own component hierarchy, unattached to the hierarchy shown in this figure.



As the figure shows, even the simplest Swing program has multiple levels in its containment hierarchy. The root of the containment hierarchy is always a top-level container. The top-level container provides a place for its descendent Swing components to paint themselves.

Tip: To view the containment hierarchy for any frame or dialog, click its border to select it, and then press Control-Shift-F1. A list of the containment hierarchy will be written to the standard output stream.

Every top-level container indirectly contains an intermediate container known as a *content pane*. For most programs, you don't need to know what's between a top-level container and its content pane. (If you really want to know, see How to Use Root Panes◆.)

As a rule, the content pane contains, directly or indirectly, all of the visible components in the window's GUI. The big exception to the rule is that if the top-level container has a menu bar, then by convention the menu bar goes in a special place outside of the content pane.

To add a component to a container, you use one of the various forms of the `add` method.

The `add` method has at least one argument -- the component to be added. Sometimes an additional argument is required to provide layout information. For example, the last line of the following code sample specifies that the panel should be in the center of the its container (the content pane). For more information about the `add` method, see the how-to page for the container's layout manager. Also see the table The JComponent Class◆.

Here is the code that adds the button and label to the panel, and the panel to the content pane:

```
frame = new JFrame(...);
button = new JButton(...);
label = new JLabel(...);
pane = new JPanel();
pane.add(button);
pane.add(label);
frame.getContentPane().add(pane, BorderLayout.CENTER);
```

To see all the Swing components, go to A Visual Index to the Swing Components◆.

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

public class TopLevelDemo {
    public static void main(String s[]) {
        JFrame frame = new JFrame("TopLevelDemo");

        frame.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });

        JLabel yellowLabel = new JLabel("");
        yellowLabel.setOpaque(true);
        yellowLabel.setBackground(Color.yellow);
        yellowLabel.setPreferredSize(new Dimension(200, 180));

        JMenuBar cyanMenuBar = new JMenuBar();
        cyanMenuBar.setOpaque(true);
        cyanMenuBar.setBackground(Color.cyan);
        cyanMenuBar.setPreferredSize(new Dimension(200, 20));

        frame.setJMenuBar(cyanMenuBar);
        frame.getContentPane().add(yellowLabel, BorderLayout.CENTER);

        frame.pack();
        frame.setVisible(true);
    }

}
```

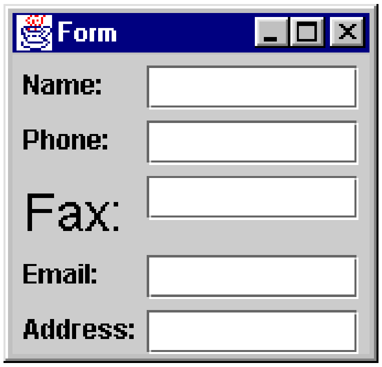
Trail: Creating a GUI with JFC/Swing
Lesson: Laying Out Components Within a Container

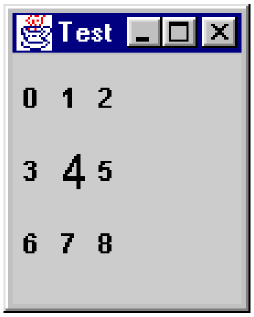
How to Use SpringLayout

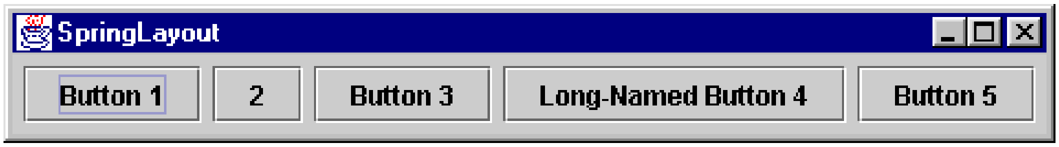
[NOTE: This is an early draft of documentation on `SpringLayout`. We're publishing it before its completion so that you can get examples and a bit of explanation as soon as possible. If you have suggestions for this page, please send us mail.]

The `SpringLayout` class was added in v 1.4 to support layout in GUI builders. It produces layouts that are similar to absolute positioning, but that react more appropriately to container resizing, changes in text and font, and so on.

`SpringLayout` can produce many kinds of layouts. Here are pictures of three configurations produced by spring layout:







The first window, labeled "Form" (and described in Springs in the Form Example), uses a `SpringLayout` to align pairs of items -- in this case, labels with text fields. The second, labeled "Test" (implemented in `Grid.java`), uses a `SpringLayout` to create rows and columns, similar to what a `GridLayout` does. Unlike grid layout, however, this example makes the grid as compact as possible. The third window, labeled "SpringLayout", creates a single-row layout similar to the default layout produced by a `FlowLayout`. It's discussed in the section Example: SpringWindow.

How Spring Layouts Work

Spring layouts do their job by defining relationships between the edges of components. For example, you might define that the left edge of one component is a fixed distance (5 pixels, say) from the right edge of another component. By default, a spring layout defines the width and height of a component (the distance between its left and right edges and between its top and bottom edges) to be somewhere between the component's minimum and maximum sizes -- if possible, at its preferred size.

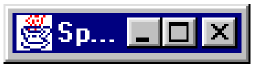
Distances between edges are represented by `Spring` objects. Each spring has four properties -- its *minimum*, *preferred*, and *maximum* values, and its actual (current) *value*. The springs associated with each component are collected into a `SpringLayout.Constraints` object.

Example: SpringWindow

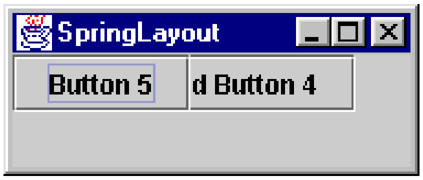
This section takes you through the typical steps of specifying the constraints for a container that uses `SpringLayout`. The first example, `SpringWindow1.java`◆, is a modified version of the `FlowWindow` application. . It just creates a `SpringLayout`, sets it as the layout manager for a frame's content pane, and then adds components to the content pane. Here's the relevant code:

```
public class SpringWindow1 extends JFrame {

    public SpringWindow1() {
        Container contentPane = getContentPane();
        contentPane.setLayout(new SpringLayout());

        contentPane.add(new JButton("Button 1"));
        contentPane.add(new JButton("2"));
        contentPane.add(new JButton("Button 3"));
        contentPane.add(new JButton("Long-Named Button 4"));
        contentPane.add(new JButton("Button 5"));
        ...
    }

    public static void main(String args[]) {
        SpringWindow1 window = new SpringWindow1();
        ...
        window.pack();
        window.setVisible(true);
    }
}
```

Here's what the GUI looks like when it first comes up:



Here's what it looks like when it's resized to be bigger:



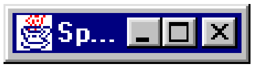
Obviously, we have a problem. Not only does the frame come up way too small, but even when it's resized the components all are located at (0,0). This happens because we have set no springs specifying the components' positions and the width of the container. One small consolation is that at least the buttons are at their preferred sizes -- we get that for free from the default springs created by `SpringLayout` for each component.

Our next example, `SpringWindow2.java`◆, improves the situation a bit by specifying *x* and *y* locations for each component. In this example, we'll specify that all the components appear at their preferred size in a single row. Each component will be exactly 5 pixels away from each other component. The following code specifies the locations (`parent` is the content pane):

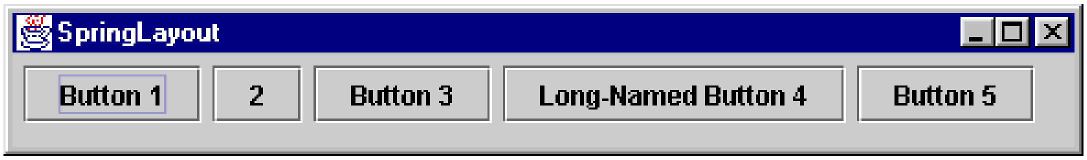
```
Component[] components = parent.getComponents();
SpringLayout layout = (SpringLayout)parent.getLayout();;
Spring xPad = Spring.constant(5);
Spring ySpring = Spring.constant(5);
Spring xSpring = xPad;

// Make every component 5 pixels away from the component to its left.
for (int i = 0; i < components.length; i++) {
    SpringLayout.Constraints cons = layout.getConstraints(components[i]);
    cons.setX(xSpring);
    xSpring = Spring.sum(xPad, cons.getConstraint("East"));
    cons.setY(ySpring);
}
```

The red lines of code set the springs that determine the *x* and *y* coordinates of each component in the container. The *y* coordinate is always 5. The *x* coordinate is set so that the components are always 5 pixels apart, horizontally. For example, the first component's origin is at *x*=5. The second component's *x* coordinate is 5 + the first component's width. The third component's is at 5 + the first component's width + 5 + the second component's width. And so on. We use the `Spring.sum` method to create a `Spring` that depends on the values of other springs.

The previous example still has the problem of the container coming up too small:



But when we resize the window, every component is in its place:

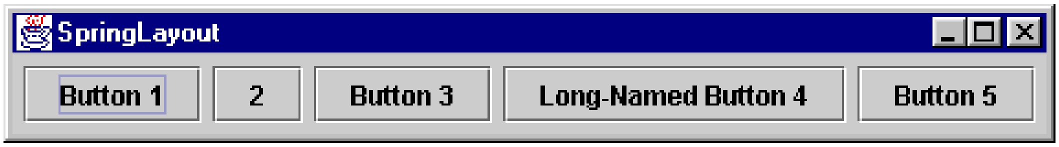


To make the container the initially appear at the right size, we need to set springs between its right (east) and left edges, and between its bottom (south) and top edges. Here is the code that does this (taken from `SpringWindow3.java`):

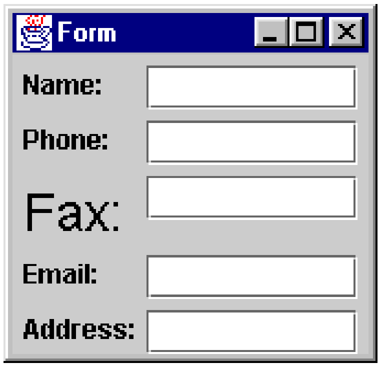
```
Spring maxHeightSpring = Spring.constant(0);
for (int i = 0; i < components.length; i++) {
    ...
    maxHeightSpring = Spring.max(maxHeightSpring,
                                 cons.getConstraint("South"));
//cons is the SpringLayout.Constraints object for components[i]
    ...
}

// Make the window's preferred size depend on its components.
SpringLayout.Constraints pCons = layout.getConstraints(parent);
```

```
pCons.setConstraint("East", xSpring);
pCons.setConstraint("South", Spring.sum(maxHeightSpring, ySpring));
```

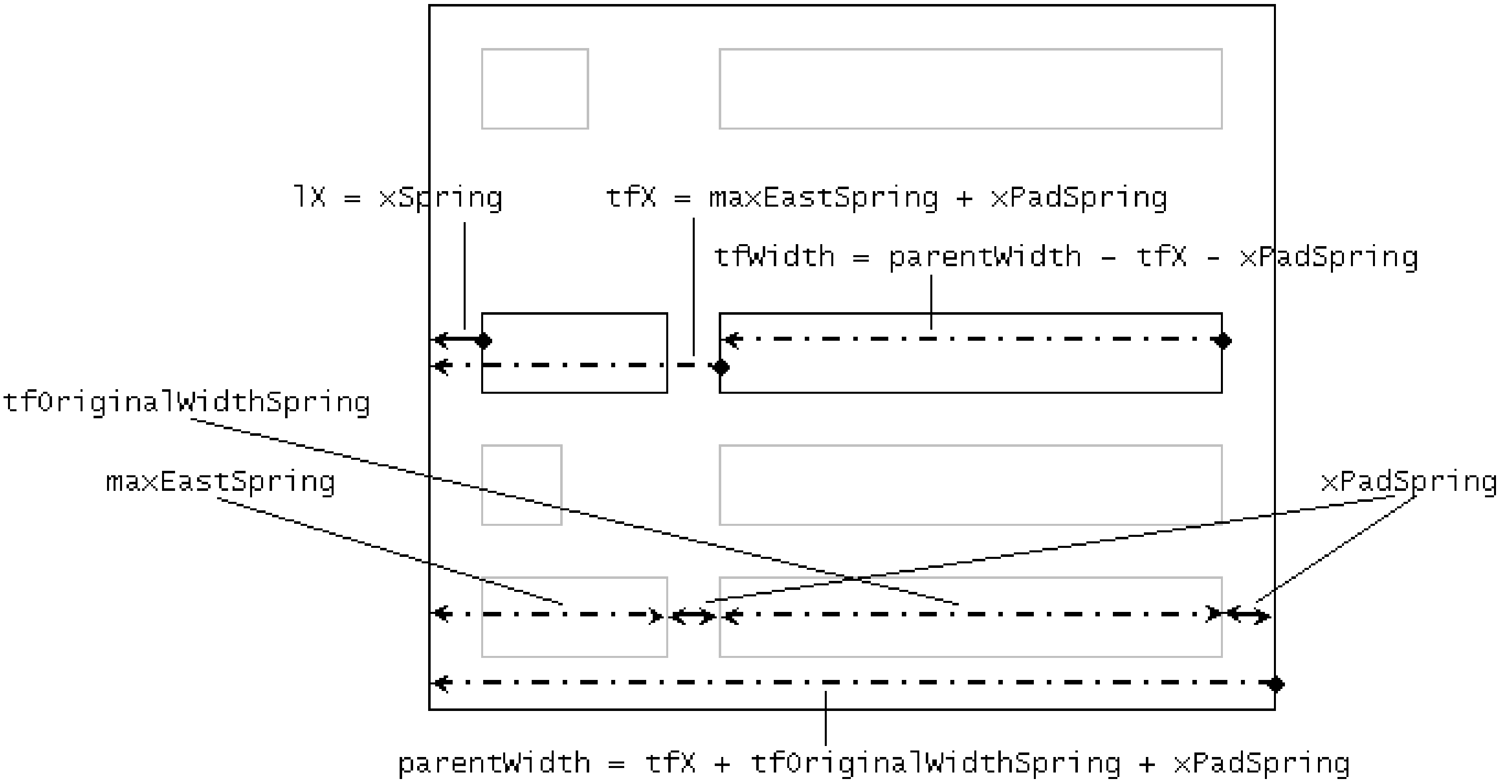
Finally, the window comes up at the right size:



Springs in the Form Example



The following figure shows the important horizontal springs used in the `Form` application (Form.java). It doesn't show the default springs that control each label's width. Leaving these springs at the default means that each label appears at its preferred width. [PENDING: Explain the figure in more detail.]


lX = xSpring
tfX = maxEastSpring + xPadSpring
tfWidth = parentWidth - tfX - xPadSpring
tfOriginalWidthSpring
maxEastSpring
xPadSpring
parentWidth = tfX + tfOriginalWidthSpring + xPadSpring

[PENDING: Discuss/show the vertical springs?]

[PENDING: Discuss the intricacies of working with springs. Discuss proxies vs. original Springs.]

The SpringLayout API

The `SpringLayout` class has a single constructor, which takes no argument:

```
public SpringLayout()
```

[PENDING: Discuss the important API for `SpringLayout`, `SpringLayout.Constraints`, and `Spring`.]

Examples that Use SpringLayout

The following table lists the examples that use spring layout.

Example	Where Described	Notes
`SpringWindow3`	This page	Uses `SpringLayout` to create a row of evenly spaced, natural-size components.
`Form`	This page	Uses `SpringLayout` to align labels with text fields.
`Grid`	This page	Uses `SpringLayout` to create a compact grid.

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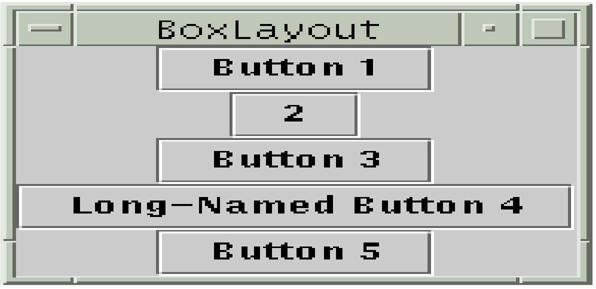
Run BoxLayout Demo

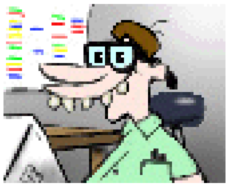
Since you can't run the applet, here's a picture of it:



Note: Because the preceding applet uses the Swing 1.1 API, it requires Java Plug-in 1.1.2 or Java Plug-in 1.2. It won't work with Java Plug-in 1.1.1 or uncustomized 1.1 browsers. For more information about running applets in the tutorial, refer to About Our Examples. That page includes a section about Downloading Java Plug-in.

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

public class BoxLayoutDemo {
    protected static int NUM_COMPONENTS = 3;
    protected static float[] xAlignment = {Component.LEFT_ALIGNMENT,
                                 Component.CENTER_ALIGNMENT,
                                 Component.RIGHT_ALIGNMENT};
    protected static float[] hue = {0.0f, 0.33f, 0.67f};
    protected static boolean restrictSize = true;
    protected static boolean sizeIsRandom = false;
    protected static BLDComponent[] bldComponent =
        new BLDComponent[NUM_COMPONENTS];

    public static void main(String[] args) {
        final JPanel panel = new JPanel();
        panel.setLayout(new BoxLayout(panel, BoxLayout.Y_AXIS));

        //Create the rectangles.
        int shortSideSize = 15;
        for (int i = 0; i < NUM_COMPONENTS; i++) {
            if (sizeIsRandom) {
                shortSideSize = (int)(30.0 * Math.random()) + 30;
            } else {
                shortSideSize += 10;
            }
            bldComponent[i] = new BLDComponent(xAlignment[i], hue[i],
                                             shortSideSize,
                                             restrictSize,
                                             sizeIsRandom,
                                             String.valueOf(i));
            panel.add(bldComponent[i]);
        }

        //Create the instructions.
        JLabel label = new JLabel("Click a rectangle to "
                                + "change its X alignment.");
        JCheckBox cb = new JCheckBox("Restrict maximum rectangle size.");
        cb.setSelected(restrictSize);
        cb.addItemListener(new ItemListener() {
            public void itemStateChanged(ItemEvent e) {
                if (e.getStateChange() == ItemEvent.SELECTED) {
                    restrictSize = true;
                } else {
                    restrictSize = false;
                }
                notifyBLDComponents();
            }
        });

        JFrame f = new JFrame("BoxLayoutDemo");
        Container contentPane = f.getContentPane();
        contentPane.add(panel, BorderLayout.CENTER);
        panel.setBorder(BorderFactory.createLineBorder(Color.red));

        Box box = Box.createVerticalBox();
        box.add(label);
        box.add(cb);

        contentPane.add(box, BorderLayout.SOUTH);
        f.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });
        f.pack();
        f.setVisible(true);
    }

    static public void notifyBLDComponents() {
        for (int i = 0; i < NUM_COMPONENTS; i++) {
            bldComponent[i].setSizeRestriction(restrictSize);
        }
        bldComponent[0].revalidate();
    }
}
```

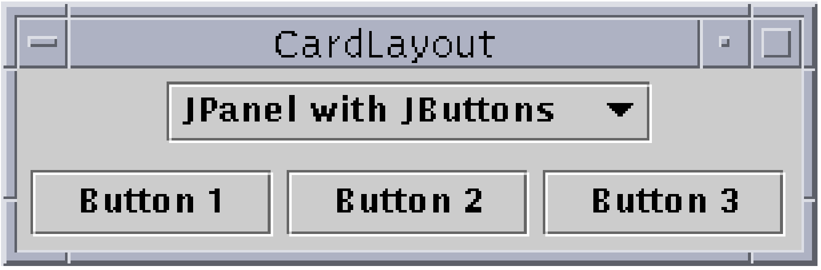
```
import java.awt.*;
import java.awt.event.*;
import javax.swing.*;

/** A rectangle that has a fixed size. */
class BLDComponent extends JComponent {
    private Color normalHue;
    private final Dimension preferredSize;
    private String name;
    private boolean restrictMaximumSize;
    private boolean printSize;

    public BLDComponent(float alignmentX, float hue,
                     int shortSideSize,
                     boolean restrictSize,
                     boolean printSize,
                     String name) {
        this.name = name;
        this.restrictMaximumSize = restrictSize;
        this.printSize = printSize;
        setAlignmentX(alignmentX);
        normalHue = Color.getHSBColor(hue, 0.4f, 0.85f);
        preferredSize = new Dimension(shortSideSize*2, shortSideSize);

        MouseListener l = new MouseAdapter() {
            public void mousePressed(MouseEvent e) {
                int width = getWidth();
                float alignment = (float)(e.getX())
                                / (float)width;

                // Round to the nearest 1/10th.
                int tmp = Math.round(alignment * 10.0f);
                alignment = (float)tmp / 10.0f;

                setAlignmentX(alignment);
                revalidate(); // this GUI needs relayout
                repaint();
            }
        };
        addMouseListener(l);
    }

    /**
     * Our BLDComponents are completely opaque, so we override
     * this method to return true.  This lets the painting
     * system know that it doesn't need to paint any covered
     * part of the components underneath this component.  The
     * end result is possibly improved painting performance.
     */
    public boolean isOpaque() {
        return true;
    }

    public void paint(Graphics g) {
        int width = getWidth();
        int height = getHeight();
        float alignmentX = getAlignmentX();

        g.setColor(normalHue);
        g.fill3DRect(0, 0, width, height, true);

        /* Draw a vertical white line at the alignment point.*/
        // XXX: This code is probably not the best.
        g.setColor(Color.white);
        int x = (int)(alignmentX * (float)width) - 1;
        g.drawLine(x, 0, x, height - 1);

        /* Say what the alignment point is. */
        g.setColor(Color.black);
        g.drawString(Float.toString(alignmentX), 3, height - 3);

        if (printSize) {
            System.out.println("BLDComponent " + name + ": size is "
                               + width + "x" + height
                               + "; preferred size is "
                               + getPreferredSize().width + "x"
                               + getPreferredSize().height);
        }
    }

    public Dimension getPreferredSize() {
        return preferredSize;
    }

    public Dimension getMinimumSize() {
        return preferredSize;
    }

    public Dimension getMaximumSize() {
        if (restrictMaximumSize) {
            return preferredSize;
        } else {
            return super.getMaximumSize();
        }
    }

    public void setSizeRestriction(boolean restrictSize) {
        restrictMaximumSize = restrictSize;
    }

}
```



Trail: Creating a GUI with JFC/Swing
Lesson: Laying Out Components Within a Container

Run CardLayout Demo

Since you can't run the applet, here's a picture of it:



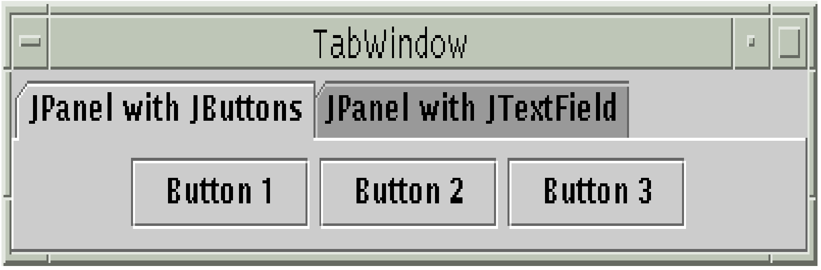
Note: Because the preceding applet uses the Swing 1.1 API, it requires Java Plug-in 1.1.2 or Java Plug-in 1.2. It won't work with Java Plug-in 1.1.1 or uncustomized 1.1 browsers. For more information about running applets in the tutorial, refer to About Our Examples. That page includes a section about Downloading Java Plug-in.

The Java^{TM} Tutorial

Trail: Creating a GUI with JFC/Swing
Lesson: Laying Out Components Within a Container

Run TabDemo

Since you can't run the applet, here's a picture of it:



Note: Because the preceding applet uses the Swing 1.1 API, it requires Java Plug-in 1.1.2 or Java Plug-in 1.2. It won't work with Java Plug-in 1.1.1 or uncustomized 1.1 browsers. For more information about running applets in the tutorial, refer to About Our Examples. That page includes a section about Downloading Java Plug-in.

```
/*
 * Swing version.
 */

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

public class TabWindow extends JFrame {
    boolean inAnApplet = true;

    final static String BUTTONPANEL = "JPanel with JButtons";
    final static String TEXTPANEL = "JPanel with JTextField";

    public TabWindow() {
        Container contentPane = getContentPane();

        JTabbedPane tabbedPane = new JTabbedPane();

        JPanel p1 = new JPanel() {
            //Force the window to be 400+ pixels wide.
            public Dimension getPreferredSize() {
                Dimension size = super.getPreferredSize();
                size.width = 400;
                return size;
            }
        };
        p1.add(new JButton("Button 1"));
        p1.add(new JButton("Button 2"));
        p1.add(new JButton("Button 3"));
        tabbedPane.addTab(BUTTONPANEL, p1);

        JPanel p2 = new JPanel();
        p2.add(new JTextField("TextField", 20));
        tabbedPane.addTab(TEXTPANEL, p2);

        contentPane.add(tabbedPane, BorderLayout.CENTER);

        addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                if (inAnApplet) {
                    dispose();
                } else {
                    System.exit(0);
                }
            }
        });
    }

    public static void main(String args[]) {
        TabWindow window = new TabWindow();
        window.inAnApplet = false;

        window.setTitle("TabWindow");
        window.pack();
        window.setVisible(true);
    }
}
```

```
/*
 * Swing version.
 */

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

public class CardWindow extends JFrame
                        implements ItemListener {
    boolean inAnApplet = true;

    JPanel cards;
    final static String BUTTONPANEL = "JPanel with JButtons";
    final static String TEXTPANEL = "JPanel with JTextField";

    public CardWindow() {
        Container contentPane = getContentPane();

        //Put the JComboBox in a JPanel to get a nicer look.
        String comboBoxItems[] = { BUTTONPANEL, TEXTPANEL };
        JPanel cbp = new JPanel();
        JComboBox c = new JComboBox(comboBoxItems);
        c.setEditable(false);
        c.addItemListener(this);
        cbp.add(c);

        //Use the default layout manager, BorderLayout
        contentPane.add(cbp, BorderLayout.NORTH);

        cards = new JPanel();
        cards.setLayout(new CardLayout());

        JPanel p1 = new JPanel();
        p1.add(new JButton("Button 1"));
        p1.add(new JButton("Button 2"));
        p1.add(new JButton("Button 3"));

        JPanel p2 = new JPanel();
        p2.add(new JTextField("TextField", 20));

        cards.add(p1, BUTTONPANEL);
        cards.add(p2, TEXTPANEL);
        contentPane.add(cards, BorderLayout.CENTER);

        addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                if (inAnApplet) {
                    dispose();
                } else {
                    System.exit(0);
                }
            }
        });
    }

    public void itemStateChanged(ItemEvent evt) {
        CardLayout cl = (CardLayout)(cards.getLayout());
        cl.show(cards, (String)evt.getItem());
    }

    public static void main(String args[]) {
        CardWindow window = new CardWindow();
        window.inAnApplet = false;

        window.setTitle("CardLayout");
        window.pack();
        window.setVisible(true);
    }
}
```

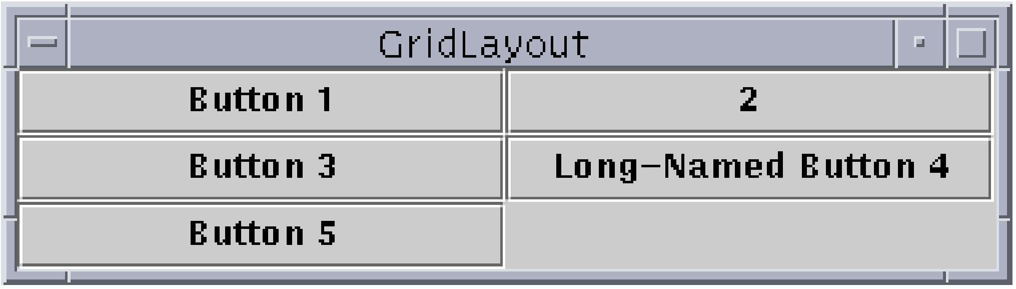
```
import javax.swing.JTabbedPane;
import javax.swing.ImageIcon;
import javax.swing.JLabel;
import javax.swing.JPanel;
import javax.swing.JFrame;

import java.awt.*;
import java.awt.event.*;

public class TabbedPaneDemo extends JPanel {
    public TabbedPaneDemo() {
        ImageIcon icon = new ImageIcon("images/middle.gif");
        JTabbedPane tabbedPane = new JTabbedPane();

        Component panel1 = makeTextPanel("Blah");
        tabbedPane.addTab("One", icon, panel1, "Does nothing");
        tabbedPane.setSelectedIndex(0);

        Component panel2 = makeTextPanel("Blah blah");
        tabbedPane.addTab("Two", icon, panel2, "Does twice as much nothing");

        Component panel3 = makeTextPanel("Blah blah blah");
        tabbedPane.addTab("Three", icon, panel3, "Still does nothing");

        Component panel4 = makeTextPanel("Blah blah blah blah");
        tabbedPane.addTab("Four", icon, panel4, "Does nothing at all");

        //Add the tabbed pane to this panel.
        setLayout(new GridLayout(1, 1));
        add(tabbedPane);
    }

    protected Component makeTextPanel(String text) {
        JPanel panel = new JPanel(false);
        JLabel filler = new JLabel(text);
        filler.setHorizontalAlignment(JLabel.CENTER);
        panel.setLayout(new GridLayout(1, 1));
        panel.add(filler);
        return panel;
    }

    public static void main(String[] args) {
        JFrame frame = new JFrame("TabbedPaneDemo");
        frame.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {System.exit(0);}
        });

        frame.getContentPane().add(new TabbedPaneDemo(),
                                   BorderLayout.CENTER);
        frame.setSize(400, 125);
        frame.setVisible(true);
    }
}
```

The Java^{TM} Tutorial

Trail: Creating a GUI with JFC/Swing
Lesson: Laying Out Components Within a Container

Run GridLayout Demo

Since you can't run the applet, here's a picture of it:



Note: Because the preceding applet uses the Swing 1.1 API, it requires Java Plug-in 1.1.2 or Java Plug-in 1.2. It won't work with Java Plug-in 1.1.1 or uncustomized 1.1 browsers. For more information about running applets in the tutorial, refer to About Our Examples. That page includes a section about Downloading Java Plug-in.

```
/*
 * Swing version.
 */

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

public class GridWindow extends JFrame {
    boolean inAnApplet = true;

    public GridWindow() {
        Container contentPane = getContentPane();

        contentPane.setLayout(new GridLayout(0,2));

        contentPane.add(new JButton("Button 1"));
        contentPane.add(new JButton("2"));
        contentPane.add(new JButton("Button 3"));
        contentPane.add(new JButton("Long-Named Button 4"));
        contentPane.add(new JButton("Button 5"));

        addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                if (inAnApplet) {
                    dispose();
                } else {
                    System.exit(0);
                }
            }
        });
    }

    public static void main(String args[]) {
        GridWindow window = new GridWindow();
        window.inAnApplet = false;

        window.setTitle("GridLayout");
        window.pack();
        window.setVisible(true);
    }
}
```

Trail: Creating a GUI with JFC/Swing
Lesson: Laying Out Components Within a Container

How to Use GridBagLayout: Specifying Constraints

The following code is typical of what goes in a container that uses a `GridBagLayout`. You'll see a more detailed example in the next section.

```
GridBagLayout gridbag = new GridBagLayout();
GridBagConstraints c = new GridBagConstraints();

JPanel pane = new JPanel();
pane.setLayout(gridbag);

//For each component to be added to this container:
//...Create the component...
//...Set instance variables in the GridBagConstraints instance...
gridbag.setConstraints(theComponent, c);
pane.add(theComponent);
```

As you might have guessed from the above example, you can reuse the same `GridBagConstraints` instance for multiple components, even if the components have different constraints. The `GridBagLayout` extracts the constraint values and doesn't use the `GridBagConstraints` again. You must be careful, however, to reset the `GridBagConstraints` instance variables to their default values when necessary.

You can set the following `GridBagConstraints` instance variables:

`gridx`, **`gridy`**

Specify the row and column at the upper left of the component. The leftmost column has address `gridx=0` and the top row has address `gridy=0`. Use `GridBagConstraints.RELATIVE` (the default value) to specify that the component be placed just to the right of (for `gridx`) or just below (for `gridy`) the component that was added to the container just before this component was added. We recommend specifying the `gridx` and `gridy` values for each component; this tends to result in more predictable layouts.

`gridwidth`, **`gridheight`**

Specify the number of columns (for `gridwidth`) or rows (for `gridheight`) in the component's display area. These constraints specify the number of cells the component uses, *not* the number of pixels it uses. The default value is 1. Use `GridBagConstraints.REMAINDER` to specify that the component be the last one in its row (for `gridwidth`) or column (for `gridheight`). Use `GridBagConstraints.RELATIVE` to specify that the component be the next to last one in its row (for `gridwidth`) or column (for `gridheight`).

Note: `GridBagLayout` doesn't allow components to span multiple rows unless the component is in the leftmost column or you've specified positive `gridx` and `gridy` values for the component.

`fill`

Used when the component's display area is larger than the component's requested size to determine whether and how to resize the component. Valid values (defined as `GridBagConstraints` constants) are `NONE` (the default), `HORIZONTAL` (make the component wide enough to fill its display area horizontally, but don't change its height), `VERTICAL` (make the component tall enough to fill its display area vertically, but don't change its width), and `BOTH` (make the component fill its display area entirely).

`ipadx`, `ipady`

Specifies the internal padding: how much to add to the minimum size of the component. The default value is zero. The width of the component will be at least its minimum width plus `ipadx*2` pixels, since the padding applies to both sides of the component. Similarly, the height of the component will be at least its minimum height plus `ipady*2` pixels.

`insets`

Specifies the external padding of the component -- the minimum amount of space between the component and the edges of its display area. The value is specified as an `Insets` object. By default, each component has no external padding.

`anchor`

Used when the component is smaller than its display area to determine where (within the area) to place the component. Valid values (defined as `GridBagConstraints` constants) are `CENTER` (the default), `NORTH`, `NORTHEAST`, `EAST`, `SOUTHEAST`, `SOUTH`, `SOUTHWEST`, `WEST`, and `NORTHWEST`.

`weightx`, `weighty`

Specifying weights is an art that can have a significant impact on the appearance of the components a `GridBagLayout` controls. Weights are used to determine how to distribute space among columns (`weightx`) and among rows (`weighty`); this is important for specifying resizing behavior.

Unless you specify at least one nonzero value for `weightx` or `weighty`, all the components clump together in the center of their container. This is because when the weight is 0.0 (the default), the `GridBagLayout` puts any extra space between its grid of cells and the edges of the container.

Generally weights are specified with 0.0 and 1.0 as the extremes: the numbers in between are used as necessary. Larger numbers indicate that the component's row or column should get more space. For each column, the weight is related to the highest `weightx` specified for a component within that column, with each multicolumn component's weight being split somehow between the columns the component is in. Similarly, each row's weight is related to the highest `weighty` specified for a component within that row. Extra space tends to go toward the rightmost column and bottom row.

The next section discusses constraints in depth, in the context of explaining how the example program works.

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Trail: Creating a GUI with JFC/Swing
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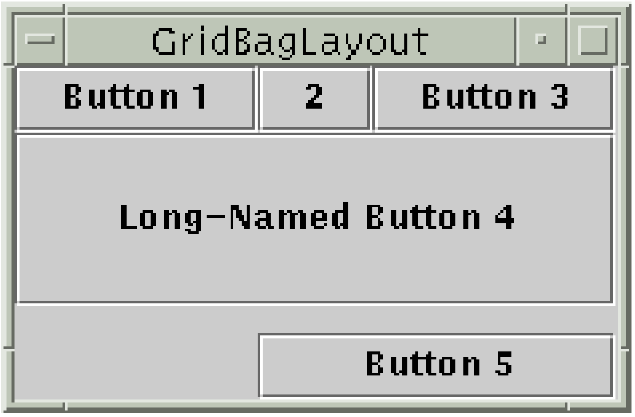
Run GridbagLayout Demo

Since you can't run the applet, here's a picture of it:

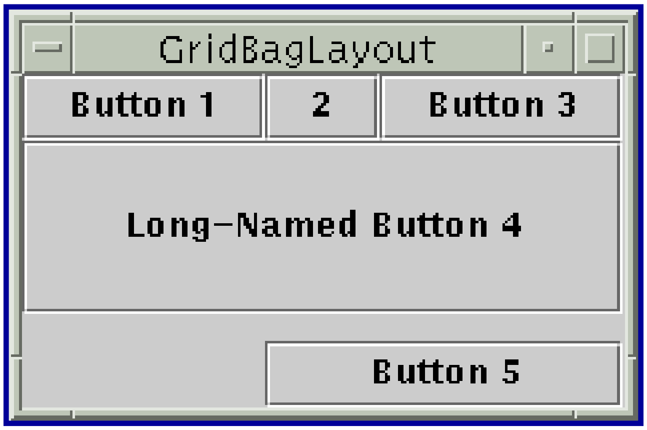


Note: Because the preceding applet uses the Swing 1.1 API, it requires Java Plug-in 1.1.2 or Java Plug-in 1.2. It won't work with Java Plug-in 1.1.1 or uncustomized 1.1 browsers. For more information about running applets in the tutorial, refer to About Our Examples. That page includes a section about Downloading Java Plug-in.

Trail: Creating a GUI with JFC/Swing
Lesson: Laying Out Components Within a Container

How to Use GridBagLayout: The Example Explained

Here, again, is the applet that shows a `GridBagLayout` in action.



This is a picture of the applet's GUI. To run the applet, click the picture. The applet will appear in a new browser window.

The following code creates the `GridBagLayout` and the components it manages. You can find the entire source file in `GridBagWindow.java`. The program runs either within an applet (with the help of `AppletButton`) or as an application.

```
JButton button;
Container contentPane = getContentPane();
GridBagLayout gridbag = new GridBagLayout();
GridBagConstraints c = new GridBagConstraints();
contentPane.setLayout(gridbag);
c.fill = GridBagConstraints.HORIZONTAL;

button = new JButton("Button 1");
c.weightx = 0.5;
c.gridx = 0;
c.gridy = 0;
gridbag.setConstraints(button, c);
contentPane.add(button);
```

```
button = new JButton("2");
c.gridx = 1;
c.gridy = 0;
gridbag.setConstraints(button, c);
contentPane.add(button);

button = new JButton("Button 3");
c.gridx = 2;
c.gridy = 0;
gridbag.setConstraints(button, c);
contentPane.add(button);

button = new JButton("Long-Named Button 4");
c.ipady = 40;      //make this component tall
c.weightx = 0.0;
c.gridwidth = 3;
c.gridx = 0;
c.gridy = 1;
gridbag.setConstraints(button, c);
contentPane.add(button);

button = new JButton("Button 5");
c.ipady = 0;       //reset to default
c.weighty = 1.0;   //request any extra vertical space
c.anchor = GridBagConstraints.SOUTH; //bottom of space
c.insets = new Insets(10,0,0,0);  //top padding
c.gridx = 1;       //aligned with button 2
c.gridwidth = 2;   //2 columns wide
c.gridy = 2;       //third row
gridbag.setConstraints(button, c);
contentPane.add(button);
```

This example uses one `GridBagConstraints` instance for all the components the `GridBagLayout` manages. Just before each component is added to the container, the code sets (or resets to default values) the appropriate instance variables in the `GridBagConstraints` object. It then uses the `setConstraints` method to record all the constraint values for that component.

For example, to make button 4 be extra tall, the example has this code:

```
c.ipady = 40;
```

And before setting the constraints of the next component, the code resets the value of `ipady` to the default:

```
c.ipady = 0;
```

For clarity, here's a table that shows all the constraints for each component the `GridBagLayout` handles. Values that aren't the default are marked in **bold font**. Values that are different from those in the previous table entry are marked in *italic font*.

Component	Constraints

All components	`ipadx = 0`
	`fill = GridBagConstraints.HORIZONTAL`

Button 1	`ipady = 0`
	`weightx = 0.5`
	`weighty = 0.0`
	`gridwidth = 1`
	`anchor = GridBagConstraints.CENTER`
	`insets = new Insets(0,0,0,0)`
	`gridx = 0`
	`gridy = 0`

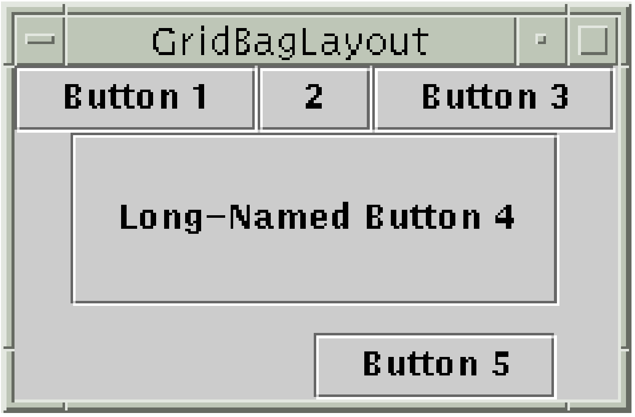
Button 2	**`weightx = 0.5`**
	`gridx = 1`
	`gridy = 0`

Button 3	**`weightx = 0.5`**
	`gridx = 2`
	`gridy = 0`

Button 4	*`ipady = 40`*
	`weightx = 0.0`
	`gridwidth = 3`
	`gridx = 0`
	`gridy = 1`

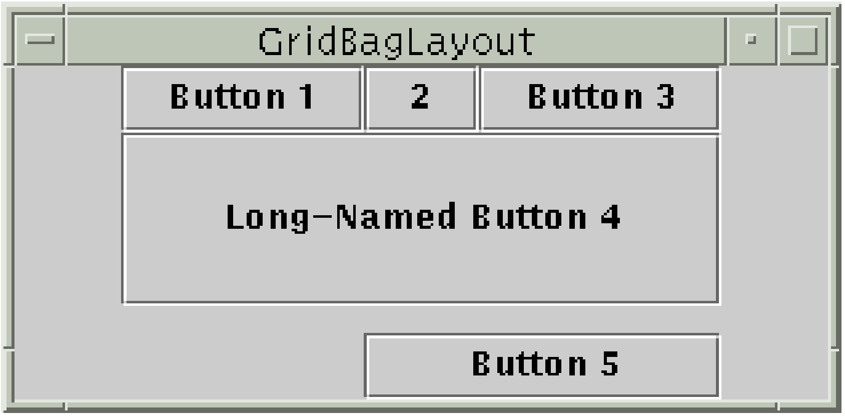
Button 5	*ipady = 0* weightx = 0.0 *weighty = 1.0* *anchor = GridBagConstraints.SOUTH* *insets = new Insets(10,0,0,0)* *gridwidth = 2* *gridx = 1* *gridy = 2*

All the components in this container are as wide as possible, given the cells that they occupy. The program accomplishes this by setting the `GridBagConstraints` `fill` instance variable to `GridBagConstraints.HORIZONTAL`, leaving it at that setting for all the components. If the program didn't specify the fill, the buttons would be at their natural width, like this:



This program has two components that span multiple columns (buttons 4 and 5). To make button 4 tall, we added internal padding (`ipady`) to it. To put space between buttons 4 and 5, we used insets to add a minimum of 10 pixels above button 5, and we made button 5 hug the south edge of its cell.

When you enlarge the window the program brings up, the columns grow proportionately. This is because each component in the first row, where each component is one column wide, has `weightx = 1.0`. The actual value of these components' `weightx` is unimportant. What matters is that all the components, and consequently, all the columns, have an equal weight that is greater than 0. If no component managed by the `GridBagLayout` had `weightx` set, then when the components' container was made wider, the components would stay clumped together in the center of the container, like this:



Note that if you enlarge the window, the last row is the only one that gets taller. This is because only button 5 has `weighty` greater than zero.

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```
/*
 * Swing version.
 */

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

public class GridBagWindow extends JFrame {
    boolean inAnApplet = true;
    final boolean shouldFill = true;
    final boolean shouldWeightX = true;

    public GridBagWindow() {
        JButton button;
        Container contentPane = getContentPane();
        GridBagLayout gridbag = new GridBagLayout();
        GridBagConstraints c = new GridBagConstraints();
        contentPane.setLayout(gridbag);
        if (shouldFill) {
            //natural height, maximum width
            c.fill = GridBagConstraints.HORIZONTAL;
        }

        button = new JButton("Button 1");
        if (shouldWeightX) {
            c.weightx = 0.5;
        }
        c.gridx = 0;
        c.gridy = 0;
        gridbag.setConstraints(button, c);
        contentPane.add(button);

        button = new JButton("2");
        c.gridx = 1;
        c.gridy = 0;
        gridbag.setConstraints(button, c);
        contentPane.add(button);

        button = new JButton("Button 3");
        c.gridx = 2;
        c.gridy = 0;
        gridbag.setConstraints(button, c);
        contentPane.add(button);

        button = new JButton("Long-Named Button 4");
        c.ipady = 40;      //make this component tall
        c.weightx = 0.0;
        c.gridwidth = 3;
        c.gridx = 0;
        c.gridy = 1;
        gridbag.setConstraints(button, c);
        contentPane.add(button);

        button = new JButton("Button 5");
        c.ipady = 0;       //reset to default
        c.weighty = 1.0;   //request any extra vertical space
        c.anchor = GridBagConstraints.SOUTH; //bottom of space
        c.insets = new Insets(10,0,0,0);  //top padding
        c.gridx = 1;       //aligned with button 2
        c.gridwidth = 2;   //2 columns wide
        c.gridy = 2;       //third row
        gridbag.setConstraints(button, c);
        contentPane.add(button);

        addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                if (inAnApplet) {
                    dispose();
                } else {
                    System.exit(0);
                }
            }
        });
    }

    public static void main(String args[]) {
        GridBagWindow window = new GridBagWindow();
        window.inAnApplet = false;

        window.setTitle("GridBagLayout");
        window.pack();
        window.setVisible(true);
    }
}
```

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Trail: Creating a GUI with JFC/Swing
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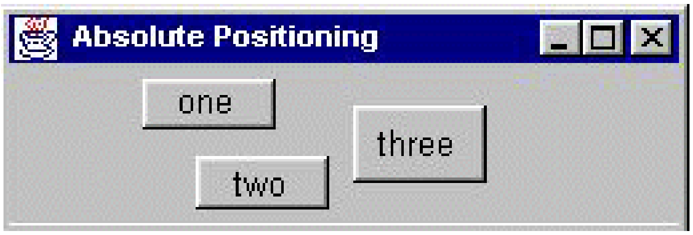
Run Absolute Positioning Demo

Since you can't run the applet, here's a picture of it:



Note: Because the preceding applet uses the Swing 1.1 API, it requires Java Plug-in 1.1.2 or Java Plug-in 1.2. It won't work with Java Plug-in 1.1.1 or uncustomized 1.1 browsers. For more information about running applets in the tutorial, refer to About Our Examples. That page includes a section about Downloading Java Plug-in.

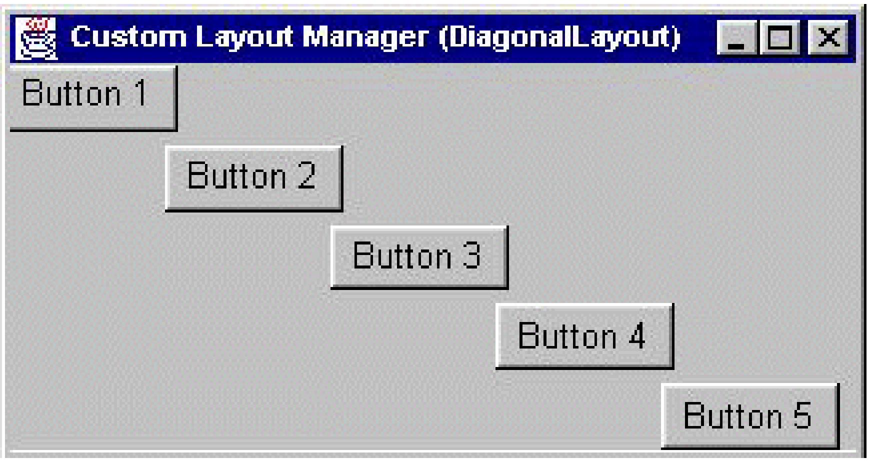
```java
/*
 * Swing version.
 */

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

public class NoneWindow extends JFrame {
    boolean inAnApplet = true;
    private boolean laidOut = false;
    private JButton b1, b2, b3;

    public NoneWindow() {
        Container contentPane = getContentPane();
        contentPane.setLayout(null);

        b1 = new JButton("one");
        contentPane.add(b1);
        b2 = new JButton("two");
        contentPane.add(b2);
        b3 = new JButton("three");
        contentPane.add(b3);

        Insets insets = contentPane.getInsets();
        b1.setBounds(25 + insets.left, 5 + insets.top, 75, 20);
        b2.setBounds(55 + insets.left, 35 + insets.top, 75, 20);
        b3.setBounds(150 + insets.left, 15 + insets.top, 75, 30);

        addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                if (inAnApplet) {
                    dispose();
                } else {
                    System.exit(0);
                }
            }
        });
    }

    public static void main(String args[]) {
        NoneWindow window = new NoneWindow();
        Insets insets = window.getInsets();
        window.inAnApplet = false;

        window.setTitle("Absolute Positioning");
        window.setSize(250 + insets.left + insets.right,
                       90 + insets.top + insets.bottom);
        window.setVisible(true);
    }
}
```

```
/*
 * 1.1 version.  For the 1.2 version, you would probably
 * change getSize() to getWidth() or getHeight().
 */

import java.awt.*;
import java.util.Vector;

public class DiagonalLayout implements LayoutManager {
    private int vgap;
    private int minWidth = 0, minHeight = 0;
    private int preferredWidth = 0, preferredHeight = 0;
    private boolean sizeUnknown = true;

    public DiagonalLayout() {
        this(5);
    }

    public DiagonalLayout(int v) {
        vgap = v;
    }

    /* Required by LayoutManager. */
    public void addLayoutComponent(String name, Component comp) {
    }

    /* Required by LayoutManager. */
    public void removeLayoutComponent(Component comp) {
    }

    private void setSizes(Container parent) {
        int nComps = parent.getComponentCount();
        Dimension d = null;

        //Reset preferred/minimum width and height.
        preferredWidth = 0;
        preferredHeight = 0;
        minWidth = 0;
        minHeight = 0;

        for (int i = 0; i < nComps; i++) {
            Component c = parent.getComponent(i);
            if (c.isVisible()) {
                d = c.getPreferredSize();

                if (i > 0) {
                    preferredWidth += d.width/2;
                    preferredHeight += vgap;
                } else {
                    preferredWidth = d.width;
                }
                preferredHeight += d.height;

                minWidth = Math.max(c.getMinimumSize().width,
                                    minWidth);
                minHeight = preferredHeight;
            }
        }
    }


    /* Required by LayoutManager. */
    public Dimension preferredLayoutSize(Container parent) {
        Dimension dim = new Dimension(0, 0);
        int nComps = parent.getComponentCount();

        setSizes(parent);

        //Always add the container's insets!
        Insets insets = parent.getInsets();
        dim.width = preferredWidth
                    + insets.left + insets.right;
        dim.height = preferredHeight
                     + insets.top + insets.bottom;

        sizeUnknown = false;

        return dim;
    }

    /* Required by LayoutManager. */
    public Dimension minimumLayoutSize(Container parent) {
        Dimension dim = new Dimension(0, 0);
        int nComps = parent.getComponentCount();

        //Always add the container's insets!
        Insets insets = parent.getInsets();
        dim.width = minWidth
                    + insets.left + insets.right;
        dim.height = minHeight
                     + insets.top + insets.bottom;

        sizeUnknown = false;

        return dim;
    }

    /* Required by LayoutManager. */
    /*
     * This is called when the panel is first displayed,
     * and every time its size changes.
     * Note: You CAN'T assume preferredLayoutSize or
     * minimumLayoutSize will be called -- in the case
     * of applets, at least, they probably won't be.
     */
    public void layoutContainer(Container parent) {
        Insets insets = parent.getInsets();
        int maxWidth = parent.getSize().width
                       - (insets.left + insets.right);
        int maxHeight = parent.getSize().height
                        - (insets.top + insets.bottom);
        int nComps = parent.getComponentCount();
        int previousWidth = 0, previousHeight = 0;
        int x = 0, y = insets.top;
        int rowh = 0, start = 0;
        int xFudge = 0, yFudge = 0;
        boolean oneColumn = false;

        // Go through the components' sizes, if neither
        // preferredLayoutSize nor minimumLayoutSize has
        // been called.
        if (sizeUnknown) {
            setSizes(parent);
        }
        if (maxWidth <= minWidth) {
            oneColumn = true;
        }

        if (maxWidth != preferredWidth) {
            xFudge = (maxWidth - preferredWidth)/(nComps - 1);
        }

        if (maxHeight > preferredHeight) {
            yFudge = (maxHeight - preferredHeight)/(nComps - 1);
        }

        for (int i = 0 ; i < nComps ; i++) {
            Component c = parent.getComponent(i);
            if (c.isVisible()) {
                Dimension d = c.getPreferredSize();

                 // increase x and y, if appropriate
                if (i > 0) {
                    if (!oneColumn) {
                        x += previousWidth/2 + xFudge;
                    }
                    y += previousHeight + vgap + yFudge;
                }

                // If x is too large,
                if ((!oneColumn) &&
                    (x + d.width) >
                    (parent.getSize().width - insets.right)) {
                    // reduce x to a reasonable number.
                    x = parent.getSize().width
                        - insets.bottom - d.width;
                }

                // If y is too large,
                if ((y + d.height)
                    > (parent.getSize().height - insets.bottom)) {
                    // do nothing.
                    // Another choice would be to do what we do to x.
                }

                // Set the component's size and position.
                c.setBounds(x, y, d.width, d.height);

                previousWidth = d.width;
                previousHeight = d.height;
            }
        }
    }

    public String toString() {
        String str = "";
        return getClass().getName() + "[vgap=" + vgap + str + "]";
    }
}
```

Trail: Creating a GUI with JFC/Swing
Lesson: Laying Out Components Within a Container

Run Custom Layout Manager Demo

Since you can't run the applet, here's a picture of it:



Note: Because the preceding applet uses the Swing 1.1 API, it requires Java Plug-in 1.1.2 or Java Plug-in 1.2. It won't work with Java Plug-in 1.1.1 or uncustomized 1.1 browsers. For more information about running applets in the tutorial, refer to About Our Examples. That page includes a section about Downloading Java Plug-in.

```
import java.awt.*;
import java.util.Hashtable;

/**
 * The <code>GraphPaperLayout</code> class is a layout manager that
 * lays out a container's components in a rectangular grid, similar
 * to GridLayout.  Unlike GridLayout, however, components can take
 * up multiple rows and/or columns.  The layout manager acts as a
 * sheet of graph paper.  When a component is added to the layout
 * manager, the location and relative size of the component are
 * simply supplied by the constraints as a Rectangle.
 * <p><code><pre>
 * import java.awt.*;
 * import java.applet.Applet;
 * public class ButtonGrid extends Applet {
 *     public void init() {
 *         setLayout(new GraphPaperLayout(new Dimension(5,5)));
 *         // Add a 1x1 Rect at (0,0)
 *         add(new Button("1"), new Rectangle(0,0,1,1));
 *         // Add a 2x1 Rect at (2,0)
 *         add(new Button("2"), new Rectangle(2,0,2,1));
 *         // Add a 1x2 Rect at (1,1)
 *         add(new Button("3"), new Rectangle(1,1,1,2));
 *         // Add a 2x2 Rect at (3,2)
 *         add(new Button("4"), new Rectangle(3,2,2,2));
 *         // Add a 1x1 Rect at (0,4)
 *         add(new Button("5"), new Rectangle(0,4,1,1));
 *         // Add a 1x2 Rect at (2,3)
 *         add(new Button("6"), new Rectangle(2,3,1,2));
 *     }
 * }
 * </pre></code>
 *
 * @author      Michael Martak
 */

public class GraphPaperLayout implements LayoutManager2 {
    int hgap;            //horizontal gap
    int vgap;            //vertical gap
    Dimension gridSize;  //grid size in logical units (n x m)
    Hashtable compTable; //constraints (Rectangles)

    /**
     * Creates a graph paper layout with a default of a 1 x 1 graph, with no
     * vertical or horizontal padding.
     */
    public GraphPaperLayout() {
        this(new Dimension(1,1));
    }

    /**
     * Creates a graph paper layout with the given grid size, with no vertical
     * or horizontal padding.
     */
    public GraphPaperLayout(Dimension gridSize) {
        this(gridSize, 0, 0);
    }

    /**
     * Creates a graph paper layout with the given grid size and padding.
     * @param gridSize size of the graph paper in logical units (n x m)
     * @param hgap horizontal padding
     * @param vgap vertical padding
     */
    public GraphPaperLayout(Dimension gridSize, int hgap, int vgap) {
        if ((gridSize.width <= 0) || (gridSize.height <= 0)) {
            throw new IllegalArgumentException(
                "dimensions must be greater than zero");
        }
        this.gridSize = new Dimension(gridSize);
        this.hgap = hgap;
        this.vgap = vgap;
        compTable = new Hashtable();
    }

    /**
     * @return the size of the graph paper in logical units (n x m)
     */
    public Dimension getGridSize() {
        return new Dimension( gridSize );
    }

    /**
     * Set the size of the graph paper in logical units (n x m)
     */
    public void setGridSize( Dimension d ) {
        setGridSize( d.width, d.height );
    }

    /**
     * Set the size of the graph paper in logical units (n x m)
     */
    public void setGridSize( int width, int height ) {
        gridSize = new Dimension( width, height );
    }

    public void setConstraints(Component comp, Rectangle constraints) {
        compTable.put(comp, new Rectangle(constraints));
    }

    /**
     * Adds the specified component with the specified name to
     * the layout.  This does nothing in GraphPaperLayout, since constraints
     * are required.
     */
    public void addLayoutComponent(String name, Component comp) {
    }

    /**
     * Removes the specified component from the layout.
     * @param comp the component to be removed
     */
    public void removeLayoutComponent(Component comp) {
        compTable.remove(comp);
    }

    /**
     * Calculates the preferred size dimensions for the specified
     * panel given the components in the specified parent container.
     * @param parent the component to be laid out
     *
     * @see #minimumLayoutSize
     */
    public Dimension preferredLayoutSize(Container parent) {
        return getLayoutSize(parent, true);
    }

    /**
     * Calculates the minimum size dimensions for the specified
     * panel given the components in the specified parent container.
     * @param parent the component to be laid out
     * @see #preferredLayoutSize
     */
    public Dimension minimumLayoutSize(Container parent) {
        return getLayoutSize(parent, false);
    }

    /**
     * Algorithm for calculating layout size (minimum or preferred).
     * <p>
     * The width of a graph paper layout is the largest cell width
     * (calculated in <code>getLargestCellSize()</code> times the number of
     * columns, plus the horizontal padding times the number of columns
     * plus one, plus the left and right insets of the target container.
     * <p>
     * The height of a graph paper layout is the largest cell height
     * (calculated in <code>getLargestCellSize()</code> times the number of
     * rows, plus the vertical padding times the number of rows
     * plus one, plus the top and bottom insets of the target container.
     *
     * @param parent the container in which to do the layout.
     * @param isPreferred true for calculating preferred size, false for
     *                    calculating minimum size.
     * @return the dimensions to lay out the subcomponents of the specified
     *         container.
     * @see java.awt.GraphPaperLayout#getLargestCellSize
     */
    protected Dimension getLayoutSize(Container parent, boolean isPreferred) {
        Dimension largestSize = getLargestCellSize(parent, isPreferred);
        Insets insets = parent.getInsets();
        largestSize.width = ( largestSize.width * gridSize.width ) +
            ( hgap * ( gridSize.width + 1 ) ) + insets.left + insets.right;
        largestSize.height = ( largestSize.height * gridSize.height ) +
            ( vgap * ( gridSize.height + 1 ) ) + insets.top + insets.bottom;
        return largestSize;
    }

    /**
     * Algorithm for calculating the largest minimum or preferred cell size.
     * <p>
     * Largest cell size is calculated by getting the applicable size of each
     * component and keeping the maximum value, dividing the component's width
     * by the number of columns it is specified to occupy and dividing the
     * component's height by the number of rows it is specified to occupy.
     *
     * @param parent the container in which to do the layout.
     * @param isPreferred true for calculating preferred size, false for
     *                    calculating minimum size.
     * @return the largest cell size required.
     */
    protected Dimension getLargestCellSize(Container parent,
                                           boolean isPreferred) {
        int ncomponents = parent.getComponentCount();
        Dimension maxCellSize = new Dimension(0,0);
        for ( int i = 0; i < ncomponents; i++ ) {
            Component c = parent.getComponent(i);
            Rectangle rect = (Rectangle)compTable.get(c);
            if ( c != null && rect != null ) {
                Dimension componentSize;
                if ( isPreferred ) {
                    componentSize = c.getPreferredSize();
                } else {
                    componentSize = c.getMinimumSize();
                }
                // Note: rect dimensions are already asserted to be > 0 when the
                // component is added with constraints
                maxCellSize.width = Math.max(maxCellSize.width,
                    componentSize.width / rect.width);
                maxCellSize.height = Math.max(maxCellSize.height,
                    componentSize.height / rect.height);
            }
        }
        return maxCellSize;
    }

    /**
     * Lays out the container in the specified container.
     * @param parent the component which needs to be laid out
     */
    public void layoutContainer(Container parent) {
        synchronized (parent.getTreeLock()) {
            Insets insets = parent.getInsets();
            int ncomponents = parent.getComponentCount();

            if (ncomponents == 0) {
                return;
            }

            // Total parent dimensions
            Dimension size = parent.getSize();
            int totalW = size.width - (insets.left + insets.right);
            int totalH = size.height - (insets.top + insets.bottom);

            // Cell dimensions, including padding
            int totalCellW = totalW / gridSize.width;
            int totalCellH = totalH / gridSize.height;

            // Cell dimensions, without padding
            int cellW = (totalW - ( (gridSize.width + 1) * hgap) )
                    / gridSize.width;
            int cellH = (totalH - ( (gridSize.height + 1) * vgap) )
                    / gridSize.height;

            for ( int i = 0; i < ncomponents; i++ ) {
                Component c = parent.getComponent(i);
                Rectangle rect = (Rectangle)compTable.get(c);
                if ( rect != null ) {
                    int x = insets.left + ( totalCellW * rect.x ) + hgap;
                    int y = insets.top + ( totalCellH * rect.y ) + vgap;
                    int w = ( cellW * rect.width ) - hgap;
                    int h = ( cellH * rect.height ) - vgap;
                    c.setBounds(x, y, w, h);
                }
            }
        }
    }
    // LayoutManager2 /////////////////////////////////////////////////////////

    /**
     * Adds the specified component to the layout, using the specified
     * constraint object.
     * @param comp the component to be added
     * @param constraints  where/how the component is added to the layout.
     */
    public void addLayoutComponent(Component comp, Object constraints) {
        if (constraints instanceof Rectangle) {
            Rectangle rect = (Rectangle)constraints;
            if ( rect.width <= 0 || rect.height <= 0 ) {
                throw new IllegalArgumentException(
                    "cannot add to layout: rectangle must have positive width and height");
            }
            if ( rect.x < 0 || rect.y < 0 ) {
                throw new IllegalArgumentException(
                    "cannot add to layout: rectangle x and y must be >= 0");
            }
            setConstraints(comp, rect);
        } else if (constraints != null) {
            throw new IllegalArgumentException(
                "cannot add to layout: constraint must be a Rectangle");
        }
    }

    /**
     * Returns the maximum size of this component.
     * @see java.awt.Component#getMinimumSize()
     * @see java.awt.Component#getPreferredSize()
     * @see LayoutManager
     */
    public Dimension maximumLayoutSize(Container target) {
        return new Dimension(Integer.MAX_VALUE, Integer.MAX_VALUE);
    }

    /**
     * Returns the alignment along the x axis.  This specifies how
     * the component would like to be aligned relative to other
     * components.  The value should be a number between 0 and 1
     * where 0 represents alignment along the origin, 1 is aligned
     * the furthest away from the origin, 0.5 is centered, etc.
     */
    public float getLayoutAlignmentX(Container target) {
        return 0.5f;
    }

    /**
     * Returns the alignment along the y axis.  This specifies how
     * the component would like to be aligned relative to other
     * components.  The value should be a number between 0 and 1
     * where 0 represents alignment along the origin, 1 is aligned
     * the furthest away from the origin, 0.5 is centered, etc.
     */
    public float getLayoutAlignmentY(Container target) {
        return 0.5f;
    }

    /**
     * Invalidates the layout, indicating that if the layout manager
     * has cached information it should be discarded.
     */
    public void invalidateLayout(Container target) {
        // Do nothing
    }
}
```

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

public class GraphPaperTest extends JPanel {
    public GraphPaperTest() {
        setLayout(new GraphPaperLayout(new Dimension(5,5)));

        // Add a 1x1 Rect at (0,0)
        add(new JButton("1"), new Rectangle(0,0,1,1));

        // Add a 2x1 Rect at (2,0)
        add(new JButton("2"), new Rectangle(2,0,2,1));

        // Add a 1x2 Rect at (1,1)
        add(new JButton("3"), new Rectangle(1,1,1,2));

        // Add a 2x2 Rect at (3,2)
        add(new JButton("4"), new Rectangle(3,2,2,2));

        // Add a 1x1 Rect at (0,4)
        add(new JButton("5"), new Rectangle(0,4,1,1));

        // Add a 1x2 Rect at (2,3)
        add(new JButton("6"), new Rectangle(2,3,1,2));
    }

    public static void main(String[] args) {
        JFrame f = new JFrame("GraphPaperTest");
        f.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });

        f.getContentPane().add(new GraphPaperTest(),
                               BorderLayout.CENTER);
        f.pack();
        f.setVisible(true);
    }
}
```

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

import java.util.*;

public class SplitPaneDemo2 extends JFrame
                            implements ListSelectionListener {
    private JLabel label;

    public SplitPaneDemo2() {
        super("SplitPaneDemo2");

        //Create an instance of SplitPaneDemo
        SplitPaneDemo splitPaneDemo = new SplitPaneDemo();
        JSplitPane top = splitPaneDemo.getSplitPane();
        splitPaneDemo.getImageList().addListSelectionListener(this);

        //XXXX: Bug #4131528, borders on nested split panes accumulate.
        //Workaround: Set the border on any split pane within
        //another split pane to null. Components within nested split
        //panes need to have their own border for this to work well.
        top.setBorder(null);

        //Create a regular old label
        label = new JLabel("Click on an image name in the list.",
                           JLabel.CENTER);

        //Create a split pane and put "top" (a split pane)
        //and JLabel instance in it.
        JSplitPane splitPane = new JSplitPane(JSplitPane.VERTICAL_SPLIT,
                                              top, label);
        splitPane.setOneTouchExpandable(true);
        splitPane.setDividerLocation(180);

        //Provide minimum sizes for the two components in the split pane
        top.setMinimumSize(new Dimension(100, 50));
        label.setMinimumSize(new Dimension(100, 30));

        //Add the split pane to this frame
        getContentPane().add(splitPane);
    }

    public void valueChanged(ListSelectionEvent e) {
        if (e.getValueIsAdjusting())
            return;

        JList theList = (JList)e.getSource();
        if (theList.isSelectionEmpty()) {
            label.setText("Nothing selected.");
        } else {
            int index = theList.getSelectedIndex();
            label.setText("Selected image number " + index);
        }
    }

    public static void main(String s[]) {
        JFrame frame = new SplitPaneDemo2();

        frame.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {System.exit(0);}
        });
        frame.pack();
        frame.setVisible(true);
    }
}
```

Trail: Creating a GUI with JFC/Swing
Lesson: Converting to Swing

Solving Common Conversion Problems

Problem: I'm seeing weird problems that seem either intermittent or dependent on timing.

- Does your main thread modify the GUI after it's visible? If so, either move the code so that it executes before the GUI is shown, or execute the GUI-modifying code in the event-dispatching thread.
- Does your program have multiple threads or query/modify the GUI in response to messages from other programs? If so, you should ensure that all GUI-related code is executed in the event-dispatching thread.
- If your program is an applet that implements the `stop` and `start` methods, make sure that any GUI work performed by those methods is executed in the event-dispatching thread.
- The preceding suggestions assume that your problem is caused by code that isn't thread safe. See Threads and Swing◆ for information about thread safety, and How to Use Threads◆ for information about API you can use to help make your programs thread safe.

Problem: My applet/dialog/frame is blank.

- Does the applet/frame/dialog perform custom drawing? If so, you need to move the custom drawing code out of the `JApplet`/`JDialog`/`JFrame` subclass and into a custom component that you add to the content pane. For more information, see Step 8 of the 12-step conversion plan.
- Do you either set the applet/frame/dialog's content pane or add components to the existing content pane? You should. See Using Top-Level Containers◆ for more information.

Problem: In the Swing version of my program, the list/text component is missing its scroll bars.

- Swing list and text components don't have automatic scroll bars. Instead, you need to add the list or text component to a scroll pane, as described in Component-Specific Conversion Tips.

Problem: Although I'm using the same grid bag layout code as before, one scrollable component is tiny.

- Make sure you set constraints on the scroll pane, rather than on its client.

Problem: I'm not getting the kinds of events I expected for the Swing component I'm using.

- Read both the conversion tips and how-to section for the component you're using. Chances are that the relevant event details are covered in those sections.
- If you think the problem might be a bug, search the bug database at the Java Developer Connection: http://developer.java.sun.com/◆ .

If you can't find your problem on this page, check Solving Common Component Problems ◆.

Start of Tutorial > Start of Trail > Start of Lesson

Search
Feedback Form

```
/*
 * Shows how to specify alignments when you're using
 * a BoxLayout for components with maximum sizes
 * and different default alignments.
 */

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

public class AlignmentDemo extends JFrame {
    public AlignmentDemo() {
        super("AlignmentDemo");

        JTabbedPane tabbedPane = new JTabbedPane();

        JPanel buttonRow = new JPanel();
        //Use default FlowLayout.
        buttonRow.add(createButtonRow(false));
        buttonRow.add(createButtonRow(true));
        tabbedPane.addTab("Altering alignments", buttonRow);

        JPanel labelAndComponent = new JPanel();
        //Use default FlowLayout.
        labelAndComponent.add(createLabelAndComponent(false));
        labelAndComponent.add(createLabelAndComponent(true));
        tabbedPane.addTab("X alignment mismatch", labelAndComponent);

        JPanel buttonAndComponent = new JPanel();
        //Use default FlowLayout.
        buttonAndComponent.add(createYAlignmentExample(false));
        buttonAndComponent.add(createYAlignmentExample(true));
        tabbedPane.addTab("Y alignment mismatch", buttonAndComponent);

        //Add tabbedPane to this frame.
        getContentPane().add(tabbedPane, BorderLayout.CENTER);
    }

    protected JPanel createButtonRow(boolean changeAlignment) {
        JButton button1 = new JButton("A JButton",
                                      new ImageIcon("images/middle.gif"));
        button1.setVerticalTextPosition(AbstractButton.BOTTOM);
        button1.setHorizontalTextPosition(AbstractButton.CENTER);

        JButton button2 = new JButton("Another JButton",
                                      new ImageIcon("images/geek-cght.gif"));
        button2.setVerticalTextPosition(AbstractButton.BOTTOM);
        button2.setHorizontalTextPosition(AbstractButton.CENTER);

        String title;
        if (changeAlignment) {
            title = "Desired";
            button1.setAlignmentY(BOTTOM_ALIGNMENT);
            button2.setAlignmentY(BOTTOM_ALIGNMENT);
        } else {
            title = "Default";
        }

        JPanel pane = new JPanel();
        pane.setBorder(BorderFactory.createTitledBorder(title));
        pane.setLayout(new BoxLayout(pane, BoxLayout.X_AXIS));
        pane.add(button1);
        pane.add(button2);
        return pane;
    }

    protected JPanel createLabelAndComponent(boolean doItRight) {
        JPanel pane = new JPanel();

        JComponent component = new JPanel();
        Dimension size = new Dimension(150,100);
        component.setMaximumSize(size);
        component.setPreferredSize(size);
        component.setMinimumSize(size);
        TitledBorder border = new TitledBorder(
                                  new LineBorder(Color.black),
                                  "A JPanel",
                                  TitledBorder.CENTER,
                                  TitledBorder.BELOW_TOP);
        border.setTitleColor(Color.black);
        component.setBorder(border);

        JLabel label = new JLabel("This is a JLabel");
        String title;
        if (doItRight) {
            title = "Matched";
            label.setAlignmentX(CENTER_ALIGNMENT);
        } else {
            title = "Mismatched";
        }

        pane.setBorder(BorderFactory.createTitledBorder(title));
        pane.setLayout(new BoxLayout(pane, BoxLayout.Y_AXIS));
        pane.add(label);
        pane.add(component);
        return pane;
    }

    protected JPanel createYAlignmentExample(boolean doItRight) {
        JPanel pane = new JPanel();
        String title;

        JComponent component1 = new JPanel();
        Dimension size = new Dimension(100, 50);
        component1.setMaximumSize(size);
        component1.setPreferredSize(size);
        component1.setMinimumSize(size);
        TitledBorder border = new TitledBorder(
                                  new LineBorder(Color.black),
                                  "A JPanel",
                                  TitledBorder.CENTER,
                                  TitledBorder.BELOW_TOP);
        border.setTitleColor(Color.black);
        component1.setBorder(border);

        JComponent component2 = new JPanel();
        size = new Dimension(100, 50);
        component2.setMaximumSize(size);
        component2.setPreferredSize(size);
        component2.setMinimumSize(size);
        border = new TitledBorder(new LineBorder(Color.black),
                                  "A JPanel",
                                  TitledBorder.CENTER,
                                  TitledBorder.BELOW_TOP);
        border.setTitleColor(Color.black);
        component2.setBorder(border);

        if (doItRight) {
            title = "Matched";
        } else {
            component1.setAlignmentY(TOP_ALIGNMENT);
            title = "Mismatched";
        }

        pane.setBorder(BorderFactory.createTitledBorder(title));
        pane.setLayout(new BoxLayout(pane, BoxLayout.X_AXIS));
        pane.add(component1);
        pane.add(component2);
        return pane;
    }

    public static void main(String[] args) {
        JFrame frame = new AlignmentDemo();
        frame.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });

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

```
/* XXX: Not exactly like GridLayout because everything's left aligned. */

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

/**
 * An example of using SpringLayout to layout a grid. This behaves exactly
 * like <code>GridLayout</code>, with the exception that it only adjusts
 * the size to the min/pref. If given more/less space it doesn't adjust the
 * sizes.
 */
public class Grid {
    public static void main(String[] args) {
        JPanel panel = new JPanel();
        SpringLayout layout = new SpringLayout();

        panel.setLayout(layout);
        for (int counter = 0; counter < 9; counter++) {
            JLabel label = new JLabel(Integer.toString(counter));

            if (counter == 4) {
                label.setFont(label.getFont().deriveFont(Font.PLAIN, 22f));
            }
            panel.add(label);
        }
        alignGrid(panel, 3, 3, 5, 5, 5, 5);

        // The preferred size is dictated by the east/south edges of
        // Constraint associated with the Container. Setting the
        // east/south constraint will effectively dicate what the preferred
        // size is. If you do not install constraints for the east/south
        // side, the preferred size will be 0x0.
        Component lastComponent = panel.getComponent(8);
        SpringLayout.Constraints pCons = layout.getConstraints(panel);
        pCons.setConstraint("South", layout.getConstraint("South",
                                                          lastComponent));
        pCons.setConstraint("East", layout.getConstraint("East",
                                                          lastComponent));

        JFrame frame = new JFrame("Test");
        frame.getContentPane().add(panel);
        frame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
        frame.pack();
        frame.show();
    }

    /**
     * <code>alignGrid</code> aligns the first <code>rows</code> *
     * <code>cols</code> <code>Components</code> of <code>parent</code> in
     * a grid. Each <code>Component</code> will be sized to the max
     * of the preferred width/height of the <code>Component</code>s.
     *
     * @param rows Number of rows
     * @param cols Number of columns
     * @param initialX X location to start the grid at
     * @param initialY Y location to start the grid at
     * @param xPad x padding between cells
     * @param yPad y padding between cells
     */
    private static void alignGrid(Container parent, int rows, int cols,
                                  int initialX, int initialY, int xPad,
                                  int yPad) {
```

```
        SpringLayout layout = (SpringLayout)parent.getLayout();
        Spring xPadSpring = Spring.constant(xPad);
        Spring yPadSpring = Spring.constant(yPad);
        Spring initialXSpring = Spring.constant(initialX);
        Spring initialYSpring = Spring.constant(initialY);
        int max = rows * cols;

        // Calc Springs that are the max of the width/height so that all
        // cells have the same size.
        Spring maxWidthSpring = layout.getConstraints(parent.getComponent(0)).
                                    getWidth();
        Spring maxHeightSpring = layout.getConstraints(parent.getComponent(0)).
                                    getWidth();
        for (int counter = 1; counter < max; counter++) {
            SpringLayout.Constraints cons = layout.getConstraints(
                                            parent.getComponent(counter));

            maxWidthSpring = Spring.max(maxWidthSpring, cons.getWidth());
            maxHeightSpring = Spring.max(maxHeightSpring, cons.getHeight());
        }

        // Apply the new width/height Spring. This will force all the
        // components to have the same size. Alternatively if we didn't
        // want all the Components to have the same size, but still use
        // the max to calc the grid, we could use the
        // maxWidthSpring/maxHeightSpring below instead of the 'East' or
        // 'South' constraint.
        for (int counter = 0; counter < max; counter++) {
            SpringLayout.Constraints cons = layout.getConstraints(
                                            parent.getComponent(counter));

            cons.setWidth(maxWidthSpring);
            cons.setHeight(maxHeightSpring);
        }

        // Then adjust the x/y constraints of all the cells so that they
        // are aligned in a grid.
        SpringLayout.Constraints lastCons = null;
        SpringLayout.Constraints lastRowCons = null;
        for (int counter = 0; counter < max; counter++) {
            SpringLayout.Constraints cons = layout.getConstraints(
                                            parent.getComponent(counter));

            if (counter % cols > 0) {
                cons.setX(Spring.sum(lastCons.getConstraint("East"),
                                     xPadSpring));
            }
            else {
                lastRowCons = lastCons;
                cons.setX(initialXSpring);
            }
            if (counter / cols > 0) {
                cons.setY(Spring.sum(lastRowCons.getConstraint("South"),
                                     yPadSpring));
            }
            else {
                cons.setY(initialYSpring);
            }
            lastCons = cons;
        }
    }
}
```

```java
/*
 * FlowLayout converted to be SpringLayout.
 */

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

public class SpringWindow1 extends JFrame {

    public SpringWindow1() {
        Container contentPane = getContentPane();
        contentPane.setLayout(new SpringLayout());

        contentPane.add(new JButton("Button 1"));
        contentPane.add(new JButton("2"));
        contentPane.add(new JButton("Button 3"));
        contentPane.add(new JButton("Long-Named Button 4"));
        contentPane.add(new JButton("Button 5"));

        setDefaultCloseOperation(EXIT_ON_CLOSE);
    }

    public static void main(String args[]) {
        SpringWindow1 window = new SpringWindow1();

        window.setTitle("SpringLayout");
        window.pack();
        window.setVisible(true);
    }
}
```

```java
/*
 * FlowLayout converted to be SpringLayout.
 */

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

public class SpringWindow2 extends JFrame {

    public SpringWindow2() {
        Container contentPane = getContentPane();
        contentPane.setLayout(new SpringLayout());

        contentPane.add(new JButton("Button 1"));
        contentPane.add(new JButton("2"));
        contentPane.add(new JButton("Button 3"));
        contentPane.add(new JButton("Long-Named Button 4"));
        contentPane.add(new JButton("Button 5"));

        doLayout(contentPane);

        setDefaultCloseOperation(EXIT_ON_CLOSE);
    }

    public void doLayout(Container parent) {
        //assert parent.getLayout() instanceof SpringLayout

        Component[] components = parent.getComponents();
        SpringLayout layout = (SpringLayout)parent.getLayout();
        Spring xPad = Spring.constant(5);
        Spring ySpring = Spring.constant(5);
        Spring xSpring = xPad;

        // Make every component 5 pixels away from the component to its left.
        for (int i = 0; i < components.length; i++) {
            SpringLayout.Constraints cons = layout.getConstraints(components[i]);
            cons.setX(xSpring);
            xSpring = Spring.sum(xPad, cons.getConstraint("East")); //use proxy instead?

            cons.setY(ySpring);
        }
    }

    public static void main(String args[]) {
        SpringWindow2 window = new SpringWindow2();

        window.setTitle("SpringLayout");
        window.pack();
        window.setVisible(true);
    }
}
```

```
/*
 * FlowLayout converted to be SpringLayout.
 */

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

public class SpringWindow3 extends JFrame {

    public SpringWindow3() {
        Container contentPane = getContentPane();
        contentPane.setLayout(new SpringLayout());

        contentPane.add(new JButton("Button 1"));
        contentPane.add(new JButton("2"));
        contentPane.add(new JButton("Button 3"));
        contentPane.add(new JButton("Long-Named Button 4"));
        contentPane.add(new JButton("Button 5"));

        doLayout(contentPane);

        setDefaultCloseOperation(EXIT_ON_CLOSE);
    }

    public void doLayout(Container parent) {
        //assert parent.getLayout() instanceof SpringLayout

        Component[] components = parent.getComponents();
        SpringLayout layout = (SpringLayout)parent.getLayout();
        Spring xPad = Spring.constant(5);
        Spring ySpring = Spring.constant(5);
        Spring xSpring = xPad;
        Spring maxHeightSpring = Spring.constant(0);

        // Make every component 5 pixels away from the component to its left.
        for (int i = 0; i < components.length; i++) {
            SpringLayout.Constraints cons = layout.getConstraints(components[i]);

            cons.setX(xSpring);
            xSpring = Spring.sum(xPad, cons.getConstraint("East")); //use proxy instead?

            cons.setY(ySpring);
            maxHeightSpring = Spring.max(maxHeightSpring,
                                         cons.getConstraint("South"));
        }

        // Make the window's preferred size depend on its components.
        SpringLayout.Constraints pCons = layout.getConstraints(parent);

        // This doesn't work.  Why not?
        //pCons.setWidth(xSpring);
        //pCons.setHeight(Spring.sum(maxHeightSpring, ySpring));

        // Neither does this (just checking).
        // pCons.setConstraint("Width", xSpring);
        // pCons.setConstraint("Height", Spring.sum(maxHeightSpring, ySpring));

        // This works.  Why?
        pCons.setConstraint("East", xSpring);
        pCons.setConstraint("South", Spring.sum(maxHeightSpring, ySpring));

    }
    public static void main(String args[]) {
        SpringWindow3 window = new SpringWindow3();

        window.setTitle("SpringLayout");
        window.pack();
        window.setVisible(true);
    }
}
```

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

/**
 * An example of using SpringLayout to create a forms-type layout.
 */
public class Form {
    public static void main(String[] args) {
        int numPairs = 5;
        JLabel[] labels = new JLabel[numPairs];
        JTextField[] textFields = new JTextField[numPairs];

        // Create the labels (first column).
        labels[0] = new JLabel("Name:");
        labels[1] = new JLabel("Phone:");
        labels[2] = new JLabel("Fax:");
        labels[2].setFont(labels[2].getFont().deriveFont(Font.PLAIN, 24f));
        labels[3] = new JLabel("Email:");
        labels[4] = new JLabel("Address:");

        // Create the text fields (second column).
        for (int i = 0; i < numPairs; i++) {
            textFields[i] = new JTextField(10);
        }

        // For accessibility's sake, associate each label with its text field.
        for (int i = 0; i < numPairs; i++) {
            labels[i].setLabelFor(textFields[i]);
        }

        // Call the method that does all the layout work.
        Container container = createForm(labels, textFields, 5, 5, 5, 5);

        // Set up the frame and show it.
        JFrame frame = new JFrame("Form");
        frame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
        frame.setContentPane(container);
        frame.pack();
        frame.setVisible(true);
    }

    /**
     * Creates a container that uses a SpringLayout to present
     * pairs of components. The resulting layout is similar to
     * that of a form.  For example:
     * <pre>
     * LLLL  RRR
     * LL    RRR
     * L     RRR
     * LLLLL RRR
     * </pre>
     * where the max of the widths of the L (left) components dictates the
     * x location of the R (right) components. The width of the Rs is
     * locked to that of the container so that all extra space is given
     * to them.
     *
     * @param leftComponents the components in the left column
     *                (the first item of each pair);
     *                typically these are labels
     *
     * @param rightComponents the components in the right column
     *                  (the second item of each pair);
     *                  typically these are text fields
     *
     */
    private static Container createForm(Component[] leftComponents,
                                        Component[] rightComponents,
                                        int initialX, int initialY,
                                        int xPad, int yPad) {
        SpringLayout layout = new SpringLayout();
        int numRows = Math.max(leftComponents.length, rightComponents.length);

        // The constant springs we'll use to enforce spacing.
        Spring xSpring = Spring.constant(initialX);
        Spring ySpring = Spring.constant(initialY);
        Spring xPadSpring = Spring.constant(xPad);
        Spring yPadSpring = Spring.constant(yPad);
        Spring negXPadSpring = Spring.constant(-xPad);

        // Create the container and add the components to it.
        JPanel parent = new JPanel(layout);
        for (int i = 0; i < numRows; i++) {
            parent.add(leftComponents[i]);
            parent.add(rightComponents[i]);
        }

        // maxEastSpring will contain the highest min/pref/max values
        // for the right edges of the components in the first column
        // (i.e. the largest X coordinate in a first-column component).
        // We use layout.getConstraint instead of layout.getConstraints
        // (layout.getConstraints(comp).getConstraint("East"))
        // because we need a proxy -- not the current Spring.
        // Otherwise, it won't take the revised X position into account
        // for the initial layout.
        Spring maxEastSpring = layout.getConstraint("East", leftComponents[0]);
        for (int row = 1; row < numRows; row++) {
            maxEastSpring = Spring.max(maxEastSpring,
                                       layout.getConstraint("East",
                                                            leftComponents[row]));
        }

        // Lay out each pair. The left column's x is constrained based on
        // the passed x location. The y for each component in the left column
        // is the max of the previous pair's height. In the right column, x is
        // constrained by the max width of the left column (maxEastSpring),
        // y is constrained as in the left column, and the width is
        // constrained to be the x location minus the width of the
        // parent container. This last constraint makes the right column fill
        // all extra horizontal space.
        SpringLayout.Constraints lastConsL = null;
        SpringLayout.Constraints lastConsR = null;
        Spring parentWidth = layout.getConstraint("East", parent);
        Spring rWidth = null;
        Spring maxHeightSpring = null;
        Spring rX = Spring.sum(maxEastSpring, xPadSpring); //right col location
        Spring negRX = Spring.minus(rX); //negative of rX

        for (int row = 0; row < numRows; row++) {
            SpringLayout.Constraints consL = layout.getConstraints(
                                             leftComponents[row]);
            SpringLayout.Constraints consR = layout.getConstraints(
                                             rightComponents[row]);
            consL.setX(xSpring);
            consR.setX(rX);

            rWidth = consR.getWidth(); //get the spring that tracks this
                                       //component's min/pref/max width after
                                       //setting the X spring but before
                                       //setting the width spring (to avoid
                                       //a circularity); we really only
                                       //need to do this once for the
                                       //textfield case, since they have the
                                       //same size info
                                       //XXX To account for other cases,
                                       //XXX we should probably take the max
                                       //XXX of the widths.
                                       //This is used to set the container's
                                       //width after this loop.
            consR.setWidth(Spring.sum(Spring.sum(parentWidth, negRX),
                                      negXPadSpring));
            if (row == 0) {
                consL.setY(ySpring);
                consR.setY(ySpring);
                maxHeightSpring = Spring.sum(ySpring,
                                             Spring.max(consL.getHeight(),
                                                        consR.getHeight()));
            } else {  // row > 0
                Spring y = Spring.sum(Spring.max(
                                          lastConsL.getConstraint("South"),
                                          lastConsR.getConstraint("South")),
                                      yPadSpring);

                consL.setY(y);
                consR.setY(y);
                maxHeightSpring = Spring.sum(yPadSpring,
                                             Spring.sum(maxHeightSpring,
                                                        Spring.max(
                                                            consL.getHeight(),
                                                            consR.getHeight())));
            }
            lastConsL = consL;
            lastConsR = consR;
        }  // end of for loop

        // Wire up the east/south of the container so that the its preferred
        // size is valid.  The east spring is the distance to the right
        // column (rX) + the right component's width (rWidth) + the final
        // padding (xPadSpring).
        // The south side is maxHeightSpring + the final padding (yPadSpring).
        SpringLayout.Constraints consParent = layout.getConstraints(parent);
        consParent.setConstraint("East",
                                 Spring.sum(rX, Spring.sum(rWidth,
                                                           xPadSpring)));
        consParent.setConstraint("South",
                                 Spring.sum(maxHeightSpring, yPadSpring));

        return parent;
    }
}
```

```
import java.awt.GridLayout;
import java.awt.event.WindowAdapter;
import java.awt.event.WindowEvent;
import javax.swing.JLabel;
import javax.swing.JPanel;
import javax.swing.JFrame;
import javax.swing.ImageIcon;

public class LabelDemo extends JPanel {
    JLabel label1, label2, label3;

    public LabelDemo() {
        ImageIcon icon = new ImageIcon("images/middle.gif",
                                       "a pretty but meaningless splat");
        setLayout(new GridLayout(3,1));     //3 rows, 1 column

        label1 = new JLabel("Image and Text",
                            icon,
                            JLabel.CENTER);
        //Set the position of the text, relative to the icon:
        label1.setVerticalTextPosition(JLabel.BOTTOM);
        label1.setHorizontalTextPosition(JLabel.CENTER);

        label2 = new JLabel("Text-Only Label");

        label3 = new JLabel(icon);

        //Add labels to the JBufferedPane.
        add(label1);
        add(label2);
        add(label3);
    }

    public static void main(String[] args) {
        /*
         * Create a window.  Use JFrame since this window will include
         * lightweight components.
         */
        JFrame frame = new JFrame("LabelDemo");

        frame.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });

        frame.setContentPane(new LabelDemo());
        frame.pack();
        frame.setVisible(true);
    }
}
```

```
import javax.swing.*; import java.awt.*; import java.awt.event.*; public class HtmlDemo extends JPanel
{ JLabel theLabel; JTextArea htmlTextArea; public HtmlDemo() { String initialText = "\n" + "Color and
font test:\n" + "
```

\n" + "

- red\n" + "
- blue\n" + "
- green\n" + "
- small\n" + "
- large\n" + "
- *italic*\n" + "
- **bold**\n" + "

```
\n"; htmlTextArea = new JTextArea(10, 20); htmlTextArea.setText(initialText); JScrollPane scrollPane =
new JScrollPane(htmlTextArea); JButton changeTheLabel = new JButton("Change the label");
changeTheLabel.setMnemonic(KeyEvent.VK_C); changeTheLabel.addActionListener(new
ActionListener() { public void actionPerformed(ActionEvent e) { try {
theLabel.setText(htmlTextArea.getText()); } catch (Throwable exc) { JOptionPane.showMessageDialog(
HtmlDemo.this, "The HTML you specified was invalid."); } } });
changeTheLabel.setAlignmentX(Component.CENTER_ALIGNMENT); theLabel = new
JLabel(initialText) { public Dimension getPreferredSize() { return new Dimension(200, 200); } public
Dimension getMinimumSize() { return new Dimension(200, 200); } public Dimension
getMaximumSize() { return new Dimension(200, 200); } };
theLabel.setVerticalAlignment(SwingConstants.CENTER);
theLabel.setHorizontalAlignment(SwingConstants.CENTER); JPanel leftPanel = new JPanel();
leftPanel.setLayout(new BoxLayout(leftPanel, BoxLayout.Y_AXIS));
leftPanel.setBorder(BorderFactory.createCompoundBorder( BorderFactory.createTitledBorder( "Edit the
HTML, then click the button"), BorderFactory.createEmptyBorder(10,10,10,10)));
leftPanel.add(scrollPane); leftPanel.add(Box.createRigidArea(new Dimension(0,10)));
leftPanel.add(changeTheLabel); JPanel rightPanel = new JPanel(); rightPanel.setLayout(new
BoxLayout(rightPanel, BoxLayout.Y_AXIS));
rightPanel.setBorder(BorderFactory.createCompoundBorder( BorderFactory.createTitledBorder("A label
with HTML"), BorderFactory.createEmptyBorder(10,10,10,10))); rightPanel.add(theLabel);
setLayout(new BoxLayout(this, BoxLayout.X_AXIS));
setBorder(BorderFactory.createEmptyBorder(10,10,10,10)); add(leftPanel);
add(Box.createRigidArea(new Dimension(10,0))); add(rightPanel); } public static void main(String
args[]) { JFrame f = new JFrame("HtmlDemo"); f.addWindowListener(new WindowAdapter() { public
void windowClosing(WindowEvent e) { System.exit(0); } }); f.getContentPane().add(new HtmlDemo());
f.pack(); f.setVisible(true); } }
```

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

public class ComboBoxDemo extends JPanel {
    JLabel picture;

    public ComboBoxDemo() {
        String[] petStrings = { "Bird", "Cat", "Dog", "Rabbit", "Pig" };

        // Create the combo box, select the pig
        JComboBox petList = new JComboBox(petStrings);
        petList.setSelectedIndex(4);
        petList.addActionListener(new ActionListener() {
            public void actionPerformed(ActionEvent e) {
                JComboBox cb = (JComboBox)e.getSource();
                String petName = (String)cb.getSelectedItem();
                picture.setIcon(new ImageIcon("images/" + petName + ".gif"));
            }
        });

        // Set up the picture
        picture = new JLabel(new ImageIcon("images/" +
                                   petStrings[petList.getSelectedIndex()] +
                                   ".gif"));
        picture.setBorder(BorderFactory.createEmptyBorder(10,0,0,0));

        // The preferred size is hard-coded to be the width of the
        // widest image and the height of the tallest image + the border.
        // A real program would compute this.
        picture.setPreferredSize(new Dimension(177, 122+10));

        // Layout the demo
        setLayout(new BorderLayout());
        add(petList, BorderLayout.NORTH);
        add(picture, BorderLayout.SOUTH);
        setBorder(BorderFactory.createEmptyBorder(20,20,20,20));
    }

    public static void main(String s[]) {
        JFrame frame = new JFrame("ComboBoxDemo");

        frame.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {System.exit(0);}
        });

        frame.setContentPane(new ComboBoxDemo());
        frame.pack();
        frame.setVisible(true);
    }
}
```

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

public class ComboBoxDemo2 extends JPanel {
    static JFrame frame;
    JLabel result;
    String currentPattern;

    public ComboBoxDemo2() {
        String[] patternExamples = {
                 "dd MMMMM yyyy",
                 "dd.MM.yy",
                 "MM/dd/yy",
                 "yyyy.MM.dd G 'at' hh:mm:ss z",
                 "EEE, MMM d, ''yy",
                 "h:mm a",
                 "H:mm:ss:SSS",
                 "K:mm a,z",
                 "yyyy.MMMMM.dd GGG hh:mm aaa"
                 };

        currentPattern = patternExamples[0];

        // Set up the UI for selecting a pattern.
        JLabel patternLabel1 = new JLabel("Enter the pattern string or");
        JLabel patternLabel2 = new JLabel("select one from the list:");

        JComboBox patternList = new JComboBox(patternExamples);
        patternList.setEditable(true);
        patternList.setAlignmentX(Component.LEFT_ALIGNMENT);
        patternList.addActionListener(new ActionListener() {
            public void actionPerformed(ActionEvent e) {
                JComboBox cb = (JComboBox)e.getSource();
                String newSelection = (String)cb.getSelectedItem();
                currentPattern = newSelection;
                reformat();
            }
        });

        // Create the UI for displaying result
        JLabel resultLabel = new JLabel("Current Date/Time", JLabel.LEFT);
        result = new JLabel(" ");
        result.setForeground(Color.black);
        result.setBorder(BorderFactory.createCompoundBorder(
             BorderFactory.createLineBorder(Color.black),
             BorderFactory.createEmptyBorder(5,5,5,5)
        ));

        // Lay out everything
        JPanel patternPanel = new JPanel();
        patternPanel.setLayout(new BoxLayout(patternPanel, BoxLayout.Y_AXIS));
        patternPanel.add(patternLabel1);
        patternPanel.add(patternLabel2);
        patternPanel.add(patternList);

        JPanel resultPanel = new JPanel();
        resultPanel.setLayout(new GridLayout(0, 1));
        resultPanel.add(resultLabel);
        resultPanel.add(result);

        setLayout(new BoxLayout(this, BoxLayout.Y_AXIS));
        patternPanel.setAlignmentX(Component.LEFT_ALIGNMENT);
        resultPanel.setAlignmentX(Component.LEFT_ALIGNMENT);

        add(patternPanel);
        add(Box.createRigidArea(new Dimension(0, 10)));
        add(resultPanel);

        setBorder(BorderFactory.createEmptyBorder(10,10,10,10));

        reformat();
    } // constructor

    /** Formats and displays today's date. */
    public void reformat() {
        Date today = new Date();
        SimpleDateFormat formatter =
           new SimpleDateFormat(currentPattern);
        try {
            String dateString = formatter.format(today);
            result.setForeground(Color.black);
            result.setText(dateString);
        } catch (IllegalArgumentException iae) {
            result.setForeground(Color.red);
            result.setText("Error: " + iae.getMessage());
        }
    }

    public static void main(String s[]) {
         frame = new JFrame("ComboBoxDemo2");
         frame.addWindowListener(new WindowAdapter() {
             public void windowClosing(WindowEvent e) {
                 System.exit(0);
             }
         });

         frame.setContentPane(new ComboBoxDemo2());
         frame.pack();
         frame.setVisible(true);
    }
}
```

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

public class CustomComboBoxDemo extends JPanel {
    ImageIcon images[];

    public CustomComboBoxDemo() {
        //Load the pet images
        String[] petStrings = {"Bird", "Cat", "Dog", "Rabbit", "Pig"};
        images = new ImageIcon[petStrings.length];
        for (int i = 0; i < petStrings.length; i++) {
            images[i] = new ImageIcon("images/" + petStrings[i] + ".gif");
            images[i].setDescription(petStrings[i]);
        }

        // Create the combo box
        JComboBox petList = new JComboBox(images);
        ComboBoxRenderer renderer= new ComboBoxRenderer();
        renderer.setPreferredSize(new Dimension(200, 130));
        petList.setRenderer(renderer);
        petList.setMaximumRowCount(3);

        // Layout the demo
        setLayout(new BorderLayout());
        add(petList, BorderLayout.NORTH);
        setBorder(BorderFactory.createEmptyBorder(20,20,20,20));
    }

    public static void main(String s[]) {
        JFrame frame = new JFrame("CustomComboBoxDemo");
        frame.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {System.exit(0);}
        });

        frame.getContentPane().add(new CustomComboBoxDemo(),
                                   BorderLayout.CENTER);
        frame.pack();
        frame.setVisible(true);
    }

    class ComboBoxRenderer extends JLabel implements ListCellRenderer {
        public ComboBoxRenderer() {
            setOpaque(true);
            setHorizontalAlignment(CENTER);
            setVerticalAlignment(CENTER);
        }

        public Component getListCellRendererComponent(
                                           JList list,
                                           Object value,
                                           int index,
                                           boolean isSelected,
                                           boolean cellHasFocus) {
            if (isSelected) {
                setBackground(list.getSelectionBackground());
                setForeground(list.getSelectionForeground());
            } else {
                setBackground(list.getBackground());
                setForeground(list.getForeground());
            }
            ImageIcon icon = (ImageIcon)value;
            setText(icon.getDescription());
            setIcon(icon);
            return this;
        }
    }
}
```

Overview of the Swing API

The Swing package is part of the Java^{TM} Foundation Classes (JFC) in the Java platform. The JFC encompasses a group of features to help people build GUIs; Swing provides all the components from buttons to split panes and tables.

Note: "Swing" was the code name of the project that developed the new components. Although it's an unofficial name, it's frequently used to refer to the new components and related API. It's immortalized in the package names for the Swing API, which begin with `javax.swing`.

The Swing package was first available as an add-on to JDK 1.1. Prior to the introduction of the Swing package, the Abstract Window Toolkit (AWT) components provided all the UI components in the JDK 1.0 and 1.1 platforms. Although the Java 2 Platform still supports the AWT components, we strongly encourage you to use Swing components instead. You can identify Swing components because their names start with `J`. The AWT button class, for example, is named `Button`, whereas the Swing button class is named `JButton`. In addition, the AWT components are in the `java.awt` package, whereas the Swing components are in the `javax.swing` package.

As a rule, programs should not use "heavyweight" AWT components alongside Swing components. Heavyweight components include all the ready-to-use AWT components, such as `Menu` and `ScrollPane`, and all components that inherit from the AWT `Canvas` and `Panel` classes. When Swing components (and all other "lightweight" components) overlap with heavyweight components, the heavyweight component is always painted on top.

Compiling and Running Swing Programs

To compile and run your Swing programs, we recommend that you use the latest release of the Java 2 Platform downloaded from http://java.sun.com/j2se/. You can run Swing applets in any browser that has the appropriate version of the Java Plug-in.

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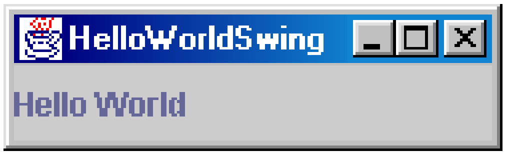
Your First Swing Program

This is the first of several sections that teach Swing basics by looking at example code. This section examines the code for a simple program, `HelloWorldSwing`. The examples in the following sections will become progressively more difficult as we introduce and explain more features.

Here's a snapshot of the `HelloWorldSwing` program:



And here's the code for `HelloWorldSwing`:

```
import javax.swing.*;

public class HelloWorldSwing {
    public static void main(String[] args) {
        JFrame frame = new JFrame("HelloWorldSwing");
        final JLabel label = new JLabel("Hello World");
        frame.getContentPane().add(label);

        frame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
        frame.pack();
        frame.setVisible(true);
    }
}
```

This is one of the simplest Swing applications you can write. It doesn't do much, but the code demonstrates the basic code in every Swing program:

1. Import the pertinent packages.
2. Set up a top-level container.

The first line imports the main Swing package:

```
import javax.swing.*;
```

This is the only package that `HelloWorldSwing` needs. However, most Swing programs also need to import two AWT packages:

```
import java.awt.*;
import java.awt.event.*;
```

These packages are required because Swing components use the AWT infrastructure, including the AWT event model. The event model governs how a component reacts to events, such as button clicks and mouse motion. You'll learn more about events in the upcoming section Handling Events◆.

Every program with a Swing GUI must contain at least one top-level Swing container. A top-level Swing container provides the support that Swing components need to perform their painting and event handling. There are three top-level Swing containers: `JFrame`, `JDialog`, and (for applets) `JApplet`. Each `JFrame` object implements a single main window, and each `JDialog` implements a secondary window (a window that's dependent on another window). Each `JApplet` object implements an applet's display area within a browser window.

The `HelloWorldSwing` example has only one top-level container, a `JFrame`. A frame, implemented as an instance of the `JFrame` class, is a window that has decorations, such as a border, a title, and buttons for iconifying and closing the window. Applications with a GUI typically use at least one frame.

Here is the code that sets up and shows the frame:

```
JFrame frame = new JFrame("HelloWorldSwing");
...
frame.pack();
frame.setVisible(true);
```

`HelloWorldSwing` also has one component, a label that reads "Hello World." These two lines of code construct and then add the component to the frame:

```
final JLabel label = new JLabel("Hello World");
frame.getContentPane().add(label);
```

To close the window when the close button ☒ is clicked, we include this code in our `HelloWorldSwing` program:

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

`JFrame` provides the `setDefaultCloseOperation` method to configure the default action for when the user clicks the close button. For single-window applications, most likely you want the application to exit. The `EXIT_ON_CLOSE` constant lets you specify this, as of version 1.3 of the Java 2 Platform. If you're using an earlier version of the platform, you implement an event listener to exit when the window closes:

```
frame.addWindowListener(new WindowAdapter() {
    public void windowClosing(WindowEvent e) {
        System.exit(0);
    }
});
```

The next example will go into more details on event listeners.

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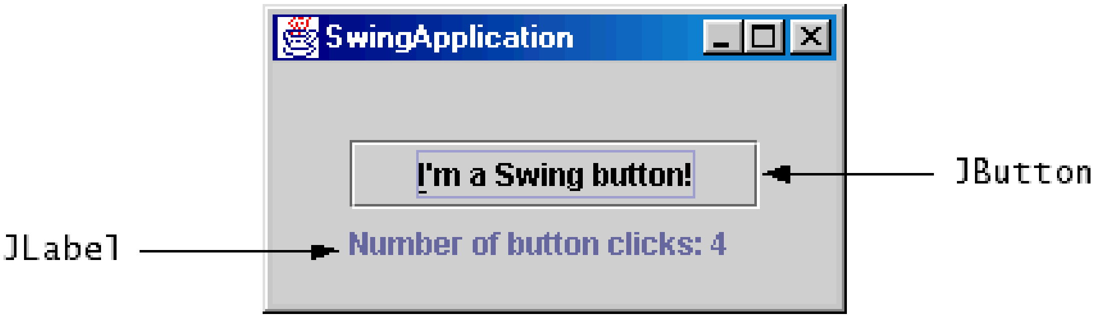
Example Two: `SwingApplication`

Topics illustrated in this example:

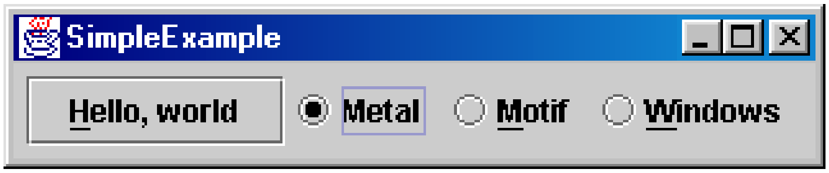
- Look and Feel
- Setting Up Buttons and Labels
- Handling Events
- Adding Borders Around Components

Let's look at another simple program, `SwingApplication`. Each time the user clicks the button (`JButton`), the label (`JLabel`) is updated.

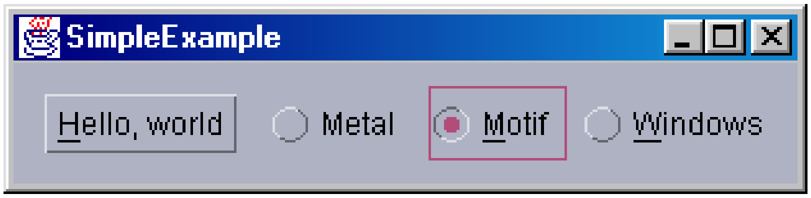


Look and Feel

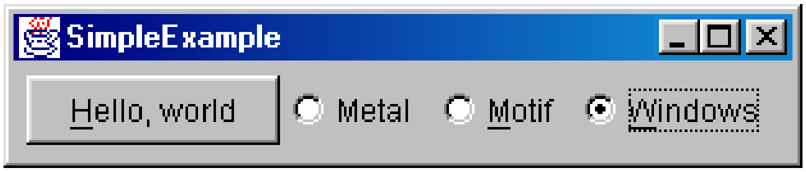
The following figure shows three views of a GUI that uses Swing components. Each picture shows the same program, `SimpleExample`, but with a different look and feel.



Java look and feel



CDE/Motif look and feel



Windows look and feel

Swing allows you to specify which look and feel your program uses--Java look and feel, CDE/Motif look and feel, Windows look and feel, and so on. The code in boldface type in the following snippet shows you how `SwingApplication` specifies its look and feel:

```
public static void main(String[] args) {
    try {
        UIManager.setLookAndFeel(
            UIManager.getCrossPlatformLookAndFeelClassName());
    } catch (Exception e) { }
    ...// Create and show the GUI...
}
```

The preceding code essentially says, "I don't care whether the user has chosen a look and feel-use the cross-platform look and feel (the Java look and feel)."

Setting Up Buttons and Labels

Like most GUIs, the `SwingApplication` GUI contains a button and a label. (Unlike most GUIs, that's about all that `SwingApplication` contains.) Here's the code that initializes the button:

```
JButton button = new JButton("I'm a Swing button!");
button.setMnemonic('i');
button.addActionListener(...create an action listener...);
```

The first line creates the button. The second sets the letter "`i`" as the mnemonic that the user can use to simulate a click of the button. For example, in the Java look and feel, typing `Alt-i` results in a button click. The third line registers an event handler for the button click, as discussed later in this section.

Here's the code that initializes and manipulates the label:

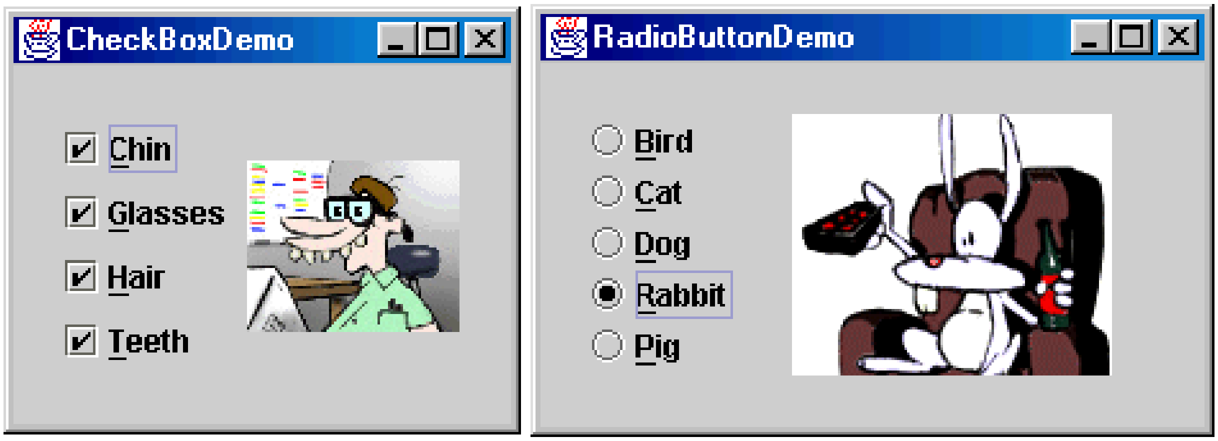
```
.../// where instance variables are declared:
private static String labelPrefix = "Number of button clicks: ";
private int numClicks = 0;

.../// in GUI initialization code:
final JLabel label = new JLabel(labelPrefix + "0    ");
...
label.setLabelFor(button);

.../// in the event handler for button clicks:
label.setText(labelPrefix + numClicks);
```

The preceding code is pretty straightforward, except for the line that invokes the `setLabelFor` method. That code exists solely to hint to assistive technologies that the label describes the button.

Now that you know how to set up buttons, you also know how to set up check boxes and radio buttons, as they all inherit from the `AbstractButton` class. Check boxes are similar to radio buttons, but by convention their selection models are different. Any number of check boxes in a group-none, some, or all-can be selected. On the other hand, only one button can be selected from a group of radio buttons. The following figures show screenshots of two programs that use check boxes and radio buttons.



Caption: As you'd expect, the `CheckBoxDemo` application shows the use of check boxes, and the `RadioButtonDemo` application shows the use of radio buttons.

You'll get a chance to take a closer look at radio buttons in the section Example Five:

VoteDialog◆.

Handling Events

Every time the user types a character or pushes a mouse button, an event occurs. Any object can be notified of the event. All the object has to do is implement the appropriate interface and be registered as an event listener on the appropriate event source.

How to Implement an Event Handler

Every event handler requires three pieces of code:

1. In the declaration for the event handler class, one line of code specifies that the class either implements a listener interface or extends a class that implements a listener interface. For example:

   ```
   public class MyClass implements ActionListener {
   ```

2. Another line of code registers an instance of the event handler class as a listener on one or more components. For example:

   ```
   someComponent.addActionListener(instanceOfMyClass);
   ```

3. In the event handler class, a few lines of code implement the methods in the listener interface. For example:

   ```
   public void actionPerformed(ActionEvent e) {
       ...//code that reacts to the action...
   }
   ```

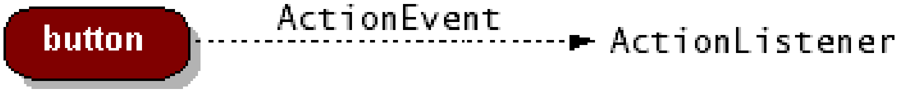
Event handlers can be instances of any class. Often an event handler that has only a few lines of code is implemented using an *anonymous inner class*--an unnamed class defined inside of another class. Anonymous inner classes can be confusing at first, but once you're used to them, they make the code clearer by keeping the implementation of an event handler close to where the event handler is registered.

`SwingApplication` has two event handlers. One handles window closing (window events); the other handles button clicks (action events). We've already seen the window-closing code. Here is the code that handles button clicks in the `SwingApplication`:

```
button.addActionListener(new ActionListener() {
    public void actionPerformed(ActionEvent e) {
        numClicks++;
```

```
                label.setText(labelPrefix + numClicks);
            }
        });
```

In general, to detect when the user clicks an on-screen button (or does the keyboard equivalent), a program must have an object that implements the `ActionListener` interface. The program must register this object as an action listener on the button (the event source), using the `addActionListener` method. When the user clicks the on-screen button, the button fires an action event. This results in the invocation of the action listener's `actionPerformed` method (the only method in the `ActionListener` interface). The single argument to the method is an `ActionEvent` object that gives information about the event and its source.



Swing components can generate many kinds of events. The following table lists a few examples.

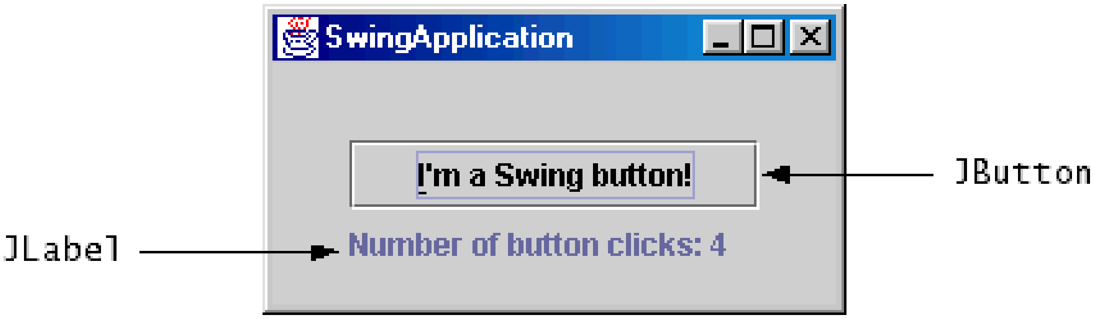
Examples of Events and Their Associated Event Listeners	
Act that Results in the Event	**Listener Type**
User clicks a button, presses Return while typing in a text field, or chooses a menu item	`ActionListener`
User closes a frame (main window)	`WindowListener`
User presses a mouse button while the cursor is over a component	`MouseListener`
User moves the mouse over a component	`MouseMotionListener`
Component becomes visible	`ComponentListener`
Component gets the keyboard focus	`FocusListener`
Table or list selection changes	`ListSelectionListener`

To learn more about how to detect events from a particular component, refer to each component's how-to section in Using Swing Components◆.

Note: Event-handling code executes in an single thread, the event-dispatching thread. This ensures that each event handler finishes execution before the next one executes. For instance, the `actionPerformed` method in the preceding example executes in the event-dispatching thread. Painting code also executes in the event-dispatching thread. Therefore, while the `actionPerformed` method is executing, the program's GUI is frozen--it won't repaint or respond to mouse clicks. See the section Threads and Swing for more information.

Adding Borders Around Components

If you take another look at the snapshot of `SwingApplication`, you'll notice that there is extra space surrounding the `JPanel` on all four edges.



Here is the code that adds a border to the panel:

```
pane.setBorder(BorderFactory.createEmptyBorder(
                                30, //top
                                30, //left
                                10, //bottom
                                30) //right
                                );
```

This border simply provides some empty space around the panel's contents--30 extra pixels on the top, left, and right, and 10 extra pixels on the bottom. Borders are a feature that `JPanel` inherits from the `JComponent` class.

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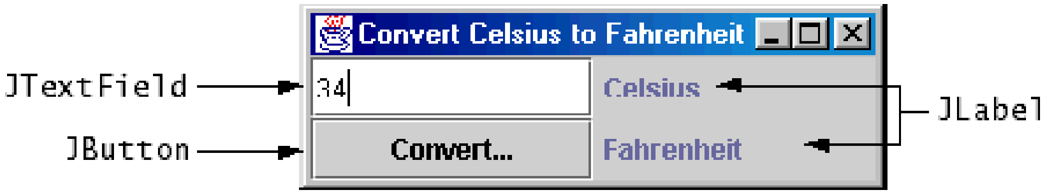
Example Three: `CelsiusConverter`

Topics illustrated in this example:

- Adding HTML
- Adding an Icon

Our next example, `CelsiusConverter`, does something that's somewhat useful: It is a simple conversion tool. The user enters a temperature in degrees Celsius and clicks the `Convert...` button, and a label displays the equivalent in degrees Fahrenheit.



Let's examine the code to see how `CelsiusConverter` parses the number entered in the `JTextField`. First, here's the code that sets up the `JTextField`:

```
JTextField tempCelsius = null;
...
tempCelsius = new JTextField(5);
```

The integer argument passed in the `JTextField` constructor, `5` in the example, indicates the number of columns in the field. This number is used along with metrics provided by the current font to calculate the field's preferred width. This number does not limit how many character the user can enter.

We want to handle the button-click event, so we add an event listener to the button.

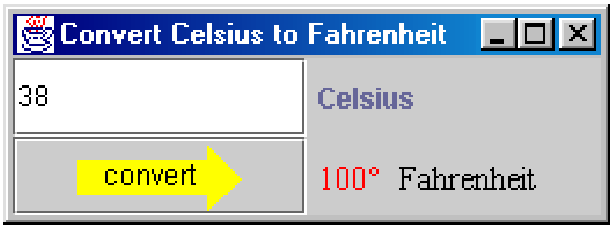
```
JButton convertTemp;
...
convertTemp.addActionListener(this);
...
public void actionPerformed(ActionEvent event) {
    // Parse degrees Celsius as a double and convert to Fahrenheit.
    int tempFahr = (int)((Double.parseDouble(tempCelsius.getText()))
                         * 1.8 + 32);
    fahrenheitLabel.setText(tempFahr + " Fahrenheit");
}
```

The `getText` method is called on the text field, `tempCelsius`, to retrieve the data within it. Next, the `parseDouble` method parses the text as a double before converting the temperature and casting the result to an integer. Finally, the setText method is called on the `fahrenheitLabel` to display the converted temperature. All this code is found in the event handler for the button, as the conversion happens only once the button is clicked.

> **Note:** You can make a `JButton` be the default button. At most one button in a top-level container can be the default button. The default button typically has a highlighted appearance and acts clicked whenever the top-level container has the keyboard focus and the user presses the `Return` or `Enter` key. The exact implementation depends on the look and feel. You set the default button by invoking the `setDefaultButton` method on a top-level container's root pane:
>
> ```
> //In the constructor for a JDialog subclass:
> getRootPane().setDefaultButton(setButton);
> ```

Adding HTML

You can use HTML to specify the text on some Swing components, such as buttons and labels. We can spice up the `CelsiusConverter` program by adding HTML text to the `fahrenheitLabel` and adding an image to the `convertTemp` button. The revised program is `CelsiusConverter2`.



First, let's look at how we specify the HTML tags for the `fahrenheitLabel`. As you can see from this code, the temperature (`tempFahr`) is displayed one of three different colors, depending on how hot or cold the converted temperature is:

```
// Set fahrenheitLabel to new value and font color based on temperature.
if (tempFahr <= 32) {
    fahrenheitLabel.setText("<html><font color=blue>" + tempFahr
                            + "&#176  Fahrenheit </font></html>");

} else if (tempFahr <= 80) {
    fahrenheitLabel.setText("<html><font color=green>" + tempFahr
                            + "&#176  Fahrenheit </font></html>");

} else {
    fahrenheitLabel.setText("<html><font color=red>" + tempFahr
                            + "&#176  Fahrenheit </font></html>");
}
```

To add HTML code to the label, simply put the `<HTML>` tag at the beginning of a string, and then use any valid HTML code in the remainder of the string. Using HTML can be useful for varying the text font or color within a button and for adding line breaks. To display the degree symbol, we use the HTML code `&#176`.

Note: If the string is to be all one size and color, you don't have to use HTML. You can call the `setFont`◆ method to specify the font of any component.

Warning: Don't use HTML in buttons unless you're absolutely sure that the program is running in a release that supports this feature. In releases that don't support HTML text, such as Swing 1.1, putting HTML in a button results in one ugly-looking button whose label starts (not surprisingly) with `<HTML>`.

Adding an Icon

Some Swing components can be decorated with an *icon*--a fixed-size image. A Swing icon is an object that adheres to the `Icon` interface. Swing provides a particularly useful implementation of the `Icon` interface: `ImageIcon`. `ImageIcon` paints an icon from a GIF or a JPEG image. Here's the code that adds the arrow graphic to the `convertTemp` button:

```
ImageIcon icon = new ImageIcon("images/convert.gif",
                               "Convert temperature");
...
convertTemp = new JButton(icon);
```

The first argument of the `ImageIcon` constructor specifies the file to load, relative to the directory containing the application's class file. The second argument provides a description of the icon that assistive technologies can use.

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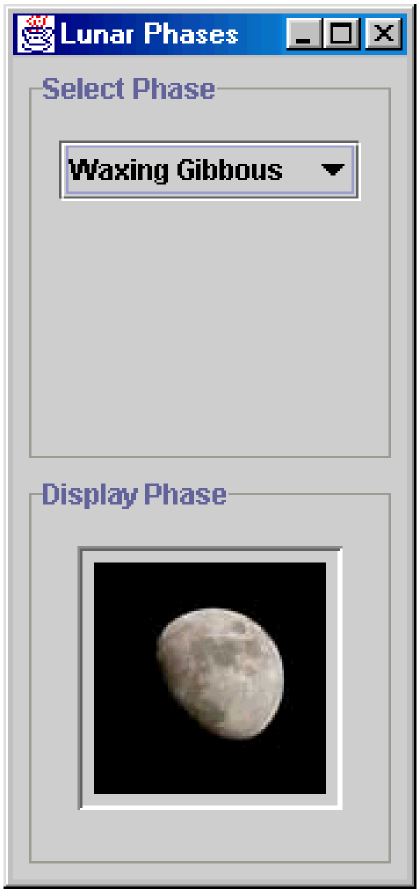
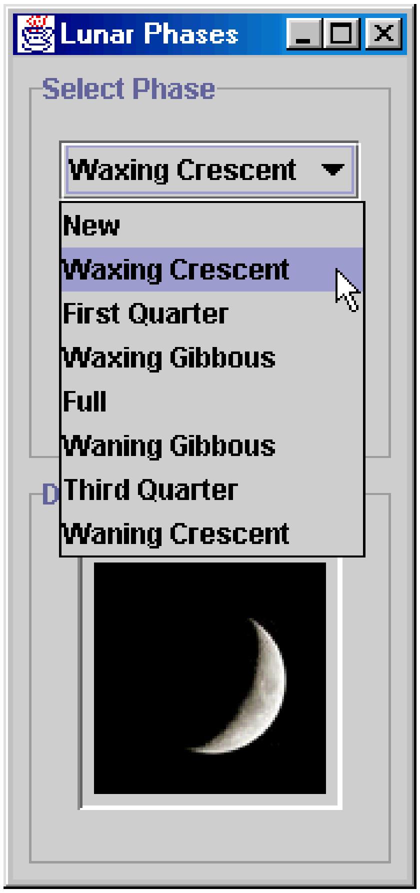
Example Four: `LunarPhases`

Topics covered in this example include:

- Compound Borders
- Combo Boxes
- Loading Multiple Images

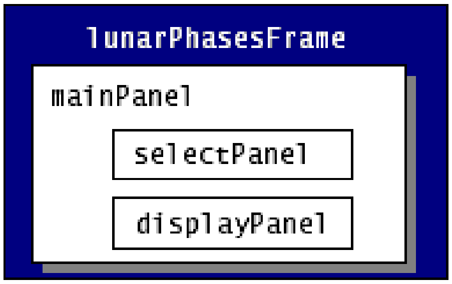
This next example, `LunarPhases`, is a more complicated example of how to use images in your application. As an added bonus, you'll also see how to implement combo boxes. Here are two pictures of the `LunarPhases` application:





In this program, the user chooses the lunar phase from the combo box, and the selected phase of the moon is shown in the lower panel. This is the first example we've seen that uses multiple panels to group components. Let's take a quick look at how we set up these panels.

`LunarPhases` has three panels, as shown in the following figure.



In the following code in the `LunarPhases` constructor, we construct all three panels and add the two subpanels (`selectPanel` and `displayPanel`) to `mainPanel`.

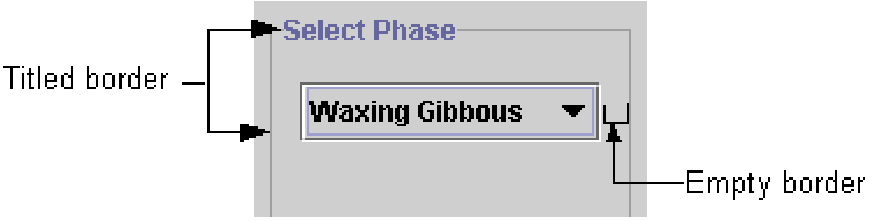
```
    // Create the phase selection and display panels.
    selectPanel = new JPanel();
    displayPanel = new JPanel();

    // Add various widgets to the subpanels.
    addWidgets();

    // Create the main panel to contain the two subpanels.
    mainPanel = new JPanel();

    mainPanel.setLayout(new GridLayout(2,1,5,5));
    mainPanel.setBorder(BorderFactory.createEmptyBorder(5,5,5,5));

    // Add the select and display panels to the main panel.
    mainPanel.add(selectPanel);
    mainPanel.add(displayPanel);
```

When we add the subpanels to the main panel, how can we make sure that they're added in the right place? By default, each container has a *layout manager*--an object that performs layout management for the components within the container. *Layout management* is the process of determining the size and the position of components. The default layout manager for the containers we've looked at is `FlowLayout`. With `FlowLayout`, the components are simply positioned in the container from left to right in the order they are added.

In the previous code snippet, we use a layout manager called `GridLayout` to position the components within. Layout is further discussed in the section Layout Management◆.

Compound Borders

In previous examples, we've added a simple border to add a buffer of space around components. In this example, both subpanels, `selectPanel` and `displayPanel`, have a compound border. This compound border consists of a titled border (an outlined border with a title) and an empty border (to add extra space), as shown in the following figure:



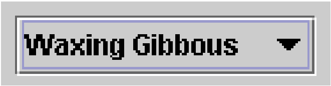
The code for the selectPanel border follows.

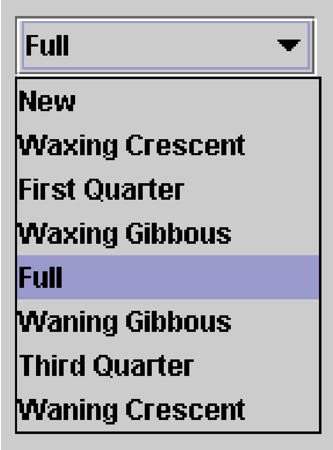
```
// Add border around the select panel
selectPanel.setBorder(BorderFactory.createCompoundBorder(
                      BorderFactory.createTitledBorder("Select Phase"),
                      BorderFactory.createEmptyBorder(5,5,5,5)));
```

The `displayPanel` sets its own border in the same way.

Combo Boxes

A combo box enables user choice. A combo box can be either editable or uneditable, but by default it is uneditable. An uneditable combo box looks like a button until the user interacts with it. When the user clicks it, the combo box displays a menu of items.





Use an uneditable combo box to display one-of-many choices when space is limited, when the number of choices is large, or when the menu items are computed at runtime. The following code in `LunarPhases.java` creates an uneditable combo box, `phaseChoices`, and sets it up:

```
JComboBox phaseChoices = null;
...
// Create combo box with lunar phase choices
String[] phases = { "New", "Waxing Crescent", "First Quarter",
                    "Waxing Gibbous", "Full", "Waning Gibbous",
                    "Third Quarter", "Waning Crescent" };
phaseChoices = new JComboBox(phases);
phaseChoices.setSelectedIndex(START_INDEX);
```

The code initializes the combo box with an array of strings, `phases`. You can also put icons in a combo box or initialize the combo box with a vector. In the last line of code, the `setSelectedIndex` method specifies which phase of the moon should be shown when the program starts.

Handling Events on a Combo Box

The combo box fires an action event when the user selects an item from the combo box's menu. The following code from `LunarPhases` registers and implements an action listener on the combo box:

```
phaseChoices.addActionListener(this);
...
public void actionPerformed(ActionEvent event) {
    if ("comboBoxChanged".equals(event.getActionCommand())) {
        // update the icon to display the new phase
        phaseIconLabel.setIcon(images[phaseChoices.getSelectedIndex()]);
    }
}
```

This action listener gets the newly selected item from the combo box, uses that item to compute the name of an image file, and updates a label to display the image.

Multiple Images

In the `CelsiusConverter` program, we saw how to add a single `ImageIcon` to a button. The `LunarPhases` uses eight images. Only one image of the eight is used at a time, so we have a choice as to whether we load all the images up front or load the images as they are needed (known as "lazy image loading"). In this example, the images are all loaded up front when the class is constructed.

```
final static int NUM_IMAGES = 8;
final static int START_INDEX = 3;

ImageIcon[] images = new ImageIcon[NUM_IMAGES];
...

// Create the widgets to select and display the phases of the moon.
private void addWidgets() {
    // Get the images and put them into an array of ImageIcon.
    for (int i = 0; i < NUM_IMAGES; i++) {
        String imageName = "images/image" + i + ".jpg";
        URL iconURL = ClassLoader.getSystemResource(imageName);

        ImageIcon icon = new ImageIcon(iconURL);
        images[i] = icon;
    }
}
```

Note the use of `getSystemResource`, a method in `ClassLoader` that searches the classpath to find the image file names so that we don't have to specify the fully qualified path name.

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Example Five: VoteDialog

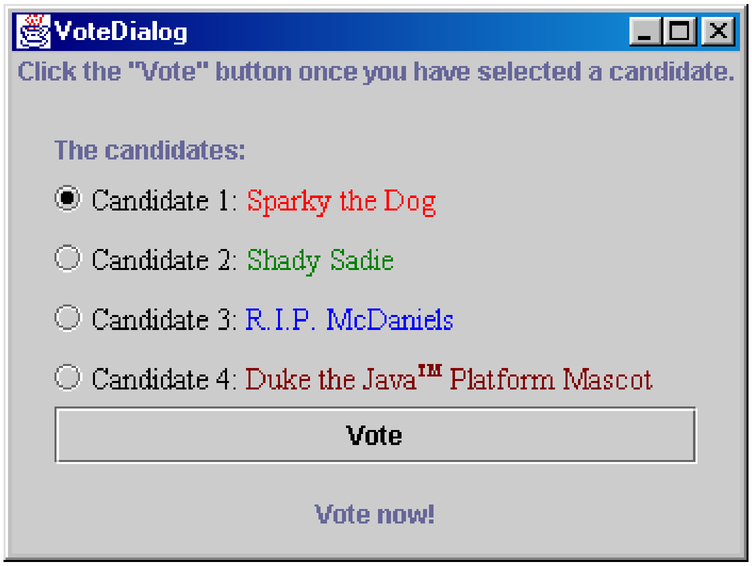
Topics covered in this example include:

- Radio Buttons
- Dialogs

The last example in this lesson is VoteDialog. The main purpose of this example is to illustrate the use of dialogs, but we'll also explain how to set up radio buttons.

In this program, the user casts a vote by selecting a radio button and clicking the Vote button. After the button is clicked, a dialog appears with an informational message or a follow-up question. You can close the dialog either by clicking a button in the dialog or explicitly by clicking the close button.

Here's a picture of the VoteDialog application:



VoteDialog
Click the "Vote" button once you have selected a candidate.
The candidates:
● Candidate 1: Sparky the Dog
○ Candidate 2: Shady Sadie
○ Candidate 3: R.I.P. McDaniels
○ Candidate 4: Duke the Java™ Platform Mascot
Vote
Vote now!

Radio Buttons

This application has one action listener that listens to clicks on the Vote button. Each time the action listener receives an event, the application determines which radio button was selected and displays the appropriate dialog. For each group of radio buttons, you need to create a ButtonGroup instance and add each radio button to it. The ButtonGroup takes care of unselecting the previously selected button when the user selects another button in the group. You should generally initialize a group of radio buttons so that one is selected. However, the API doesn't enforce this rule; a group of radio buttons can have no initial selection. Once the user has made a selection, exactly one button is selected from then on.

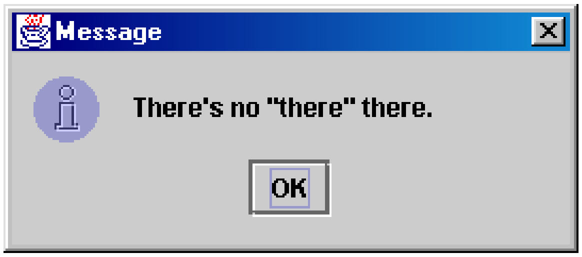
Here is the code from VoteDialog.java in which we create the ButtonGroup instance and add four radio buttons to it. The setActionCommand method associates a specific dialog with each radio button item. We use the setSelected method to specify the default selected radio button.

```
final int numButtons = 4;
JRadioButton[] radioButtons = new JRadioButton[numButtons];

final ButtonGroup group = new ButtonGroup();
...

final String defaultMessageCommand = "default";
final String yesNoCommand = "yesno";
final String yeahNahCommand = "yeahnah";
final String yncCommand = "ync";

radioButtons[0] = new JRadioButton("<html>Candidate 1:
      <font color=red>Sparky the Dog</font></html>");
radioButtons[0].setActionCommand(defaultMessageCommand);

radioButtons[1] = new JRadioButton("<html>Candidate 2:
      <font color=green>Shady Sadie</font></html>");
radioButtons[1].setActionCommand(yesNoCommand);

radioButtons[2] = new JRadioButton("<html>Candidate 3:
      <font color=blue>R.I.P. McDaniels</font></html>");
radioButtons[2].setActionCommand(yeahNahCommand);

radioButtons[3] = new JRadioButton("<html>Candidate 4:
      <font color=maroon>Duke the Java<font size=-2><sup>TM</sup>
      </font size> Platform Mascot</font></html>");
radioButtons[3].setActionCommand(yncCommand);

for (int i = 0; i < numButtons; i++) {
    group.add(radioButtons[i]);
}

// Select the first button by default.
radioButtons[0].setSelected(true);
```

Note the use of HTML code on the radio buttons. This feature was added to the version 1.3 of the Java 2 platform.

Dialogs

In our previous examples, our top-level container has always been a JFrame. Several classes support *dialogs*--windows that are more limited than frames. To create simple, standard dialogs, you use the JOptionPane◆ class. The dialogs that JOptionPane provides are modal. When a modal dialog is visible, it blocks user input to all other windows in the program.



There's no "there" there.

The code for simple dialogs can be minimal. For example, the figure above shows an instructive dialog.

Here is the code that creates and shows that dialog:

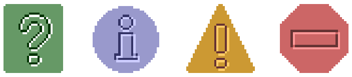
```
    JOptionPane.showMessageDialog(frame, "There's no \"there\" there.");
```

Every dialog is dependent on a frame. When that frame is destroyed, so are its dependent dialogs. When the frame is iconified, its dependent dialogs disappear from the screen. When the frame is deiconified, its dependent dialogs return to the screen. The AWT automatically provides this behavior.

JOptionPane Features

Using `JOptionPane`, you can create and customize several kinds of dialogs. `JOptionPane` provides support for laying out standard dialogs, providing icons, specifying the dialog's title and text, and customizing the button text. Other features allow you to customize the components the dialog displays and to specify where the dialog should appear on-screen.

`JOptionPane`'s icon support lets you easily specify which icon the dialog displays. You can use a custom icon, no icon at all, or any one of four standard `JOptionPane` icons (question, information, warning, and error). Each look and feel has its own versions of the four standard icons. The following figure shows the icons used in the Java look and feel.



Caption: Question, information, warning, and error icons provided by `JOptionPane` (Java look and feel shown).

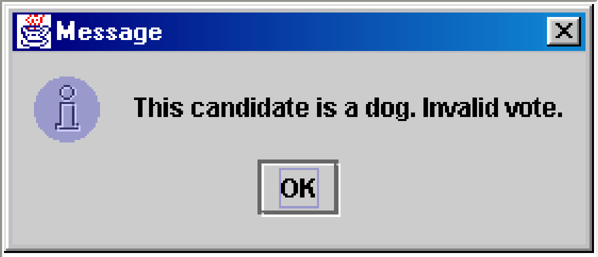
Creating and Showing Simple Dialogs

For most simple modal dialogs, you can use either the `showMessageDialog` or the `showOptionDialog` method. The `showMessageDialog` method displays a simple, one-button dialog. The `showOptionDialog` method displays a customized dialog--it can display a variety of buttons with customized button text and can contain a standard text message or a collection of components.

`showMessageDialog`

Displays a modal dialog with one button, which is labeled OK (or the localized equivalent). You can easily specify the message, icon, and title that the dialog displays. The following table shows an example of the use of `showMessageDialog` in `VoteDialog`.

An Example Using `showMessageDialog`



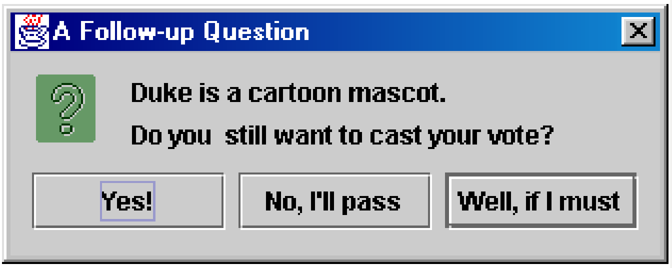
This candidate is a dog. Invalid vote.

```
//default title and icon
JOptionPane.showMessageDialog(frame,
   "This candidate is a dog. " +
   "Invalid vote.");
```

`showOptionDialog`

Displays a modal dialog with the specified buttons, icons, message, title, and so on. You can use this method to change the text that appears on the buttons of standard dialogs. You can also perform many other kinds of customization. The following table shows an example that uses `showOptionDialog`.

An Example Using `showOptionDialog`



Duke is a cartoon mascot.
Do you still want to cast your vote?

```
//default title and icon
Object[] options = {"Yes!",
                    "No, I'll pass",
                    "Well, if I must"};
int n = JOptionPane.showOptionDialog(frame,
    "Duke is a cartoon mascot. \n"
    + "Do you still want to cast your vote?",
    "A Follow-up Question",
    JOptionPane.YES_NO_CANCEL_OPTION,
    JOptionPane.QUESTION_MESSAGE,
    null,
    options,
    options[2]);
```

The arguments to all the `showXxxDialog` methods and `JOptionPane` constructors are standardized, although the number of arguments for each method and constructor varies. The following list describes each argument.

`Component parentComponent`

The first argument to each `showXxxDialog` method is always the parent component, which must be a frame, a component inside a frame, or null. If you specify a frame, the dialog will appear over the center of the frame and will depend on that frame. If you specify a component inside a frame, the dialog will appear over the center of that component and will depend on that component's frame. If you specify null, the look and feel picks an appropriate position for the dialog-generally the center of the screen-and the dialog doesn't depend on any visible frame.

The `JOptionPane` constructors do not include this argument. Instead, you specify the parent frame when you create the `JDialog` that contains the `JOptionPane`, and you use the `JDialog` `setLocationRelativeTo` method to set the dialog's position.

`Object message`

This required argument specifies what the dialog should display in its main area. Generally you specify a string, which results in the dialog's displaying a label with the specified text.

`String title`

This is the title of the dialog.

`int optionType`

This specifies the set of buttons that appears at the bottom of the dialog. You can choose one of the following four standard sets: `DEFAULT_OPTION`, `YES_NO_OPTION`, `YES_NO_CANCEL_OPTION`, `OK_CANCEL_OPTION`.

`int messageType`

This argument determines the icon displayed in the dialog. Choose from one of the following values: `PLAIN_MESSAGE` (no icon), `ERROR_MESSAGE`, `INFORMATION_MESSAGE`, `WARNING_MESSAGE`, `QUESTION_MESSAGE`.

`Icon icon`

This specifies the custom icon to display in the dialog.

`Object[] options`

This further specifies the option buttons to appear at the button of the dialog. Generally, you specify an array of strings for the buttons.

`Object initialValue`

This specifies the default value to be selected. You can either let the default icon be used or specify the icon, using the `messageType` or the `icon` argument. By default, a dialog created with `showMessageDialog` displays the information icon, and a dialog created with `showConfirmDialog` displays the question icon. To specify that the dialog display a standard icon or no icon, specify the message type. To specify a custom icon, use the `icon` argument.

Getting User Input from a Dialog

As the code snippets in two tables above show, the `showMessageDialog` and `showOptionDialog` methods return an integer indicating the user's choice. The values for this integer are `YES_OPTION`, `NO_OPTION`, `CANCEL_OPTION`, `OK_OPTION`, and `CLOSED_OPTION`. Each option, except for `CLOSED_OPTION`, corresponds to the button the user clicked. When `CLOSED_OPTION` is returned, it indicates that the user closed the dialog window explicitly rather than by choosing a button inside the option pane. The following code detects whether the yes or no button was selected or the dialog was closed and then sets the frame's label with the appropriate text.

```
// yes/no dialog
} else if (command == yesNoCommand) {
    int n = JOptionPane.showConfirmDialog(
                        frame, "This candidate is a convicted felon. \n
                                Do you still want to vote for her?",
                        "A Follow-up Question",
                        JOptionPane.YES_NO_OPTION);
    if (n == JOptionPane.YES_OPTION) {
        setLabel("OK. Keep an eye on your wallet.");
    } else if (n == JOptionPane.NO_OPTION) {
        setLabel("Whew! Good choice.");
    } else {
        setLabel("It is your civic duty to cast your vote.");
    }
...
```

Even if you change the strings that the standard dialog buttons display, the return value is still one of the predefined integers. For example, a `YES_NO_OPTION` dialog always returns one of the following values: `YES_OPTION`, `NO_OPTION`, or `CLOSED_OPTION`.

You can get more information on dialogs in the section How to Make Dialogs◆.

Now that we've finished our progress through the examples in this chapter, it's time to look at two important topics: Layout Management◆ and Threads and Swing◆.

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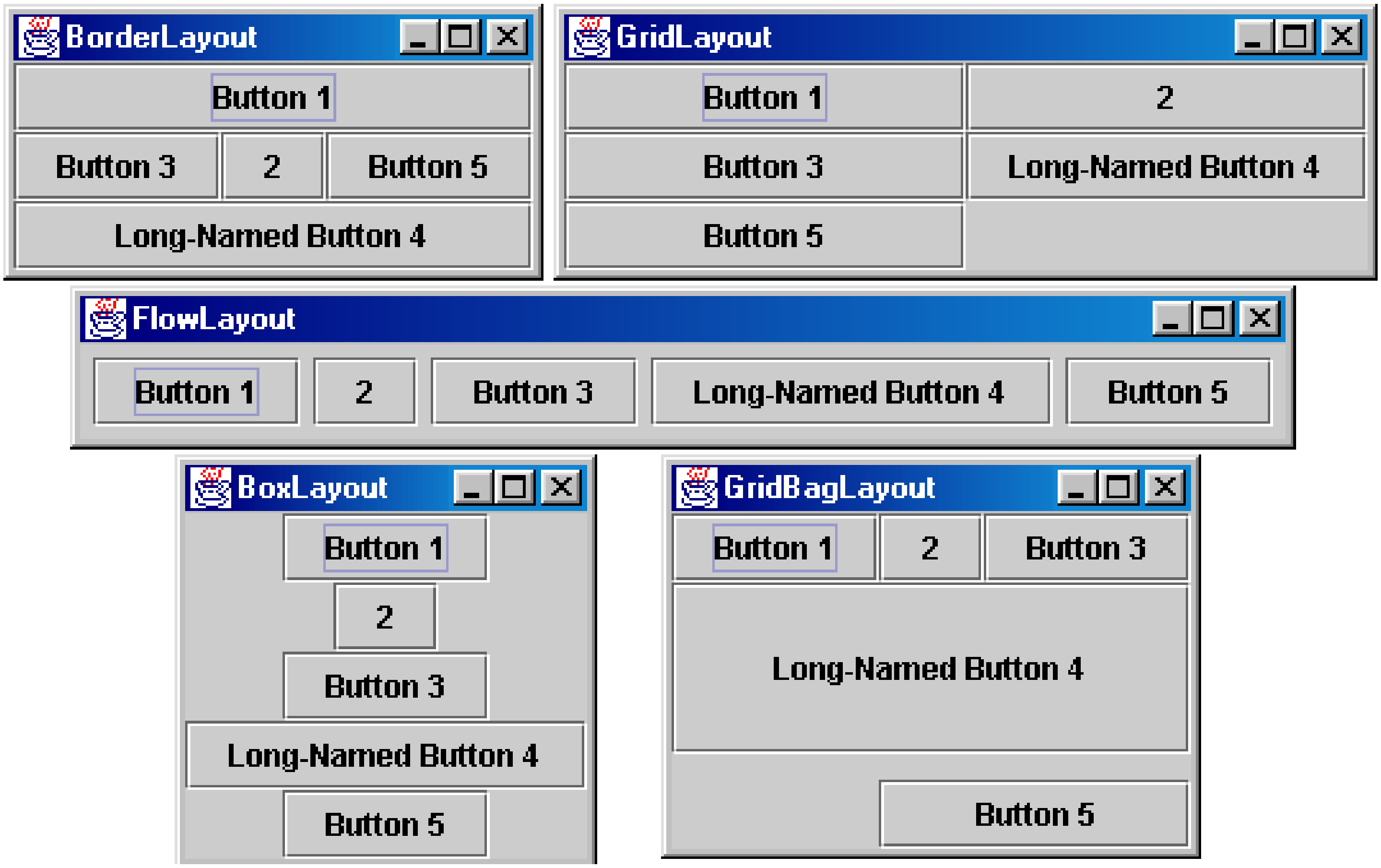
Layout Management

The following figure shows the GUIs of five programs, each of which displays five buttons. The buttons are identical, and the code for the programs is almost identical. So why do the GUIs look so different? Because they use different layout managers to control the size and the position of the buttons.



The Java platform supplies five commonly used layout managers: `BorderLayout`, `BoxLayout`, `FlowLayout`, `GridBagLayout`, and `GridLayout`.

Using Layout Managers

By default, every container has a layout manager. All `JPanel` objects use a

FlowLayout by default, whereas content panes (the main containers in JApplet, JDialog, and JFrame objects) use BorderLayout by default. As a rule, the only time you have to think about layout managers is when you create a JPanel or add components to a content pane. If you don't like the default layout manager that a panel or content pane uses, you can change it to a different one. Just invoke the container's setLayout method. For example, here's the code that makes a panel use BorderLayout:

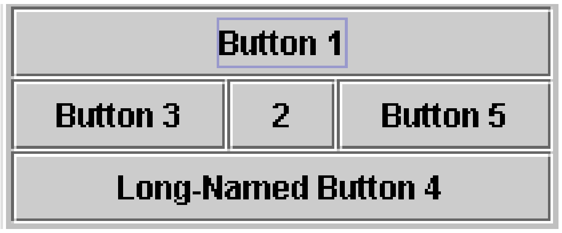
```
JPanel pane = new JPanel();
pane.setLayout(new BorderLayout());
```

When you add components to a panel or a content pane, the arguments you specify to the add method depend on the layout manager that the panel or content pane is using. So be sure to check the API documentation for the layout manager for details.

Here's a quick summary of the various layout managers and where to find more information in *The Java Tutorial* and API documentation.

BorderLayout

BorderLayout is the default layout manager for every content pane. The content pane is the main container in all frames, applets, and dialogs. A BorderLayout has five areas available to hold components: north, south, east, west, and center. All extra space is placed in the center area.

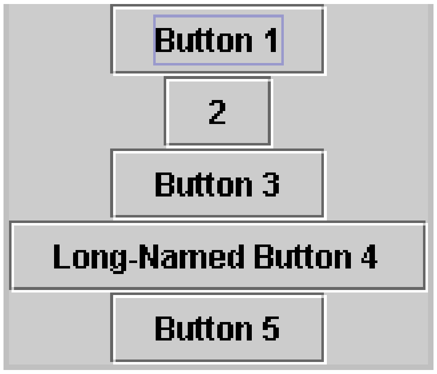


Tutorial: How to Use BorderLayout

API documentation: BorderLayout

BoxLayout

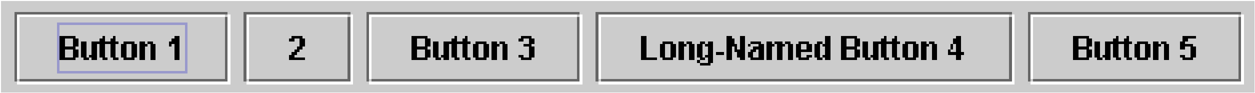
The BoxLayout class puts components in a single row or column. This class respects the components' requested maximum sizes and also lets you align components.



Tutorial: How to Use BoxLayout◆ API documentation: `BoxLayout`◆

`FlowLayout`

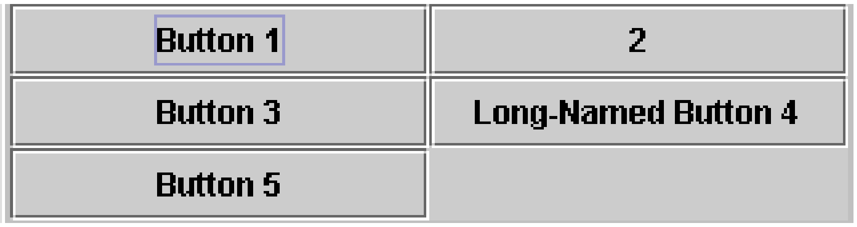
FlowLayout is the default layout manager for every JPanel. This layout manager simply lays out components from left to right, starting new rows, if necessary.



Tutorial: How to Use FlowLayout◆ API documentation: `FlowLayout`◆

`GridLayout`

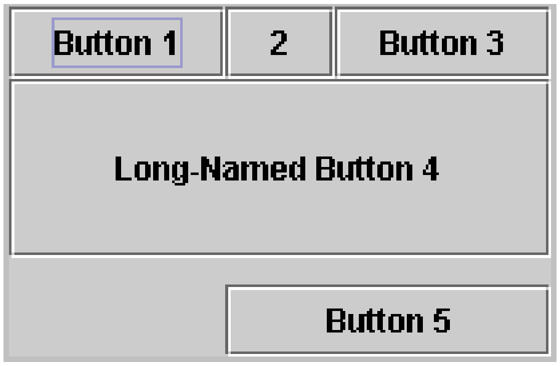
GridLayout simply makes a bunch of components equal in size and displays them in the requested number of rows and columns.



Tutorial: How to Use GridLayout◆ API documentation: `GridLayout`◆

`GridBagLayout`

GridBagLayout is the most sophisticated, flexible layout manager the Java platform provides. This layout manager aligns components by placing them within a grid of cells, allowing some components to span more than one cell. The rows in the grid aren't necessarily all the same height; similarly, grid columns can have different widths.



Tutorial: How to Use GridBagLayout◆

API documentation: `GridBagLayout`◆

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Threads and Swing

If your program creates and refers to its GUI the correct way, you might not need to worry about threads. If your program is an applet, it's safe to construct its GUI in the `init` method. You're also safe if your program is an application with the following common pattern:

```
//Thread-safe example
public class MyApplication {
    public static void main(String[] args) {
        JFrame f = new JFrame(...);
        ...//Add components to the frame here...
        f.pack();
        f.setVisible(true);
        //Don't do any more GUI work here.
    }

    ...
    //All manipulation of the GUI -- setText, getText, etc.
    //is performed in event handlers such as actionPerformed().
    ...
}
```

However, if your program creates threads to perform tasks that affect the GUI or if it manipulates an already visible GUI in response to anything but a standard event, read on.

The Single-Thread Rule

Swing components can be accessed by only one thread at a time, generally the event-dispatching thread. Thus, the single-thread rule is as follows.

Rule: Once a Swing component has been realized, all code that might affect or depend on the state of that component should be executed in the event-dispatching thread.

This rule might sound scary, but for many simple programs, you don't have to worry about threads.

Before we go into detail about how to write Swing code, let's define the term *realized*. "Realized" means that the component has been painted on-screen or that it is ready to be painted. A Swing component that's a top-level window is realized by having one of these methods invoked on it: `setVisible(true)`, `show`, or `pack`. Once a window is realized, all the components it contains are realized. Another way to realize a component is to add it to a container that's already realized. You'll see examples of realizing components later.

> **Note:** The show method does the same thing as `setVisible(true)`.

Exceptions to the Rule

The rule that all code that might affect a realized Swing component must run in the event-dispatching thread has a few exceptions.

A few methods are thread safe.

In the Swing API documentation, thread-safe methods are marked with this text:

This method is thread safe, although most Swing methods are not.

An application's GUI can often be constructed and shown in the main thread.

As long as no Swing or other components have been realized in the current runtime environment, it's fine to construct and show a GUI in the main thread of an application. To help you see why, here's an analysis of the thread safety of the thread-safe example. To refresh your memory, here are the important lines from the example:

```
public static void main(String[] args) {
    JFrame f = new JFrame(...);
    ...//Add components to the frame here...
    f.pack();
    f.setVisible(true);
    //Don't do any more GUI work here.
}
```

1. The example constructs the GUI in the main thread. In general, you can construct (but not show) a GUI in any thread, as long as you don't make any calls that refer to or affect already realized components.
2. The components in the GUI are realized by the `pack` call.
3. Immediately afterward, the components in the GUI are shown with the `setVisible`

(or `show`) call. Technically the `setVisible` call is unsafe, because the components have already been realized by the `pack` call. However, because the program doesn't already have a visible GUI, it's exceedingly unlikely that a paint request will occur before `setVisible` returns.

4. The main thread executes no GUI code after the `setVisible` call. This means that all GUI work moves from the main thread to the event-dispatching thread, and the example is, in practice, thread safe.

An applet's GUI can be constructed and shown in the `init` method.

Existing browsers don't paint an applet until after its `init` and `start` methods have been called. Thus constructing the GUI in the applet's `init` method is safe, as long as you never call `show()` or `setVisible(true)` on the applet object.

These `JComponent` methods are safe to call from any thread: `repaint` and `revalidate`.

These methods queue requests to be executed on the event-dispatching thread.

Listener lists can be modified from any thread.

It's always safe to call the `add`*`ListenerTypeListener`* and `remove`*`ListenerTypeListener`* methods. The add/remove operations have no effect on an event dispatch that's under way.

How to Execute Code in the Event-Dispatching Thread

Most postinitialization GUI work naturally occurs in the event-dispatching thread. Once the GUI is visible, most programs are driven by events, such as button actions or mouse clicks, which are always handled in the event-dispatching thread.

However, some programs need to perform nonevent-driven GUI work after the GUI is visible. Here are two examples.

Programs that must perform a lengthy initialization operation before they can be used

This kind of program should generally show some GUI while the initialization is occurring and then update or change the GUI. The initialization should not occur in the event-dispatching thread; otherwise, repainting and event dispatching would stop. However, after initialization, the GUI update or change should occur in the event-dispatching thread, for thread-safety reasons.

Programs whose GUI must be updated as the result of nonstandard events

For example, suppose that a server program can get requests from other programs that might be running on different machines. These requests can come at any time, and they result in one of the server's methods being invoked in a possibly unknown thread. How can that method update the GUI? By executing the GUI-update code in the event-dispatching thread.

The `SwingUtilities` class provides two methods to help you run code in the event-dispatching thread:

`invokeLater`
: Requests that some code be executed in the event-dispatching thread. This method returns immediately, without waiting for the code to execute.

`invokeAndWait`
: Acts like invokeLater, except that this method waits for the code to execute. As a rule, you should use invokeLater rather than this method.

For more information on deploying threads in your Swing programs, see the section How to Use Threads◆

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Summary

This lesson glossed over many details and left some things unexplained, but you should have some understanding now of what you can build with Swing components. You should now have a general understanding of the following:

- How to set up the containment hierarchy of each Swing component. To add a component to a container, you use some form of the add method.
- How to implement many standard GUI components, such as buttons, labels, combo boxes, and radio buttons, which you combine to create your program's GUI.
- How to change the layout of components by using layout managers.
- How to handle events and accommodate threads in Swing programs. Recall that the event-handling mechanism is based on the AWT event-handling model in which you register event listeners upon the components which generate events.

For a quick, visual reference of the Swing components see A Visual Index to the Swing Components◆.

For more complete information on Swing, see the full trail: Creating a GUI with JFC/Swing◆ This trail is also published as a book, The JFC Swing Tutorial.

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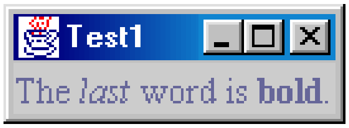
Questions and Exercises: User Interfaces That Swing

Questions

Use the API documentation to answer these questions.

1. Show the code that creates a label displaying the following text, with the italics and boldface as shown in this screenshot:



The *last* word is **bold**.

2. Use the API documentation or online tutorial, if necessary, to answer the following questions:

   a. Assume that you have a Swing label that tends to have more horizontal space than it needs to display its text. What code would you use to make the text within a label (`Jlabel`) be centered instead of left-aligned?

   b. What method do you use to enable and disable such components as Swing buttons?

   c. How do you add a component to the rightmost (east) cell in a container that uses `BorderLayout`?

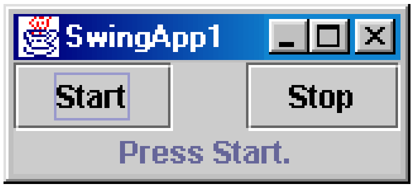
3. Is the following code thread-safe? If so, why? If not, what can you do to make it thread-safe?

```
JLabel label;

Container createGUI() {
    ...
      //create a JPanel; add components to it, including label
     ...
     return panel;
}

public static void main(String[] args) {
        JFrame f = new JFrame("A Frame");
        f.setContentPane(createGUI());
        f.pack();
        f.setVisible(true);
        String labelText = findTextFromSomewhere();
        label.setText(labelText);
    }
```

Exercises

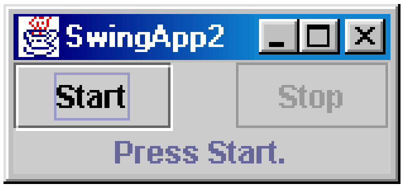
You'll need to work on these exercises in order, as they build upon each other. *Hint:* Your answer to question 2 will be useful.

1. Write an application called `SwingApp1` that has two buttons and one label, arranged as shown in the following screenshot:

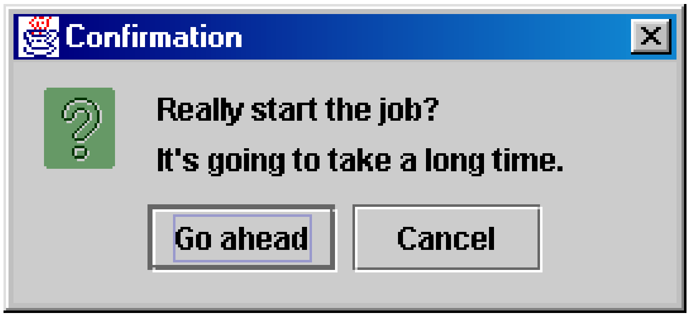


Hint: You can use the content pane's default `BorderLayout` to manage the buttons and label.

2. Copy `SwingApp1.java` to `SwingApp2.java`, and modify `SwingApp2` so that the Stop button is initially disabled. Implement and register one or two action listeners so that when the user clicks either button, the clicked button is disabled, the other button is enabled, and the label is updated appropriately. Your application should look like this:



3. Copy `SwingApp2.java` to `SwingApp3.java`, and modify `SwingApp3` so that its Start button brings up a dialog that looks like this:



If the user chooses the Go ahead button, the Start button should do exactly what it did in `SwingApp2`. If the user does anything else, the application should update the label to report the cancellation and leave the buttons in their existing state.

Check your answers.◆

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Compiling and Running Swing Programs (Java 2 Platform)

Here are the steps for compiling and running your first Swing program with the Java 2 SDK, v 1.2 or 1.3:

1. Download the latest release of the Java 2 Platform, if you haven't already done so.
2. Create a program that uses Swing components.
3. Compile the program.
4. Run the program.

Download the Latest Release of the Java 2 Platform

Two versions of the Java 2 Platform are available, both for free. The first is the Java 2 SDK, Standard Edition, v 1.2, which is sometimes called "v 1.2" for short (or, incorrectly, "JDK 1.2"). The second is Java 2 SDK, Standard Edition, v 1.3, which is sometimes called simply "v 1.3".

For information about the differences between 1.2 and 1.3, see the Java 2 SDK v 1.3 documentation.

Create a Program That Uses Swing Components

You can use a simple program we provide, called `SwingApplication`. Please download and save this file: `SwingApplication.java`. The spelling and capitalization of the file's name must be exactly "SwingApplication.java".

Compile a Program That Uses Swing Components

Your next step is to compile the program. Compiling a Swing program with one of the Java 2 SDKs is simple, since the Swing packages are part of the Standard Edition of the Java 2 Platform. Here is an example:

```
javac -deprecation SwingApplication.java
```

If you can't compile `SwingApplication.java`, it's probably either because you're using a JDK 1.1 compiler instead of a v 1.2 or 1.3 compiler, or because you're using a beta release of v 1.2. Once you update a more recent release of the Java 2 Platform, you should be able to use the programs in this trail without change. See Swing Package Names for information about the package names that were used in the 1.2 beta releases.

Run the Program

After you compile the program successfully, you can run it. This section tells you how to run an application. For instructions on running an applet, see Running Swing Applets.

Assuming that your program uses a standard look and feel -- such as the Java look and feel, Windows look and feel, or CDE/Motif look and feel -- you can use the v 1.2 or 1.3 interpreter to run the program without adding anything to your class path. For example:

```
java SwingApplication
```

If you use a nonstandard look and feel, you must make sure that its package is included in the class path. For example:

```
Solaris:
    java -classpath .:/home/me/lnfdir/newlnf.jar SwingApplication
Win32:
    java -classpath .;C:\java\lnfdir\newlnf.jar SwingApplication
```

Note: Don't include the core classes in the class path. The v 1.2 and 1.3 interpreters find them automatically.

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Trail: Creating a GUI with JFC/Swing
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Compiling and Running Swing Programs (JDK 1.1)

Here are the steps for compiling and running your first Swing program with JDK 1.1 and JFC/Swing:

1. Download the latest JDK 1.1 release, if you haven't already done so.
2. Download the latest JFC 1.1 release.
3. Create a program that uses Swing components.
4. Compile the program.
5. Run the program.

Download the Latest JDK 1.1 Release

You can download the reference implementation of JDK 1.1◆ for free from java.sun.com. Just go to the appropriate page for your platform -- Solaris◆ or Win32◆ .

Download the Latest JFC/Swing Release

You can download the latest JFC 1.1 release from the JFC home page◆ .This trail describes the Swing 1.1 version of JFC 1.1.

Create a Program That Uses Swing Components

You can use a simple program we provide, called `SwingApplication`. Please download and save this file: `SwingApplication.java`◆. The spelling and capitalization of the file's name must be exactly "SwingApplication.java".

Compile a Program That Uses Swing Components

Your next step is to compile the program. Here's a general explanation of how to compile a Swing application with JDK 1.1.

1. Make a note of where your copy of the JFC 1.1 (Swing 1.1) release is installed. The Swing class archive file, `swing.jar`, is in the top directory of this release. You might want to create an environment variable called `SWING_HOME` that contains the path of the top directory of the JFC 1.1 release.

   Note: Don't bother unarchiving `swing.jar`!

2. Make a note of where your copy of the JDK release is installed. You'll need this to be able to find the proper versions of the JDK classes and interpreter. You might want to create an environment variable, `JAVA_HOME`, and set it to the top directory of the JDK release.

The JDK classes are in the `lib` directory of the JDK release, in a file called `classes.zip`. Don't uncompress that file! The interpreter for the Java programming language is in the `bin` directory of the JDK release.

3. Compile the application, specifying a class path that includes the `swing.jar` file, the JDK `classes.zip` file, and the directory containing the program's classes (usually "."). *Be sure that the JDK `classes.zip` file and the compiler you use are from exactly the same release of the JDK!*

The following example shows how to compile `SwingApplication` on a UNIX system. It assumes that you've set up the environment variables `JAVA_HOME` and `SWING_HOME`.

```
$JAVA_HOME/bin/javac
    -classpath .:$SWING_HOME/swing.jar:$JAVA_HOME/lib/classes.zip
    SwingApplication.java
```

If you choose not to use the environment variables, you might instead use a command like this:

```
javac
    -classpath .:/home/me/swing-1.1/swing.jar:/home/me/jdk1.1.7/lib/classes.zip
    SwingApplication.java
```

Here's an example of compiling on Win32:

```
%JAVA_HOME%\bin\javac
    -deprecation
    -classpath .;%SWING_HOME%\swing.jar;%JAVA_HOME%\lib\classes.zip
    SwingApplication.java
```

Here's an alternative that doesn't use environment variables:

```
javac
    -deprecation
    -classpath .;C:\java\swing-1.1\swing.jar;C:\java\jdk1.1.7\lib\classes.zip
    SwingApplication.java
```

Note: If you can't compile `SwingApplication.java`, it's probably due either to having the wrong files in your class path or to using a version of JFC 1.1 that has old Swing API. You should be able to use the programs in this book without change once you update to the most recent JFC 1.1 release. Before Swing 1.1 Beta 3, the Swing API used different package names. Here is how to change `SwingApplication.java` to use the old package names:

```
//import javax.swing.*;       //comment out this line
import com.sun.java.swing.*;  //uncomment this line
```

See Swing Package Names for more information about differences in package names.

Run the Program

Once the program has successfully compiled, you can run it. This section tells you how to run an application. For instructions on running an applet, see Running Swing Applets.

Make sure that the interpreter's class path includes not only what you needed to compile the file, but also the archive file for the look and feel the program uses. The Java look and feel, which is the default, is in the `swing.jar` file. The Windows look and feel is in `windows.jar`, and the CDE/Motif look and feel is in `motif.jar`. You aren't limited to these look-and-feel options: you can use any look and feel designed for use with the Swing 1.1 API.

This application uses the Java look and feel, so you need only `swing.jar` in the class path. Thus, the command for running it is similar to the command for compiling it. Just substitute `java` for `javac`, and remove the `.java` suffix. For example, on UNIX:

```
java -classpath .:/home/me/swing-1.1/swing.jar:/home/me/jdk1.1.7/lib/classes.zip
     SwingApplication
```

Here's an example of running an application that uses the Windows look and feel:

```
%JAVA_HOME%\bin\java
    -classpath
.;%SWING_HOME%\swing.jar;%JAVA_HOME%\lib\classes.zip;%SWING_HOME%\windows.jar
    SomeClass
```

While you're developing your application, you can simplify the class path by using `swingall.jar`, which includes all the classes in the JFC 1.1 release. So instead of putting `swing.jar` and `windows.jar` in your class path, for example, you can just put in `swingall.jar`.

Important: Avoid using `swingall.jar` in your final application. It contains information used by builders, as well as more look-and-feel packages than a typical application uses. You can save space by simply using the `swing.jar` file plus any look-and-feel archives that you need.

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Run HelloSwingApplet

Note: Because the preceding applet uses the Swing 1.1 API, it requires Java Plug-in 1.1.2 or Java Plug-in 1.2. It won't work with Java Plug-in 1.1.1 or uncustomized 1.1 browsers. For more information about running applets in the tutorial, refer to About Our Examples. That page includes a section about Downloading Java Plug-in.

```java
import javax.swing.*;          //This is the final package name.
//import com.sun.java.swing.*; //Used by JDK 1.2 Beta 4 and all
                               //Swing releases before Swing 1.1 Beta 3.
import java.awt.*;

public class HelloSwingApplet extends JApplet {

    // This is a hack to avoid an ugly error message in 1.1.
    public HelloSwingApplet() {
        getRootPane().putClientProperty("defeatSystemEventQueueCheck",
                                        Boolean.TRUE);
    }

    public void init() {
        JLabel label = new JLabel(
                           "You are successfully running a Swing applet!");
        label.setHorizontalAlignment(JLabel.CENTER);

        //Add border.  Should use createLineBorder, but then the bottom
        //and left lines don't appear -- seems to be an off-by-one error.
        label.setBorder(BorderFactory.createMatteBorder(1,1,2,2,Color.black));

        getContentPane().add(label, BorderLayout.CENTER);
    }
}
```

The Java^{TM} Tutorial

Trail: Creating a GUI with JFC/Swing
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Run AppletDemo

Note: Because the preceding applet uses the Swing 1.1 API, it requires Java Plug-in 1.1.2 or Java Plug-in 1.2. It won't work with Java Plug-in 1.1.1 or uncustomized 1.1 browsers. For more information about running applets in the tutorial, refer to About Our Examples. That page includes a section about Downloading Java Plug-in.

```
/*
 * Swing 1.1 version (compatible with both JDK 1.1 and Java 2).
 */
import javax.swing.*;
import java.awt.*;
import java.awt.event.*;
import java.net.URL;

public class AppletDemo extends JApplet
                        implements ActionListener {
    protected JButton b1, b2, b3;

    protected static final String DISABLE = "disable";
    protected static final String ENABLE = "enable";

    protected String leftButtonFilename = "images/right.gif";
    protected String middleButtonFilename = "images/middle.gif";
    protected String rightButtonFilename = "images/left.gif";

    private boolean inAnApplet = true;
    URL codeBase; //used for applet version only

    //Hack to avoid ugly message about system event access check.
    public AppletDemo() {
        this(true);
    }

    public AppletDemo(boolean inAnApplet) {
        this.inAnApplet = inAnApplet;
        if (inAnApplet) {
            getRootPane().putClientProperty("defeatSystemEventQueueCheck",
                                            Boolean.TRUE);
        }
    }

    public void init() {
        setContentPane(makeContentPane());
    }

    public Container makeContentPane() {
        ImageIcon leftButtonIcon;
        ImageIcon middleButtonIcon;
        ImageIcon rightButtonIcon;

        if (inAnApplet) {
            URL leftButtonURL = getURL(leftButtonFilename);
            URL middleButtonURL = getURL(middleButtonFilename);
            URL rightButtonURL = getURL(rightButtonFilename);

            leftButtonIcon = new ImageIcon(leftButtonURL);
            middleButtonIcon = new ImageIcon(middleButtonURL);
            rightButtonIcon = new ImageIcon(rightButtonURL);
        } else {
            leftButtonIcon = new ImageIcon(leftButtonFilename);
            middleButtonIcon = new ImageIcon(middleButtonFilename);
            rightButtonIcon = new ImageIcon(rightButtonFilename);
        }

        b1 = new JButton("Disable middle button", leftButtonIcon);
        b1.setVerticalTextPosition(AbstractButton.CENTER);
        b1.setHorizontalTextPosition(AbstractButton.LEFT);
        b1.setMnemonic(KeyEvent.VK_D);
        b1.setActionCommand(DISABLE);

        b2 = new JButton("Middle button", middleButtonIcon);
        b2.setVerticalTextPosition(AbstractButton.BOTTOM);
        b2.setHorizontalTextPosition(AbstractButton.CENTER);
        b2.setMnemonic(KeyEvent.VK_M);

        b3 = new JButton("Enable middle button", rightButtonIcon);
        //Use the default text position of CENTER, RIGHT.
        b3.setMnemonic(KeyEvent.VK_E);
        b3.setActionCommand(ENABLE);
        b3.setEnabled(false);

        //Listen for actions on buttons 1 and 3.
        b1.addActionListener(this);
        b3.addActionListener(this);

        b1.setToolTipText("Click this button to disable the middle button.");
        b2.setToolTipText("This middle button does nothing when you click it.");
        b3.setToolTipText("Click this button to enable the middle button.");

        //Add Components to a JPanel, using the default FlowLayout.
        JPanel pane = new JPanel();
        pane.add(b1);
        pane.add(b2);
        pane.add(b3);
        pane.setBackground(new Color(255,255,204));
        pane.setBorder(BorderFactory.createMatteBorder(1,1,2,2,Color.black));

        return pane;
    }

    public void actionPerformed(ActionEvent e) {
        if (e.getActionCommand().equals(DISABLE)) {
            b2.setEnabled(false);
            b1.setEnabled(false);
            b3.setEnabled(true);
        } else {
            b2.setEnabled(true);
            b1.setEnabled(true);
            b3.setEnabled(false);
        }
    }

    /* One day, JApplet will make this method obsolete. */
    protected URL getURL(String filename) {
        URL url = null;
        if (codeBase == null) {
            codeBase = getCodeBase();
        }

        try {
            url = new URL(codeBase, filename);
        } catch (java.net.MalformedURLException e) {
            System.out.println("Couldn't create image: badly specified URL");
            return null;
        }

        return url;
    }

    public static void main(String[] args) {
        JFrame frame = new JFrame("Application version: AppletDemo");

        frame.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });

        AppletDemo applet = new AppletDemo(false);
        frame.setContentPane(applet.makeContentPane());
        frame.pack();
        frame.setVisible(true);
    }
}
```

Trail: Creating a GUI with JFC/Swing
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Platform-Specific Details: Setting the Browser's Class Path

You can make sure your browser's class path includes the Swing release in one of two ways:

- Use a browser-specific option to set your browser's class path.
- Set the `CLASSPATH` environment variable (this works for browsers based on the Java programming language but might not work for others).

Warning: Permanently setting the `CLASSPATH` environment variable can lead to trouble, since it's easy to forget to update it when you use a different version of the JDK or Swing. Instead, try to specify the class path programmatically, such as with a `-classpath` command-line option. Or specify it at a shell prompt, rather than saving it in a file.

The following instructions give examples of each approach. For more information on setting the class path, see Managing Source and Class Files◆.

The directory paths used below assume that you have installed both the JDK and Swing releases under `/home/me` (for Solaris) or on drive C (for Windows). You should adjust the directory paths to reflect your installation.

Solaris

If you're using the JDK Applet Viewer, then instead of specifying the `CLASSPATH` environment variable, then you can use the `-J` option of the `appletviewer` command to specify options to the interpreter. For example:

```
appletviewer -J-classpath -J.:/home/me/swing-
1.1.1/swing.jar:/home/me/jdk1.1.8/lib/classes.zip
http://java.sun.com/docs/books/tutorial/uiswing/start/HelloSwingApplet.atag
```

If you choose to set the `CLASSPATH` environment variable, use a command like the following:

```
setenv CLASSPATH .:/home/me/swing-1.1.1/swing.jar
```

Then invoke your browser as usual.

Win32

If you're using the JDK Applet Viewer, then instead of specifying the `CLASSPATH` environment variable (as described in Setting Environment Variables), you can use the `-J` option of the `appletviewer` command. For example:

```
appletviewer -J"-classpath c:\swing-1.1.1\swing.jar;c:\jdk1.1.8\lib\classes.zip"
http://java.sun.com/docs/books/tutorial/uiswing/start/HelloSwingApplet.atag
```

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```
import javax.swing.*;          //This is the final package name.
//import com.sun.java.swing.*; //Used by JDK 1.2 Beta 4 and all
                               //Swing releases before Swing 1.1 Beta 3.
import java.awt.*;
import java.awt.event.*;

public class SwingApplication {
    private static String labelPrefix = "Number of button clicks: ";
    private int numClicks = 0;

    public Component createComponents() {
        final JLabel label = new JLabel(labelPrefix + "0    ");

        JButton button = new JButton("I'm a Swing button!");
        button.setMnemonic(KeyEvent.VK_I);
        button.addActionListener(new ActionListener() {
            public void actionPerformed(ActionEvent e) {
                numClicks++;
                label.setText(labelPrefix + numClicks);
            }
        });
        label.setLabelFor(button);

        /*
         * An easy way to put space between a top-level container
         * and its contents is to put the contents in a JPanel
         * that has an "empty" border.
         */
        JPanel pane = new JPanel();
        pane.setBorder(BorderFactory.createEmptyBorder(
                                        30, //top
                                        30, //left
                                        10, //bottom
                                        30) //right
                                        );
        pane.setLayout(new GridLayout(0, 1));
        pane.add(button);
        pane.add(label);

        return pane;
    }

    public static void main(String[] args) {
        try {
            UIManager.setLookAndFeel(
                UIManager.getCrossPlatformLookAndFeelClassName());
        } catch (Exception e) { }

        //Create the top-level container and add contents to it.
        JFrame frame = new JFrame("SwingApplication");
        SwingApplication app = new SwingApplication();
        Component contents = app.createComponents();
        frame.getContentPane().add(contents, BorderLayout.CENTER);

        //Finish setting up the frame, and show it.
        frame.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });
        frame.pack();
        frame.setVisible(true);
    }
}
```

Trail: Creating a GUI with JFC/Swing
Lesson: Getting Started with Swing

Swing Package Names

The names of the Swing packages have varied over time. This trail uses the final Swing package names, which generally start with `javax.swing`. If you have code that uses earlier package names, such as `com.sun.java.swing`, then you will need to convert it.

This section has two parts:

- How to Convert to the Final Package Names
- The History of the Swing Package Names

How to Convert to the Final Package Names

Between the Beta 2 and Beta 3 releases of Swing 1.1, the names of the Swing packages changed. In Swing 1.1 Beta 2, for example, the main Swing package was called `com.sun.java.swing`, while in Swing 1.1 Beta 3, the name is `javax.swing`. The same changes occurred between the Beta 4 and RC1 releases of the Java 2 Platform, v 1.2.

Converting the package names is easy, although it can be tedious to do by hand when many source files are involved. Fortunately, the Swing team provides a utility called `PackageRenamer` that converts programs to use the final Swing package names. You can find the program at `http://java.sun.com/products/jfc/PackageRenamer`.

The following table shows how the names have changed:

Old Name **(Swing 1.1 Beta 2, Java 2 Platform v 1.2 Beta 4)**	**New, Final Name** **(Swing 1.1 [Beta 3 and later], Java 2 Platform v 1.2 RC1)**
`com.sun.java.accessibility`	`javax.accessibility`
`com.sun.java.swing`	`javax.swing`

`com.sun.java.swing.border`	`javax.swing.border`
`com.sun.java.swing.colorchooser`	`javax.swing.colorchooser`
`com.sun.java.swing.event`	`javax.swing.event`
`com.sun.java.swing.filechooser`	`javax.swing.filechooser`
`com.sun.java.swing.plaf`	`javax.swing.plaf`
`com.sun.java.swing.plaf.basic`	`javax.swing.plaf.basic`
`com.sun.java.swing.plaf.metal`	`javax.swing.plaf.metal`
`com.sun.java.swing.plaf.motif`	`com.sun.java.swing.plaf.motif` (*no change)*
`com.sun.java.swing.plaf.multi`	`javax.swing.plaf.multi`
`com.sun.java.swing.plaf.windows`	`com.sun.java.swing.plaf.windows` (*no change)*
`com.sun.java.swing.table`	`javax.swing.table`
`com.sun.java.swing.text`	`javax.swing.text`
`com.sun.java.swing.text.html`	`javax.swing.text.html`
`com.sun.java.swing.tree`	`javax.swing.tree`
`com.sun.java.swing.undo`	`javax.swing.undo`
`com.sun.java.swing.plaf.mac`	`com.sun.java.swing.plaf.mac` (*no change)*
`com.sun.java.accessibility.util`	`com.sun.java.accessibility.util` (*no change)*

Note: The `com.sun.java.accessibility.util` package isn't part of the JFC 1.1 release or Java 2 Platform. It's distributed separately as part of the Accessibility Utilities.

The `com.sun.java.swing.plaf.mac` package is distributed only in the Macintosh download of JFC 1.1 and the Mac OS Runtime for Java, also known as MRJ.

The History of the Swing Package Names

At various times, the Swing API has used the following package names:

- `com.sun.java.swing`
- `java.awt.swing`
- `javax.swing`

In the end, the core Swing API is under the `javax.swing` package, with some additional Sun-provided packages under `com.sun.java.swing`. The previous table gives details of the final package names. Now let's look at how the names have varied over time.

In all the JFC 1.1 releases up through Swing 1.1 Beta 2, the name of the main Swing package was `com.sun.java.swing`. The JFC 1.1 releases were meant to be used with JDK 1.1. There was no built-in support for Swing until the 1.2 Beta 2 version of the Java 2 Platform.

In the Beta 2 and Beta 3 releases of the Java 2 Platform v 1.2, the Swing API was in a new package: `java.awt.swing`. However, some of our customers told us that they wanted the Swing package names to be the same in JFC 1.1 and the Java 2 Platform, so that they would be able to use the exact same code for both releases.

As a result, in v 1.2 Beta 4 the Swing team moved the main Swing package to `com.sun.java.swing`. Unfortunately, many people didn't like this change. One of the reasons for the discontent was that having a core API in a package that didn't begin with "java" seemed to imply that Swing wasn't a core API.

The Swing team reacted by floating a proposal to move the Swing packages to `javax.swing` in both JFC 1.1 and the Java 2 Platform. The proposal was favorably greeted by the user community, and the new package names were introduced in Swing 1.1 Beta 3 and the Java 2 SDK v 1.2 RC1. The right column of the preceding table shows the final package names.

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

public class ScrollDemo extends JPanel {
    private Rule columnView;
    private Rule rowView;
    private JToggleButton isMetric;
    private ScrollablePicture picture;

    public ScrollDemo() {
        // Start loading the image icon now.
        ImageIcon david = new ImageIcon("images/youngdad.jpeg");

        // Create the row and column headers.
        columnView = new Rule(Rule.HORIZONTAL, true);
        columnView.setPreferredWidth(david.getIconWidth());
        rowView = new Rule(Rule.VERTICAL, true);
        rowView.setPreferredHeight(david.getIconHeight());

        // Create the corners.
        JPanel buttonCorner = new JPanel();
        isMetric = new JToggleButton("cm", true);
        isMetric.setFont(new Font("SansSerif", Font.PLAIN, 11));
        isMetric.setMargin(new Insets(2,2,2,2));
        isMetric.addItemListener(new UnitsListener());
        buttonCorner.add(isMetric); //Use the default FlowLayout

        // Set up the scroll pane.
        picture = new ScrollablePicture(david, columnView.getIncrement());
        JScrollPane pictureScrollPane = new JScrollPane(picture);
        pictureScrollPane.setPreferredSize(new Dimension(300, 250));
        pictureScrollPane.setViewportBorder(
                BorderFactory.createLineBorder(Color.black));

        pictureScrollPane.setColumnHeaderView(columnView);
        pictureScrollPane.setRowHeaderView(rowView);

        pictureScrollPane.setCorner(JScrollPane.UPPER_LEFT_CORNER,
                                    buttonCorner);
        pictureScrollPane.setCorner(JScrollPane.LOWER_LEFT_CORNER,
                                    new Corner());
        pictureScrollPane.setCorner(JScrollPane.UPPER_RIGHT_CORNER,
                                    new Corner());

        // Put it in this panel.
        setLayout(new BoxLayout(this, BoxLayout.X_AXIS));
        add(pictureScrollPane);
        setBorder(BorderFactory.createEmptyBorder(20,20,20,20));
    }

    class UnitsListener implements ItemListener {
        public void itemStateChanged(ItemEvent e) {
            if (e.getStateChange() == ItemEvent.SELECTED) {
                // Turn it to metric.
                rowView.setIsMetric(true);
                columnView.setIsMetric(true);
            } else {
                // Turn it to inches.
                rowView.setIsMetric(false);
                columnView.setIsMetric(false);
            }
            picture.setMaxUnitIncrement(rowView.getIncrement());
        }
    }

    public static void main(String s[]) {
        JFrame frame = new JFrame("ScrollDemo");
        frame.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });

        frame.setContentPane(new ScrollDemo());
        frame.pack();
        frame.setVisible(true);
    }
}
```

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

public class Rule extends JComponent {
    public static final int INCH = Toolkit.getDefaultToolkit().
            getScreenResolution();
    public static final int HORIZONTAL = 0;
    public static final int VERTICAL = 1;
    public static final int SIZE = 35;

    public int orientation;
    public boolean isMetric;
    private int increment;
    private int units;

    public Rule(int o, boolean m) {
        orientation = o;
        isMetric = m;
        setIncrementAndUnits();
    }

    public void setIsMetric(boolean isMetric) {
        this.isMetric = isMetric;
        setIncrementAndUnits();
        repaint();
    }

    private void setIncrementAndUnits() {
        if (isMetric) {
            units = (int)((double)INCH / (double)2.54); // dots per centimeter
            increment = units;
        } else {
            units = INCH;
            increment = units / 2;
        }
    }

    public boolean isMetric() {
        return this.isMetric;
    }

    public int getIncrement() {
        return increment;
    }

    public void setPreferredHeight(int ph) {
        setPreferredSize(new Dimension(SIZE, ph));
    }

    public void setPreferredWidth(int pw) {
        setPreferredSize(new Dimension(pw, SIZE));
    }

    public void paintComponent(Graphics g) {
        Rectangle drawHere = g.getClipBounds();

        // Fill clipping area with dirty brown/orange.
        g.setColor(new Color(230, 163, 4));
        g.fillRect(drawHere.x, drawHere.y, drawHere.width, drawHere.height);

        // Do the ruler labels in a small font that's black.
        g.setFont(new Font("SansSerif", Font.PLAIN, 10));
        g.setColor(Color.black);
        // Some vars we need.
        int end = 0;
        int start = 0;
        int tickLength = 0;
        String text = null;

        // Use clipping bounds to calculate first tick and last tick location.
        if (orientation == HORIZONTAL) {
            start = (drawHere.x / increment) * increment;
            end = (((drawHere.x + drawHere.width) / increment) + 1)
                  * increment;
        } else {
            start = (drawHere.y / increment) * increment;
            end = (((drawHere.y + drawHere.height) / increment) + 1)
                  * increment;
        }

        // Make a special case of 0 to display the number
        // within the rule and draw a units label.
        if (start == 0) {
            text = Integer.toString(0) + (isMetric ? " cm" : " in");
            tickLength = 10;
            if (orientation == HORIZONTAL) {
                g.drawLine(0, SIZE-1, 0, SIZE-tickLength-1);
                g.drawString(text, 2, 21);
            } else {
                g.drawLine(SIZE-1, 0, SIZE-tickLength-1, 0);
                g.drawString(text, 9, 10);
            }
            text = null;
            start = increment;
        }

        // ticks and labels
        for (int i = start; i < end; i += increment) {
            if (i % units == 0)  {
                tickLength = 10;
                text = Integer.toString(i/units);
            } else {
                tickLength = 7;
                text = null;
            }

            if (tickLength != 0) {
                if (orientation == HORIZONTAL) {
                    g.drawLine(i, SIZE-1, i, SIZE-tickLength-1);
                    if (text != null)
                        g.drawString(text, i-3, 21);
                } else {
                    g.drawLine(SIZE-1, i, SIZE-tickLength-1, i);
                    if (text != null)
                        g.drawString(text, 9, i+3);
                }
            }
        }
    }
}
```

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

public class Corner extends JComponent {
    public void paintComponent(Graphics g) {
        // Fill me with dirty brown/orange.
        g.setColor(new Color(230, 163, 4));
        g.fillRect(0, 0, getWidth(), getHeight());
    }
}
```

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

public class ScrollablePicture extends JLabel implements Scrollable {

    private int maxUnitIncrement = 1;

    public ScrollablePicture(ImageIcon i, int m) {
        super(i);
        maxUnitIncrement = m;
    }

    public Dimension getPreferredScrollableViewportSize() {
        return getPreferredSize();
    }

    public int getScrollableUnitIncrement(Rectangle visibleRect,
                                          int orientation,
                                          int direction) {
        //Get the current position.
        int currentPosition = 0;
        if (orientation == SwingConstants.HORIZONTAL)
            currentPosition = visibleRect.x;
        else
            currentPosition = visibleRect.y;

        //Return the number of pixels between currentPosition
        //and the nearest tick mark in the indicated direction.
        if (direction < 0) {
            int newPosition = currentPosition -
                             (currentPosition / maxUnitIncrement) *
                              maxUnitIncrement;
            return (newPosition == 0) ? maxUnitIncrement : newPosition;
        } else {
            return ((currentPosition / maxUnitIncrement) + 1) *
                   maxUnitIncrement - currentPosition;
        }
    }

    public int getScrollableBlockIncrement(Rectangle visibleRect,
                                           int orientation,
                                           int direction) {
        if (orientation == SwingConstants.HORIZONTAL)
            return visibleRect.width - maxUnitIncrement;
        else
            return visibleRect.height - maxUnitIncrement;
    }

    public boolean getScrollableTracksViewportWidth() {
        return false;
    }

    public boolean getScrollableTracksViewportHeight() {
        return false;
    }

    public void setMaxUnitIncrement(int pixels) {
        maxUnitIncrement = pixels;
    }
}
```

```java
/*
 * This code is based on an example provided by John Vella,
 * a tutorial reader.
 */

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

public class ScrollDemo2 extends JPanel {
    private Dimension size; // indicates size taken up by graphics
    private Vector objects; // rectangular coordinates used to draw graphics

    private final Color colors[] = {
        Color.red, Color.blue, Color.green, Color.orange,
        Color.cyan, Color.magenta, Color.darkGray, Color.yellow};
    private final int color_n = colors.length;

    JPanel drawingArea;

    public ScrollDemo2() {
        setOpaque(true);
        size = new Dimension(0,0);
        objects = new Vector();

        //Set up the instructions.
        JLabel instructionsLeft = new JLabel(
                        "Click left mouse button to place a circle.");
        JLabel instructionsRight = new JLabel(
                        "Click right mouse button to clear drawing area.");
        JPanel instructionPanel = new JPanel(new GridLayout(0,1));
        instructionPanel.add(instructionsLeft);
        instructionPanel.add(instructionsRight);

        //Set up the drawing area.
        drawingArea = new JPanel() {
            protected void paintComponent(Graphics g) {
                super.paintComponent(g);

                Rectangle rect;
                for (int i = 0; i < objects.size(); i++) {
                    rect = (Rectangle)objects.elementAt(i);
                    g.setColor(colors[(i % color_n)]);
                    g.fillOval(rect.x, rect.y, rect.width, rect.height);
                }
            }
        };
        drawingArea.setBackground(Color.white);
        drawingArea.addMouseListener(new MyMouseListener());

        //Put the drawing area in a scroll pane.
        JScrollPane scroller = new JScrollPane(drawingArea);
        scroller.setPreferredSize(new Dimension(200,200));

        //Layout this demo.
        setLayout(new BorderLayout());
        add(instructionPanel, BorderLayout.NORTH);
        add(scroller, BorderLayout.CENTER);
    }
    class MyMouseListener extends MouseInputAdapter {
        final int W = 100;
        final int H = 100;

        public void mouseReleased(MouseEvent e) {
            boolean changed = false;
            if (SwingUtilities.isRightMouseButton(e)) {
                // This will clear the graphic objects.
                objects.removeAllElements();
                size.width=0;
                size.height=0;
                changed = true;
            } else {
                int x = e.getX() - W/2;
                int y = e.getY() - H/2;
                if (x < 0) x = 0;
                if (y < 0) y = 0;
                Rectangle rect = new Rectangle(x, y, W, H);
                objects.addElement(rect);
                drawingArea.scrollRectToVisible(rect);

                int this_width = (x + W + 2);
                if (this_width > size.width)
                    {size.width = this_width; changed=true;}

                int this_height = (y + H + 2);
                if (this_height > size.height)
                    {size.height = this_height; changed=true;}
            }
            if (changed) {
                //Update client's preferred size because
                //the area taken up by the graphics has
                //gotten larger or smaller (if cleared).
                drawingArea.setPreferredSize(size);

                //Let the scroll pane know to update itself
                //and its scrollbars.
                drawingArea.revalidate();
            }
            drawingArea.repaint();
        }
    }

    public static void main (String args[]) {
        JFrame frame = new JFrame("ScrollDemo2");
        frame.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {System.exit(0);}
        });

        frame.setContentPane(new ScrollDemo2());
        frame.pack();
        frame.setVisible(true);
    }
}
```

```
import javax.swing.JToolBar;
import javax.swing.JButton;
import javax.swing.ImageIcon;

import javax.swing.JFrame;
import javax.swing.JTextArea;
import javax.swing.JScrollPane;
import javax.swing.JPanel;

import java.awt.*;
import java.awt.event.*;

public class ToolBarDemo extends JFrame {
    protected JTextArea textArea;
    protected String newline = "\n";

    public ToolBarDemo() {
        //Do frame stuff.
        super("ToolBarDemo");
        addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });

        //Create the toolbar.
        JToolBar toolBar = new JToolBar();
        addButtons(toolBar);

        //Create the text area used for output.
        textArea = new JTextArea(5, 30);
        JScrollPane scrollPane = new JScrollPane(textArea);

        //Lay out the content pane.
        JPanel contentPane = new JPanel();
        contentPane.setLayout(new BorderLayout());
        contentPane.setPreferredSize(new Dimension(400, 100));
        contentPane.add(toolBar, BorderLayout.NORTH);
        contentPane.add(scrollPane, BorderLayout.CENTER);
        setContentPane(contentPane);
    }

    protected void addButtons(JToolBar toolBar) {
        JButton button = null;

        //first button
        button = new JButton(new ImageIcon("images/left.gif"));
        button.setToolTipText("This is the left button");
        button.addActionListener(new ActionListener() {
            public void actionPerformed(ActionEvent e) {
                displayResult("Action for first button");
            }
        });
        toolBar.add(button);

        //second button
        button = new JButton(new ImageIcon("images/middle.gif"));
        button.setToolTipText("This is the middle button");
        button.addActionListener(new ActionListener() {
            public void actionPerformed(ActionEvent e) {
                displayResult("Action for second button");
            }
        });
        toolBar.add(button);

        //third button
        button = new JButton(new ImageIcon("images/right.gif"));
        button.setToolTipText("This is the right button");
        button.addActionListener(new ActionListener() {
            public void actionPerformed(ActionEvent e) {
                displayResult("Action for third button");
            }
        });
        toolBar.add(button);
    }

    protected void displayResult(String actionDescription) {
        textArea.append(actionDescription + newline);
    }

    public static void main(String[] args) {
        ToolBarDemo frame = new ToolBarDemo();
        frame.pack();
        frame.setVisible(true);
    }
}
```

```java
import javax.swing.JToolBar;
import javax.swing.JButton;
import javax.swing.ImageIcon;

import javax.swing.JTextField;

import javax.swing.JFrame;
import javax.swing.JTextArea;
import javax.swing.JScrollPane;
import javax.swing.JPanel;

import java.awt.*;
import java.awt.event.*;

public class ToolBarDemo2 extends JFrame {
    protected JTextArea textArea;
    protected String newline = "\n";

    public ToolBarDemo2() {
        //Do frame stuff.
        super("ToolBarDemo2");
        addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });

        //Create the toolbar.
        JToolBar toolBar = new JToolBar();
        toolBar.setFloatable(false);
        addButtons(toolBar);

        //Create the text area used for output.
        textArea = new JTextArea(5, 30);
        JScrollPane scrollPane = new JScrollPane(textArea);

        //Lay out the content pane.
        JPanel contentPane = new JPanel();
        contentPane.setLayout(new BorderLayout());
        contentPane.setPreferredSize(new Dimension(400, 100));
        contentPane.add(toolBar, BorderLayout.NORTH);
        contentPane.add(scrollPane, BorderLayout.CENTER);
        setContentPane(contentPane);
    }

    protected void addButtons(JToolBar toolBar) {
        JButton button = null;

        //first button
        button = new JButton(new ImageIcon("images/left.gif"));
        button.setToolTipText("This is the left button");
        button.addActionListener(new ActionListener() {
            public void actionPerformed(ActionEvent e) {
                displayResult("Action for first button");
            }
        });
        toolBar.add(button);

        //second button
        button = new JButton(new ImageIcon("images/middle.gif"));
        button.setToolTipText("This is the middle button");
        button.addActionListener(new ActionListener() {
            public void actionPerformed(ActionEvent e) {
                displayResult("Action for second button");
            }
        });
        toolBar.add(button);

        //third button
        button = new JButton(new ImageIcon("images/right.gif"));
        button.setToolTipText("This is the right button");
        button.addActionListener(new ActionListener() {
            public void actionPerformed(ActionEvent e) {
                displayResult("Action for third button");
            }
        });
        toolBar.add(button);

        //separator
        toolBar.addSeparator();

        //fourth button
        button = new JButton("Another button");
        button.addActionListener(new ActionListener() {
            public void actionPerformed(ActionEvent e) {
                displayResult("Action for fourth button");
            }
        });
        toolBar.add(button);

        //fifth component is NOT a button!
        JTextField textField = new JTextField("A text field");
        //Action handler implementation would go here.
        toolBar.add(textField);
    }

    protected void displayResult(String actionDescription) {
        textArea.append(actionDescription + newline);
    }

    public static void main(String[] args) {
        ToolBarDemo2 frame = new ToolBarDemo2();
        frame.pack();
        frame.setVisible(true);
    }
}
```

```
/** Uses a SwingWorker to perform a time-consuming (and utterly fake) task. */

public class LongTask {
    private int lengthOfTask;
    private int current = 0;
    private String statMessage;

    LongTask() {
        //Compute length of task...
        //In a real program, this would figure out
        //the number of bytes to read or whatever.
        lengthOfTask = 1000;
    }

    /**
     * Called from ProgressBarDemo to start the task.
     */
    void go() {
        current = 0;
        final SwingWorker worker = new SwingWorker() {
            public Object construct() {
                return new ActualTask();
            }
        };
        worker.start();
    }

    /**
     * Called from ProgressBarDemo to find out how much work needs
     * to be done.
     */
    int getLengthOfTask() {
        return lengthOfTask;
    }

    /**
     * Called from ProgressBarDemo to find out how much has been done.
     */
    int getCurrent() {
        return current;
    }

    void stop() {
        current = lengthOfTask;
    }

    /**
     * Called from ProgressBarDemo to find out if the task has completed.
     */
    boolean done() {
        if (current >= lengthOfTask)
            return true;
        else
            return false;
    }

    String getMessage() {
        return statMessage;
    }

    /**
     * The actual long running task.  This runs in a SwingWorker thread.
     */
    class ActualTask {
        ActualTask () {
            //Fake a long task,
            //making a random amount of progress every second.
            while (current < lengthOfTask) {
                try {
                    Thread.sleep(1000); //sleep for a second
                    current += Math.random() * 100; //make some progress
                    if (current > lengthOfTask) {
                        current = lengthOfTask;
                    }
                    statMessage = "Completed " + current +
                                  " out of " + lengthOfTask + ".";
                } catch (InterruptedException e) {}
            }
        }
    }
}
```

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

public class ProgressMonitorDemo extends JFrame {
    public final static int ONE_SECOND = 1000;

    private ProgressMonitor progressMonitor;
    private Timer timer;
    private JButton startButton;
    private LongTask task;
    private JTextArea taskOutput;
    private String newline = "\n";

    public ProgressMonitorDemo() {
        super("ProgressMonitorDemo");
        task = new LongTask();

        //Create the demo's UI.
        startButton = new JButton("Start");
        startButton.setActionCommand("start");
        startButton.addActionListener(new ButtonListener());

        taskOutput = new JTextArea(5, 20);
        taskOutput.setMargin(new Insets(5,5,5,5));
        taskOutput.setEditable(false);

        JPanel contentPane = new JPanel();
        contentPane.setLayout(new BorderLayout());
        contentPane.add(startButton, BorderLayout.NORTH);
        contentPane.add(new JScrollPane(taskOutput), BorderLayout.CENTER);
        contentPane.setBorder(BorderFactory.createEmptyBorder(20, 20, 20, 20));
        setContentPane(contentPane);

        //Create a timer.
        timer = new Timer(ONE_SECOND, new TimerListener());
    }

    /**
     * The actionPerformed method in this class
     * is called each time the Timer "goes off".
     */
    class TimerListener implements ActionListener {
        public void actionPerformed(ActionEvent evt) {
            if (progressMonitor.isCanceled() || task.done()) {
                progressMonitor.close();
                task.stop();
                Toolkit.getDefaultToolkit().beep();
                timer.stop();
                if (task.done()) {
                    taskOutput.append("Task completed." + newline);
                }
                startButton.setEnabled(true);
            } else {
                progressMonitor.setNote(task.getMessage());
                progressMonitor.setProgress(task.getCurrent());
                taskOutput.append(task.getMessage() + newline);
                taskOutput.setCaretPosition(
                    taskOutput.getDocument().getLength());
            }
        }
    }
    /**
     * The actionPerformed method in this class
     * is called when the user presses the start button.
     */
    class ButtonListener implements ActionListener {
        public void actionPerformed(ActionEvent evt) {
            progressMonitor = new ProgressMonitor(ProgressMonitorDemo.this,
                                      "Running a Long Task",
                                      "", 0, task.getLengthOfTask());
            progressMonitor.setProgress(0);
            progressMonitor.setMillisToDecideToPopup(2 * ONE_SECOND);

            startButton.setEnabled(false);
            task.go();
            timer.start();
        }
    }

    public static void main(String[] args) {
        JFrame frame = new ProgressMonitorDemo();
        frame.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });

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

The Java^{TM} Tutorial

Trail: Creating a GUI with JFC/Swing
Lesson: Using Swing Components

Run TumbleItem

Your browser is completely ignoring the <APPLET> tag!

Note: Because the preceding applet uses the Swing 1.1 API, it requires Java Plug-in 1.1.2 or Java Plug-in 1.2. It won't work with Java Plug-in 1.1.1 or uncustomized 1.1 browsers. For more information about running applets in the tutorial, refer to About Our Examples. That page includes a section about Downloading Java Plug-in.

```
<applet code="AppletButton.class"
        archive="example-swing/layout.jar"
        width="350" height="60">
<param name="windowClass" value="BorderWindow">
<param name="windowTitle" value="BorderLayout">
<param name="buttonText" value="Click here to see a BorderLayout in action">

Since you can't run the applet,
here's a picture of it:

#usemacro UI_FIGURE (
    NAME borderlayout.gif
    W 222
    H 106
    ALT Five buttons laid out with a BorderLayout.
)

</applet>
```

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

public class ColorChooserDemo extends JFrame {
    public ColorChooserDemo() {
        super("ColorChooserDemo");

        //Set up the banner at the top of the window
        final JLabel banner = new JLabel("Welcome to the Tutorial Zone!",
                                         JLabel.CENTER);
        banner.setForeground(Color.yellow);
        banner.setBackground(Color.blue);
        banner.setOpaque(true);
        banner.setFont(new Font("SansSerif", Font.BOLD, 24));
        banner.setPreferredSize(new Dimension(100, 65));

        JPanel bannerPanel = new JPanel(new BorderLayout());
        bannerPanel.add(banner, BorderLayout.CENTER);
        bannerPanel.setBorder(BorderFactory.createTitledBorder("Banner"));

        //Set up color chooser for setting text color
        final JColorChooser tcc = new JColorChooser(banner.getForeground());
        tcc.getSelectionModel().addChangeListener(
            new ChangeListener() {
                public void stateChanged(ChangeEvent e) {
                    Color newColor = tcc.getColor();
                    banner.setForeground(newColor);
                }
            }
        );
        tcc.setBorder(BorderFactory.createTitledBorder(
                                             "Choose Text Color"));

        //Add the components to the demo frame
        Container contentPane = getContentPane();
        contentPane.add(bannerPanel, BorderLayout.CENTER);
        contentPane.add(tcc, BorderLayout.SOUTH);
    }

    public static void main(String[] args) {
        JFrame frame = new ColorChooserDemo();
        frame.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {System.exit(0);}
        });

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

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

public class ColorChooserDemo2 extends JFrame {
    public ColorChooserDemo2() {
        super("ColorChooserDemo2");

        //Set up banner to use as custom preview panel
        final JLabel banner = new JLabel("Welcome to the Tutorial Zone!",
                                         JLabel.CENTER);
        banner.setForeground(Color.yellow);
        banner.setBackground(Color.blue);
        banner.setOpaque(true);
        banner.setFont(new Font("SansSerif", Font.BOLD, 24));
        banner.setPreferredSize(new Dimension(100, 65));

        JPanel bannerPanel = new JPanel(new BorderLayout());
        bannerPanel.add(banner, BorderLayout.CENTER);
        bannerPanel.setBorder(BorderFactory.createTitledBorder("Banner"));

        //Set up color chooser for setting background color
        JPanel panel = new JPanel();
        JButton bcc = new JButton("Show Color Chooser...");
        bcc.addActionListener(
            new ActionListener() {
                public void actionPerformed(ActionEvent e) {
                    Color newColor = JColorChooser.showDialog(
                                                ColorChooserDemo2.this,
                                                "Choose Background Color",
                                                banner.getBackground());
                    if (newColor != null) {
                        banner.setBackground(newColor);
                    }
                }
            }
        );
        panel.add(bcc);
        panel.setBorder(BorderFactory.createTitledBorder(
                                "Choose Background Color"));

        //Set up color chooser for setting text color
        final JColorChooser tcc = new JColorChooser();
        tcc.getSelectionModel().addChangeListener(
            new ChangeListener() {
                public void stateChanged(ChangeEvent e) {
                    Color newColor = tcc.getColor();
                    banner.setForeground(newColor);
                }
            }
        );
        tcc.setBorder(BorderFactory.createTitledBorder("Choose Text Color"));

        //Remove the preview panel
        //XXXXXX: bug #4166059, in Swing 1.1 beta 2 and earlier
        //setPreviewPanel throws an exception. no known workaround.
        tcc.setPreviewPanel(new JPanel());

        //Override the chooser panels with our own
        AbstractColorChooserPanel panels[] = { new CrayonPanel() };
        tcc.setChooserPanels(panels);
        tcc.setColor(banner.getForeground());

        Container contentPane = getContentPane();
        contentPane.add(bannerPanel, BorderLayout.NORTH);
        contentPane.add(panel, BorderLayout.CENTER);
        contentPane.add(tcc, BorderLayout.SOUTH);
    }

    public static void main(String[] args) {

        JFrame frame = new ColorChooserDemo2();

        frame.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });

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

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

public class CrayonPanel extends AbstractColorChooserPanel {
    JToggleButton redCrayon;
    JToggleButton yellowCrayon;
    JToggleButton greenCrayon;
    JToggleButton blueCrayon;

    public CrayonPanel() {
        super();
    }

    public void updateChooser() {
        Color color = getColorFromModel();
        if (color.equals(Color.red)) {
            redCrayon.setSelected(true);
        } else if (color.equals(Color.yellow)) {
            yellowCrayon.setSelected(true);
        } else if (color.equals(Color.green)) {
            greenCrayon.setSelected(true);
        } else if (color.equals(Color.blue)) {
            blueCrayon.setSelected(true);
        }
    }

    protected void buildChooser() {
        setLayout(new GridLayout(0, 1));

        CrayonListener cl = new CrayonListener();
        ButtonGroup boxOfCrayons = new ButtonGroup();
        Border border = BorderFactory.createEmptyBorder(4,4,4,4);

        redCrayon = new JToggleButton(new ImageIcon("images/red.gif"));
        redCrayon.setActionCommand("red");
        redCrayon.addActionListener(cl);
        redCrayon.setBorder(border);
        boxOfCrayons.add(redCrayon);
        add(redCrayon);

        yellowCrayon = new JToggleButton(new ImageIcon("images/yellow.gif"));
        yellowCrayon.setActionCommand("yellow");
        yellowCrayon.addActionListener(cl);
        yellowCrayon.setBorder(border);
        boxOfCrayons.add(yellowCrayon);
        add(yellowCrayon);

        greenCrayon = new JToggleButton(new ImageIcon("images/green.gif"));
        greenCrayon.setActionCommand("green");
        greenCrayon.addActionListener(cl);
        greenCrayon.setBorder(border);
        boxOfCrayons.add(greenCrayon);
        add(greenCrayon);

        blueCrayon = new JToggleButton(new ImageIcon("images/blue.gif"));
        blueCrayon.setActionCommand("blue");
        blueCrayon.addActionListener(cl);
        blueCrayon.setBorder(border);
        boxOfCrayons.add(blueCrayon);
        add(blueCrayon);
    }

    class CrayonListener implements ActionListener {
        public void actionPerformed(ActionEvent e) {
            Color newColor = null;
            JToggleButton source = (JToggleButton)e.getSource();
            if (source.getActionCommand().equals("green"))
                newColor = Color.green;
            else if (source.getActionCommand().equals("red"))
                newColor = Color.red;
            else if (source.getActionCommand().equals("yellow"))
                newColor = Color.yellow;
            else if (source.getActionCommand().equals("blue"))
                newColor = Color.blue;
            getColorSelectionModel().setSelectedColor(newColor);
        }
    }

    public String getDisplayName() {
        return "Crayons";
    }

    public Icon getSmallDisplayIcon() {
        return null;
    }

    public Icon getLargeDisplayIcon() {
        return null;
    }
}
```

```
/*
 * Swing version.
 */

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

public class BoxWindow extends JFrame {
    boolean inAnApplet = true;

    public BoxWindow() {
        Container contentPane = getContentPane();
        contentPane.setLayout(new BoxLayout(contentPane,
                                            BoxLayout.Y_AXIS));

        addAButton("Button 1", contentPane);
        addAButton("2", contentPane);
        addAButton("Button 3", contentPane);
        addAButton("Long-Named Button 4", contentPane);
        addAButton("Button 5", contentPane);

        addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                if (inAnApplet) {
                    dispose();
                } else {
                    System.exit(0);
                }
            }
        });
    }

    private void addAButton(String text, Container container) {
        JButton button = new JButton(text);
        button.setAlignmentX(Component.CENTER_ALIGNMENT);
        container.add(button);
    }

    public static void main(String args[]) {
        BoxWindow window = new BoxWindow();
        window.inAnApplet = false;

        window.setTitle("BoxLayout");
        window.pack();
        window.setVisible(true);
    }
}
```

```
<applet code="AppletButton.class"
        archive="example-swing/layout.jar"
        width="350" height="60">
<param name="windowClass" value="BoxWindow">
<param name="windowTitle" value="BoxLayout">
<param name="buttonText" value="Click here to see a BoxLayout in action">

Since you can't run the applet,
here's a picture of it:

#usemacro UI_FIGURE (
    NAME boxlayout.gif
    W 222
    H 106
    ALT Five buttons laid out with a BoxLayout.
)

</applet>
```

```
<applet code="AppletButton.class"
        archive="example-swing/layout.jar"
        width="350" height="60">
<param name="windowClass" value="CardWindow">
<param name="windowTitle" value="CardLayout">
<param name="buttonText" value="Click here to see a CardLayout in action">

Since you can't run the applet,
here's a picture of it:

#usemacro UI_FIGURE (
    NAME cardlayout.gif
    W 306
    H 99
    ALT A program that puts two panels in the same space with CardLayout.
)

</applet>
```

```
/*
 * Swing version.
 */

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

public class CustomWindow extends JFrame {
    boolean inAnApplet = true;

    public CustomWindow() {
        Container contentPane = getContentPane();
        contentPane.setLayout(new DiagonalLayout());

        contentPane.add(new JButton("Button 1"));
        contentPane.add(new JButton("Button 2"));
        contentPane.add(new JButton("Button 3"));
        contentPane.add(new JButton("Button 4"));
        contentPane.add(new JButton("Button 5"));

        addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                if (inAnApplet) {
                    dispose();
                } else {
                    System.exit(0);
                }
            }
        });
    }

    public static void main(String args[]) {
        CustomWindow window = new CustomWindow();
        window.inAnApplet = false;

        window.setTitle("Custom Layout Manager");
        window.pack();
        window.setVisible(true);
    }
}
```

```
<applet code="AppletButton.class"
        archive="example-swing/layout.jar"
        width="450" height="60">
<param name="windowClass" value="CustomWindow">
<param name="windowTitle" value="Custom Layout Manager (DiagonalLayout)">
<param name="buttonText" value="Click here to see a custom layout manager in action">

Since you can't run the applet,
here's a picture of it:

#usemacro UI_FIGURE (
    NAME 13custom31.gif
    W 325
    H 170
    ALT A custom layout manager that lays out components diagonally.
)

</applet>
```

```
<applet code="AppletButton.class"
        archive="example-swing/layout.jar"
        width="350" height="60">
<param name="windowClass" value="FlowWindow">
<param name="windowTitle" value="FlowLayout">
<param name="buttonText" value="Click here to see a FlowLayout in action">

Since you can't run the applet,
here's a picture of it:

#usemacro UI_FIGURE (
    NAME flowlayout.gif
    W 542
    H 66
    ALT Five buttons laid out with a FlowLayout.
)

</applet>
```

```
<applet code="AppletButton.class"
        archive="example-swing/layout.jar"
        width="350" height="60">
<param name="windowClass" value="GridBagWindow">
<param name="windowTitle" value="GridBagLayout">
<param name="buttonText" value="Click here to see a GridBagLayout in action">

Since you can't run the applet,
here's a picture of it:

#usemacro UI_FIGURE (
    NAME gridbaglayout.gif
    W 236
    H 154
    ALT Five buttons laid out with a GridBagLayout.
)

</applet>
```

```
/*
 * Swing Version
 */

import javax.swing.*;
import javax.swing.text.*;

import java.awt.*;              //for layout managers
import java.awt.event.*;        //for action and window events

import java.net.URL;
import java.io.IOException;

public class TextSamplerDemo extends JFrame
                             implements ActionListener {
    private String newline = "\n";
    protected static final String textFieldString = "JTextField";
    protected static final String passwordFieldString = "JPasswordField";

    protected JLabel actionLabel;

    public TextSamplerDemo() {
        super("TextSamplerDemo");

        //Create a regular text field.
        JTextField textField = new JTextField(10);
        textField.setActionCommand(textFieldString);
        textField.addActionListener(this);

        //Create a password field.
        JPasswordField passwordField = new JPasswordField(10);
        passwordField.setActionCommand(passwordFieldString);
        passwordField.addActionListener(this);

        //Create some labels for the fields.
        JLabel textFieldLabel = new JLabel(textFieldString + ": ");
        textFieldLabel.setLabelFor(textField);
        JLabel passwordFieldLabel = new JLabel(passwordFieldString + ": ");
        passwordFieldLabel.setLabelFor(passwordField);

        //Create a label to put messages during an action event.
        actionLabel = new JLabel("Type text and then Return in a field.");
        actionLabel.setBorder(BorderFactory.createEmptyBorder(10,0,0,0));

        //Lay out the text controls and the labels.
        JPanel textControlsPane = new JPanel();
        GridBagLayout gridbag = new GridBagLayout();
        GridBagConstraints c = new GridBagConstraints();

        textControlsPane.setLayout(gridbag);

        JLabel[] labels = {textFieldLabel, passwordFieldLabel};
        JTextField[] textFields = {textField, passwordField};
        addLabelTextRows(labels, textFields, gridbag, textControlsPane);

        c.gridwidth = GridBagConstraints.REMAINDER; //last
        c.anchor = GridBagConstraints.WEST;
        c.weightx = 1.0;
        gridbag.setConstraints(actionLabel, c);
        textControlsPane.add(actionLabel);
        textControlsPane.setBorder(
                BorderFactory.createCompoundBorder(
                                BorderFactory.createTitledBorder("Text Fields"),
                                BorderFactory.createEmptyBorder(5,5,5,5)));

        //Create a text area.
        JTextArea textArea = new JTextArea(
                "This is an editable JTextArea " +
                "that has been initialized with the setText method. " +
                "A text area is a \"plain\" text component, " +
                "which means that although it can display text " +
                "in any font, all of the text is in the same font."
        );
        textArea.setFont(new Font("Serif", Font.ITALIC, 16));
        textArea.setLineWrap(true);
        textArea.setWrapStyleWord(true);
        JScrollPane areaScrollPane = new JScrollPane(textArea);
        areaScrollPane.setVerticalScrollBarPolicy(
                        JScrollPane.VERTICAL_SCROLLBAR_ALWAYS);
        areaScrollPane.setPreferredSize(new Dimension(250, 250));
        areaScrollPane.setBorder(
            BorderFactory.createCompoundBorder(
                BorderFactory.createCompoundBorder(
                                BorderFactory.createTitledBorder("Plain Text"),
                                BorderFactory.createEmptyBorder(5,5,5,5)),
                areaScrollPane.getBorder()));

        //Create an editor pane.
        JEditorPane editorPane = createEditorPane();
        JScrollPane editorScrollPane = new JScrollPane(editorPane);
        editorScrollPane.setVerticalScrollBarPolicy(
                        JScrollPane.VERTICAL_SCROLLBAR_ALWAYS);
        editorScrollPane.setPreferredSize(new Dimension(250, 145));
        editorScrollPane.setMinimumSize(new Dimension(10, 10));

        //Create a text pane.
        JTextPane textPane = createTextPane();
        JScrollPane paneScrollPane = new JScrollPane(textPane);
        paneScrollPane.setVerticalScrollBarPolicy(
                        JScrollPane.VERTICAL_SCROLLBAR_ALWAYS);
        paneScrollPane.setPreferredSize(new Dimension(250, 155));
        paneScrollPane.setMinimumSize(new Dimension(10, 10));

        //Put the editor pane and the text pane in a split pane.
        JSplitPane splitPane = new JSplitPane(JSplitPane.VERTICAL_SPLIT,
                                              editorScrollPane,
                                              paneScrollPane);
        splitPane.setOneTouchExpandable(true);
        JPanel rightPane = new JPanel();
        rightPane.add(splitPane);
        rightPane.setBorder(BorderFactory.createCompoundBorder(
                        BorderFactory.createTitledBorder("Styled Text"),
                        BorderFactory.createEmptyBorder(5,5,5,5)));


        //Put everything in the applet.
        JPanel leftPane = new JPanel();
        BoxLayout leftBox = new BoxLayout(leftPane, BoxLayout.Y_AXIS);
        leftPane.setLayout(leftBox);
        leftPane.add(textControlsPane);
        leftPane.add(areaScrollPane);

        JPanel contentPane = new JPanel();
        BoxLayout box = new BoxLayout(contentPane, BoxLayout.X_AXIS);
        contentPane.setLayout(box);
        contentPane.add(leftPane);
        contentPane.add(rightPane);
        setContentPane(contentPane);
    }

    private void addLabelTextRows(JLabel[] labels,
                                  JTextField[] textFields,
                                  GridBagLayout gridbag,
                                  Container container) {
        GridBagConstraints c = new GridBagConstraints();
        c.anchor = GridBagConstraints.EAST;
        int numLabels = labels.length;

        for (int i = 0; i < numLabels; i++) {
            c.gridwidth = GridBagConstraints.RELATIVE; //next-to-last
            c.fill = GridBagConstraints.NONE;      //reset to default
            c.weightx = 0.0;                       //reset to default
            gridbag.setConstraints(labels[i], c);
            container.add(labels[i]);

            c.gridwidth = GridBagConstraints.REMAINDER;     //end row
            c.fill = GridBagConstraints.HORIZONTAL;
            c.weightx = 1.0;
            gridbag.setConstraints(textFields[i], c);
            container.add(textFields[i]);
        }
    }

    public void actionPerformed(ActionEvent e) {
        String prefix = "You typed \"";
        if (e.getActionCommand().equals(textFieldString)) {
            JTextField source = (JTextField)e.getSource();
            actionLabel.setText(prefix + source.getText() + "\"");
        } else {
            JPasswordField source = (JPasswordField)e.getSource();
            actionLabel.setText(prefix + new String(source.getPassword())
                                + "\"");
        }
    }

    private JEditorPane createEditorPane() {
        JEditorPane editorPane = new JEditorPane();
        editorPane.setEditable(false);
        String s = null;
        try {
            s = "file:"
                + System.getProperty("user.dir")
                + System.getProperty("file.separator")
                + "TextSamplerDemoHelp.html";
            URL helpURL = new URL(s);
            displayURL(helpURL, editorPane);
        } catch (Exception e) {
            System.err.println("Couldn't create help URL: " + s);
        }

        return editorPane;
    }

    private void displayURL(URL url, JEditorPane editorPane) {
        try {
            editorPane.setPage(url);
        } catch (IOException e) {
            System.err.println("Attempted to read a bad URL: " + url);
        }
    }

    private JTextPane createTextPane() {
        JTextPane textPane = new JTextPane();
        String[] initString =
                { "This is an editable JTextPane, ",            //regular
                  "another ",                                   //italic
                  "styled ",                                    //bold
                  "text ",                                      //small
                  "component, ",                                //large
                  "which supports embedded components..." + newline,//regular
                  " " + newline,                                //button
                  "...and embedded icons..." + newline,         //regular
                  " ",                                          //icon
                  newline + "JTextPane is a subclass of JEditorPane that " +
                    "uses a StyledEditorKit and StyledDocument, and provides " +
                    "cover methods for interacting with those objects."
                 };

        String[] initStyles =
                { "regular", "italic", "bold", "small", "large",
                  "regular", "button", "regular", "icon",
                  "regular"
                };

        initStylesForTextPane(textPane);

        Document doc = textPane.getDocument();

        try {
            for (int i=0; i < initString.length; i++) {
                doc.insertString(doc.getLength(), initString[i],
                                 textPane.getStyle(initStyles[i]));
            }
        } catch (BadLocationException ble) {
            System.err.println("Couldn't insert initial text.");
        }

        return textPane;
    }

    protected void initStylesForTextPane(JTextPane textPane) {
        //Initialize some styles.
        Style def = StyleContext.getDefaultStyleContext().
                                        getStyle(StyleContext.DEFAULT_STYLE);

        Style regular = textPane.addStyle("regular", def);
        StyleConstants.setFontFamily(def, "SansSerif");

        Style s = textPane.addStyle("italic", regular);
        StyleConstants.setItalic(s, true);

        s = textPane.addStyle("bold", regular);
        StyleConstants.setBold(s, true);

        s = textPane.addStyle("small", regular);
        StyleConstants.setFontSize(s, 10);

        s = textPane.addStyle("large", regular);
        StyleConstants.setFontSize(s, 16);
        s = textPane.addStyle("icon", regular);
        StyleConstants.setAlignment(s, StyleConstants.ALIGN_CENTER);
        StyleConstants.setIcon(s, new ImageIcon("images/Pig.gif"));

        s = textPane.addStyle("button", regular);
        StyleConstants.setAlignment(s, StyleConstants.ALIGN_CENTER);
        JButton button = new JButton(new ImageIcon("images/sound.gif"));
        button.setMargin(new Insets(0,0,0,0));
        button.addActionListener(new ActionListener() {
            public void actionPerformed(ActionEvent e) {
                Toolkit.getDefaultToolkit().beep();
            }
        });
        StyleConstants.setComponent(s, button);
    }

    public static void main(String[] args) {
        JFrame frame = new TextSamplerDemo();

        frame.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });

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

```
<applet code="AppletButton.class"
        archive="example-swing/layout.jar"
        width="350" height="60">
<param name="windowClass" value="GridWindow">
<param name="windowTitle" value="GridLayout">
<param name="buttonText" value="Click here to see a GridLayout in action">

Since you can't run the applet,
here's a picture of it:

#usemacro UI_FIGURE (
    NAME gridlayout.gif
    W 379
    H 106
    ALT Five buttons laid out with a GridLayout.
)

</applet>
```

```
import java.io.*;
import java.awt.*;
import java.awt.event.*;
import javax.swing.*;
import javax.swing.filechooser.*;

public class FileChooserDemo extends JFrame {
    static private final String newline = "\n";

    public FileChooserDemo() {
        super("FileChooserDemo");

        //Create the log first, because the action listeners
        //need to refer to it.
        final JTextArea log = new JTextArea(5,20);
        log.setMargin(new Insets(5,5,5,5));
        log.setEditable(false);
        JScrollPane logScrollPane = new JScrollPane(log);

        //Create a file chooser
        final JFileChooser fc = new JFileChooser();

        //Create the open button
        ImageIcon openIcon = new ImageIcon("images/open.gif");
        JButton openButton = new JButton("Open a File...", openIcon);
        openButton.addActionListener(new ActionListener() {
            public void actionPerformed(ActionEvent e) {
                int returnVal = fc.showOpenDialog(FileChooserDemo.this);

                if (returnVal == JFileChooser.APPROVE_OPTION) {
                    File file = fc.getSelectedFile();
                    //this is where a real application would open the file.
                    log.append("Opening: " + file.getName() + "." + newline);
                } else {
                    log.append("Open command cancelled by user." + newline);
                }
            }
        });

        //Create the save button
        ImageIcon saveIcon = new ImageIcon("images/save.gif");
        JButton saveButton = new JButton("Save a File...", saveIcon);
        saveButton.addActionListener(new ActionListener() {
            public void actionPerformed(ActionEvent e) {
                int returnVal = fc.showSaveDialog(FileChooserDemo.this);

                if (returnVal == JFileChooser.APPROVE_OPTION) {
                    File file = fc.getSelectedFile();
                    //this is where a real application would save the file.
                    log.append("Saving: " + file.getName() + "." + newline);
                } else {
                    log.append("Save command cancelled by user." + newline);
                }
            }
        });

        //For layout purposes, put the buttons in a separate panel
        JPanel buttonPanel = new JPanel();
        buttonPanel.add(openButton);
        buttonPanel.add(saveButton);

        //Explicitly set the focus sequence.
        openButton.setNextFocusableComponent(saveButton);
        saveButton.setNextFocusableComponent(openButton);

        //Add the buttons and the log to the frame
        Container contentPane = getContentPane();
        contentPane.add(buttonPanel, BorderLayout.NORTH);
        contentPane.add(logScrollPane, BorderLayout.CENTER);
    }

    public static void main(String[] args) {
        JFrame frame = new FileChooserDemo();

        frame.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });

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

```
import java.io.File;
import javax.swing.*;
import javax.swing.filechooser.*;

public class ImageFilter extends FileFilter {

    // Accept all directories and all gif, jpg, or tiff files.
    public boolean accept(File f) {
        if (f.isDirectory()) {
            return true;
        }

        String extension = Utils.getExtension(f);
        if (extension != null) {
            if (extension.equals(Utils.tiff) ||
                extension.equals(Utils.tif) ||
                extension.equals(Utils.gif) ||
                extension.equals(Utils.jpeg) ||
                extension.equals(Utils.jpg)) {
                    return true;
            } else {
                return false;
            }
        }

        return false;
    }

    // The description of this filter
    public String getDescription() {
        return "Just Images";
    }
}
```

```
import java.io.File;

public class Utils {

    public final static String jpeg = "jpeg";
    public final static String jpg = "jpg";
    public final static String gif = "gif";
    public final static String tiff = "tiff";
    public final static String tif = "tif";

    /*
     * Get the extension of a file.
     */
    public static String getExtension(File f) {
        String ext = null;
        String s = f.getName();
        int i = s.lastIndexOf('.');

        if (i > 0 &&  i < s.length() - 1) {
            ext = s.substring(i+1).toLowerCase();
        }
        return ext;
    }
}
```

```java
import java.io.File;
import javax.swing.*;
import javax.swing.filechooser.*;

public class ImageFileView extends FileView {
    ImageIcon jpgIcon = new ImageIcon("images/jpgIcon.gif");
    ImageIcon gifIcon = new ImageIcon("images/gifIcon.gif");
    ImageIcon tiffIcon = new ImageIcon("images/tiffIcon.gif");

    public String getName(File f) {
        return null; // let the L&F FileView figure this out
    }

    public String getDescription(File f) {
        return null; // let the L&F FileView figure this out
    }

    public Boolean isTraversable(File f) {
        return null; // let the L&F FileView figure this out
    }

    public String getTypeDescription(File f) {
        String extension = Utils.getExtension(f);
        String type = null;

        if (extension != null) {
            if (extension.equals(Utils.jpeg) ||
                extension.equals(Utils.jpg)) {
                type = "JPEG Image";
            } else if (extension.equals(Utils.gif)){
                type = "GIF Image";
            } else if (extension.equals(Utils.tiff) ||
                       extension.equals(Utils.tif)) {
                type = "TIFF Image";
            }
        }
        return type;
    }

    public Icon getIcon(File f) {
        String extension = Utils.getExtension(f);
        Icon icon = null;

        if (extension != null) {
            if (extension.equals(Utils.jpeg) ||
                extension.equals(Utils.jpg)) {
                icon = jpgIcon;
            } else if (extension.equals(Utils.gif)) {
                icon = gifIcon;
            } else if (extension.equals(Utils.tiff) ||
                       extension.equals(Utils.tif)) {
                icon = tiffIcon;
            }
        }
        return icon;
    }
}
```

```
import javax.swing.*;
import java.beans.*;
import java.awt.*;
import java.io.File;

public class ImagePreview extends JComponent
                          implements PropertyChangeListener {
    ImageIcon thumbnail = null;
    File file = null;

    public ImagePreview(JFileChooser fc) {
        setPreferredSize(new Dimension(100, 50));
        fc.addPropertyChangeListener(this);
    }

    public void loadImage() {
        if (file == null) {
            return;
        }

        ImageIcon tmpIcon = new ImageIcon(file.getPath());
        if (tmpIcon.getIconWidth() > 90) {
            thumbnail = new ImageIcon(tmpIcon.getImage().
                                 getScaledInstance(90, -1,
                                                   Image.SCALE_DEFAULT));
        } else {
            thumbnail = tmpIcon;
        }
    }

    public void propertyChange(PropertyChangeEvent e) {
        String prop = e.getPropertyName();
        if (prop.equals(JFileChooser.SELECTED_FILE_CHANGED_PROPERTY)) {
            file = (File) e.getNewValue();
            if (isShowing()) {
                loadImage();
                repaint();
            }
        }
    }

    public void paintComponent(Graphics g) {
        if (thumbnail == null) {
            loadImage();
        }
        if (thumbnail != null) {
            int x = getWidth()/2 - thumbnail.getIconWidth()/2;
            int y = getHeight()/2 - thumbnail.getIconHeight()/2;

            if (y < 0) {
                y = 0;
            }

            if (x < 5) {
                x = 5;
            }
            thumbnail.paintIcon(this, g, x, y);
        }
    }
}
```

```
<applet code="AppletButton.class"
        archive="example-swing/layout.jar"
        width="350" height="60">
<param name="windowClass" value="NoneWindow">
<param name="windowTitle" value="Absolute Positioning">
<param name="buttonText" value="Click here to see absolute positioning">
<param name="windowWidth" value="260">
<param name="windowHeight" value="130">

Since you can't run the applet,
here's a picture of it:

#usemacro UI_FIGURE (
    NAME 13absolpos32.gif
    W 258
    H 85
    ALT Three buttons laid out using absolute positioning.
)

</applet>
```

```
<applet code="AppletButton.class"
        archive="example-swing/layout.jar"
        width="350" height="60">
<param name="windowClass" value="TabWindow">
<param name="windowTitle" value="Tabbed Pane">
<param name="buttonText" value="Click here to see a tabbed pane in action">

Since you can't run the applet,
here's a picture of it:

#usemacro UI_FIGURE (
    NAME TabWindow.gif
    W 306
    H 99
    ALT A program that puts two panels in the same space with a tabbed pane.
)

</applet>
```

Trail: Creating a GUI with JFC/Swing
Lesson: Converting to Swing

Why to Convert

The strongest reason to convert to Swing is because it offers many benefits to programmers and end users. Among them:

- The rich set of ready-made components means that you can easily add some snazzy features to your programs -- image buttons, tool bars, tabbed panes, HTML display, images in menu items, color choosers, ... The list goes on and on.
- You might be able to replace or reimplement some custom components with more reliable, extensible Swing components.
- Having separate data and state models makes the Swing components highly customizable, and enables sharing data between components.
- Swing's Pluggable Look & Feel architecture gives you a wide choice of look-and-feel options. Besides the usual platform-specific looks and feels, you can also use the Java Look & Feel, add an accessory look and feel (such as an audio "look and feel"), or use a third-party look and feel.
- Swing components have built-in support for accessibility, which makes your programs automatically usable with assistive technologies.
- The Swing components will continue to be enhanced in the future.

It's reasonable to put off converting if you don't think your users will be able run Swing programs conveniently. For example, if your program is an applet and you want anyone on the Internet to be able to use it, then you have to consider how many Web surfers have browsers that can run Swing programs. As of this writing, the major browsers don't have Swing support built in; the user must add it by downloading and installing [Java Plug-in](#)◆ .

You have the choice of upgrading to Java 2 (JDK 1.2) when you convert to Swing. However, you don't need to decide right now whether to upgrade. Programs written with JDK 1.1 and Swing generally work just fine in Java 2. For information about new and improved features of Java 2, see [Tables of JDK Features](#)◆.

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How to Convert

This section presents steps you can follow to convert a program to use the Swing components. Each step applies to all programs -- applications and applets, alike -- unless noted otherwise.

Step 1: Save a copy of the original program.

Copy all of the program's files, including the `.java` files and the `.class` files. You will need this copy for several reasons:

- You'll need to refer to the source during the conversion process.
- After conversion, you should run both versions of your program side by side to compare them.
- After conversion, you can compare the source code of both versions to apply what you learned to other programs you need to convert.
- Some of your program's users might not be willing or able to immediately update their VM to a version that supports the Swing classes. If you want to keep them as customers, you'll need to keep providing the old AWT-based program in the interim.

Step 2: Remove all references to the `java.awt` package.

This step puts the compiler to work for you. By removing all imports and other code that references the `java.awt` package, you make the compiler tell you each time you use a class from that package. It's OK to use some AWT classes -- layout managers, for example -- but your program should use no AWT components. Here are a couple of examples of what to delete:

```
//import java.awt.*;      //temporarily remove this import
```

or

```
//import java.awt.Button; //temporarily remove this import
import java.awt.Color;    //it's OK to leave this in, since
                          //Color isn't a component
...
/*java.awt.*/Frame = new /*java.awt.*/Frame(...);
```

Without the references to `java.awt`, the compiler generates a "not found" error every place your program uses an AWT component. This makes it easier for you to find and replace AWT components with their Swing equivalents. In Step 9, you will add back the imports for the AWT classes that you really need.

Step 3: If your program is an applet, remove the `java.applet.*` import statement (if present) and any references to `java.applet.Applet`.

You don't need to refer to the old `Applet` class because your Swing applet will be a subclass of Swing's `JApplet` class (which is itself a subclass of `Applet`). If your program uses `AppletContext`, `AppletStub`, or `AudioClip`, then of course you'll need to import those classes from the `java.applet` package. Here's an example of what to do:

```
//import java.applet.*;      //temporarily remove this import
import java.applet.AppletContext;     //add this if necessary
```

Step 4: Import the main Swing package.

Add the following import statement to your program.

```
import javax.swing.*;
```

This imports all of the Swing components plus some of Swing's other classes. If you want, you can be more meticulous and add one import statement per Swing class you use.

Step 5: Be aware of thread-safety issues!

Before you go further, remind yourself of this important fact: *Although AWT is thread-safe, Swing is not.* You must take this into consideration when converting your programs.

Most programs modify components in event-handling methods and painting methods, which are called from the event-dispatching thread. Modifying a component in those methods is safe. However, if your program modifies a component anywhere else -- such as in the main thread after the GUI is visible, or in code called by a thread you have created -- you must take explicit action to make it thread-safe.

This tutorial contains two sections about Swing and threads. First, Threads and Swing◆ provides conceptual coverage. Next, How to Use Threads◆ contains practical information and examples.

Step 6: Change each AWT component to its closest Swing equivalent.

The table provided in our resources section, Swing Replacements for AWT Components, lists each AWT component and its closest Swing equivalent. Use it as a guide for choosing a replacement for each AWT component used in your program.

In the best case, the AWT component and its Swing replacement are source-compatible, and a simple name change is all that's required. For example, to convert from an AWT button to a Swing button, you just change all occurrences of `Button` to `JButton` in your program. Here's an example:

AWT Code:

```
Button button = new Button("A Button");
button.addActionListener(this);
```

Swing Code:

```
JButton button = new JButton("A Button");
button.addActionListener(this);
```

Some Swing components are not source-compatible with the AWT component they replace. So, for some AWT components, you have to rewrite some code when replacing them with Swing components. Conversion Resources has information to help you with conversions that require more than a simple name change.

While looking at the Conversion Resources section, take notes on changes that you might want to make later to take advantage of Swing features. For example, you might want to put images in your buttons, or to share data models between two components. Before making optional changes, though, we recommend that you make the minimal changes necessary to convert your program to Swing. Once you've successfully run the Swing version of your program, you'll be better able to judge how optional changes might improve your program.

Step 7: Change calls to the add and `setLayout` methods.

In programs that use AWT components, you add components directly to frames, dialogs, and applets. Similarly, you set the layout manager directly on those containers. In contrast, when you use the Swing versions of those containers, you add components to (and set the layout manager on) something called a *content pane*. Here's an example of converting some simple, typical code:

AWT Code:

```
frame.add(panel, BorderLayout.CENTER);
```

Swing Code:

```
frame.getContentPane().add(panel, BorderLayout.CENTER);
```

Here is a slightly more complex example:

AWT Code:

```
frame.setLayout(new FlowLayout());
frame.add(button);
frame.add(label);
frame.add(textField);
```

Swing Code:

```
Container contentPane = frame.getContentPane();
contentPane.setLayout(new FlowLayout());
contentPane.add(button);
contentPane.add(label);
contentPane.add(textField);
```

Here is an example of converting an applet. Note that the default layout manager for a content pane is `BorderLayout` -- not the `FlowLayout` used by `Applet`.

AWT Code:

```
setLayout(new BorderLayout());
add(button, BorderLayout.NORTH);
add(panel, BorderLayout.CENTER);
```

Swing Code:

```
Container contentPane = getContentPane();
contentPane.add(button, BorderLayout.NORTH);
contentPane.add(panel, BorderLayout.CENTER);
```

For more information about content panes, see Swing Components and the Containment Hierarchy◆. For more information about converting applets, refer to Converting Applets.

Step 8: Move painting code out of the `paint` and `update` methods.

For Swing components, custom painting code goes in the `paintComponent` method. Other ways to paint are using standard or custom icons (which generally are used to display pictures) and borders. If your component has painting code that draws the component's edge, you might well be able to replace that code with a border.

If your program has a `Frame`, `Dialog`, or `Applet` subclass that implements `update` or `paint`, then you need to move the painting code into another component, entirely. The reason is that each of these containers is covered by a content pane, which hides any painting the container might do. Exactly which component the painting code should move to depends on the type of painting. If the container's painting can be performed by an icon, than the component can be a standard label with an icon. Otherwise, the component should generally be a `JPanel` subclass that either performs the painting in its `paintComponent` method or uses a border to do the painting. You then add the component to the frame, dialog, or applet's content pane, as described in Step 7.

See Working with Graphics◆ for details about painting.

Step 9: Use the compiler to find any other needed changes.

After you've modified the source code as indicated in the prevous steps, use the compiler to *try* to compile your program. You can find instructions in Compiling and Running Swing Programs◆. During this step, you are basically getting the compiler to help you identify any conversions you might have overlooked. Don't expect your program to compile the first time!

The compiler can help you do the following:

- Find each AWT component that you forgot to convert to its Swing equivalent. If you removed all of the `java.awt` import statements from your program as suggested in step 2, the compiler displays an error message like this for each AWT component remaining in your program:

```
TextEventDemo.java:23: Class Button not found
in type declaration.
        Button button = new Button("Clear");
        ^
```

- Identify which AWT classes your program still needs. If you removed all of the `java.awt` import statements from your program, the compiler displays an error message like this for AWT classes you still need:

  ```
  TextEventDemo.java:17: Class BorderLayout not found
  in type declaration.
          BorderLayout layout = new BorderLayout();
          ^
  ```

  The AWT classes you might still need in a Swing program are layout managers, graphics-related objects such as `Color`and `Point`, and other non-component classes. You can import them using one import statement each. Or, if you're sure that you've replaced all the AWT components with Swing components, import the entire `java.awt`package again.

- Locate any source incompatibilities between the AWT component and its Swing replacement. These typically show up as compiler errors about undefined methods. For example, although AWT text components have an `addTextListener` method, Swing text components don't. The compiler generates an error message like the following one indicating that `JTextField` doesn't have such a method.

  ```
  TextEventDemo.java:22: Method addTextListener(
  TextEventDemo.MyTextListener) not found in class
  javax.swing.JTextField.
      textField.addTextListener(new MyTextListener("Text Field"));
                               ^
  ```

- Remove uses of deprecated API. If the compiler issues a deprecation warning, recompile with the `-deprecation` flag to get details. You can find information about what deprecation means, as well as a list of alternatives to API deprecated in JDK 1.1, in Migrating to 1.1◆. Also, the API documentation for the deprecated class or method should have information about what to use instead.

Fix all problems reported by the compiler until the program compiles.

Step 10: Run the Swing program.

Run the program, as described in Compiling and Running Swing Programs◆. If you forgot to modify any calls to `add` or `setLayout`, the runtime system displays a message like this:

```
java.lang.Error: Do not use javax.swing.JFrame.add() use
 javax.swing.JFrame.getContentPane().add() instead
        at javax.swing.JFrame.createRootPaneException(JFrame.java:333)
        at javax.swing.JFrame.addImpl(JFrame.java:355)
        at java.awt.Container.add(Container.java:212)
        at AppletDemo.main(AppletDemo.java:121)
```

Go back to the source, fix the offending occurrence of `add` or `setLayout`, then compile and run again.

Step 11: Compare the Swing version to the AWT version, and make any improvements that Swing enables.

Although you might want the AWT and Swing versions of your program to be similar, be open to improvements offered by Swing. One difference you'll probably notice is that, unless your copy of the JDK has a `swing.properties` file that specifies otherwise, your converted program uses a new look and feel: the Java Look & Feel. You can specify another look and feel if you like. For more information, see Choosing the Look and Feel◆.

You might be able to improve your program's GUI by using features available only to Swing components or by using the Swing components that have no AWT equivalents. Components completely new to Swing include color choosers, editable combo boxes, progress bars, split panes, tabbed panes, tables, tool tips, and trees. Features available only to Swing components include borders, which are especially useful for panels, and icons, which you can add to many components such as labels and buttons. You might also be able to replace a component you wrote yourself with a standard or customized Swing component.

Step 12: Clean up!

Now is the time to clean up your code. If you hacked any code together to get around some of AWT's deficiencies or bugs, clean it up now! Go through the tutorial sections and examples that are relevant to your program, and make sure that you use Swing features correctly. Review your program's accessibility to make sure that your program does all it can to support assistive technologies.

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Conversion Resources

If you haven't already read How Are Swing Components Different from AWT Components?◆, consider reading it now. It provides useful background and architectural information that can put the conversion process in perspective.

This section provides the following resources to help you convert your programs to Swing:

Swing Replacements for AWT Components
: Lists each AWT component and its Swing replacement, with notes about changes you might have to make to your code. Additionally, the table sometimes notes when you might want to upgrade to a more full-featured Swing component. For example, you might want to replace an AWT text field with a Swing password field instead of a regular Swing text field.

General Conversion Tips
: Provides information about general conversion issues such as empty space, painting, and so on.

Component-Specific Conversion Tips
: Provides details about converting specific components, such as applets and text areas, that tend to require more work to convert.

Some Conversion Examples
: Shows how we converted some of the examples in the tutorial. Each example is a complete program--either an applet or an application.

Another useful section is the last section in this lesson, Solving Common Conversion Problems, which describes how to solve some problems you might encounter during conversion.

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Swing Replacements for AWT Components

Use the following table as a guide for choosing a Swing replacement for each AWT component used in your program.

AWT Component	Closest Swing Equivalent	Notes
`java.applet.Applet`	`JApplet`	AWT applets and Swing applets differ in several ways. See Converting Applets.
`Button`	`JButton`	A Swing button can include an image and/or text.
`Canvas`	`JPanel`, `JLabel`, *or another appropriate Swing component*	Your choice depends on what the program uses the canvas for. See Converting Canvases for a discussion of your conversion options.
`Checkbox`	`JCheckBox` *or* `JRadioButton`	Note the `B' is capitalized in the Swing class name but not in the AWT class name.
`CheckboxMenuItem`	`JCheckBoxMenuItem`	Note the `B' is capitalized in the Swing class name but not in the AWT class name. Also, note that Swing menu components are true components.

`Choice`	`JComboBox`	Replace a `Choice` with an uneditable (the default) `JComboBox`. You might have to re-write code that handles item events. Refer to Converting Choices.
`Dialog`	`JDialog` *or* `JOptionPane`	AWT-based programs add components directly to a dialog and directly set its layout manager. In contrast, Swing-based programs add components to and set the layout manager on a `JDialog`'s *content pane*.
`FileDialog`	`JFileChooser`	`FileDialog` is a dialog, while `JFileChooser` is a component that you can place in any top-level container. For convenience, `JFileChooser` provides methods that make it easy to display a file chooser in a dialog.
`Frame`	`JFrame`	AWT-based programs add components directly to a frame and directly set its layout manager. In contrast, Swing-based programs add components to and set the layout manager on a `JFrame`'s *content pane*.
`Label`	`JLabel`	A Swing label can include an image and/or text. To support accessibility, use `setLabelFor` to associate each label with the component it describes (if any).

`List`	`JList`	AWT lists and Swing lists differ in many ways. See Converting Lists for information and examples. If you'd like your list to display multiple columns of information, consider upgrading to a table. If the list contains hierarchical informaiton, consider using a tree.
`Menu`	`JMenu`	Swing menu components are true components.
`MenuBar`	`JMenuBar`	Swing menu components are true components.
`MenuItem`	`JMenuItem`	Swing menu components are true components.
`Panel`	`JPanel`	You can easily add borders to Swing panels.
`PopupMenu`	`JPopupMenu`	Swing menu components are true components.
`Scrollbar`	`JScrollPane` *or* `JSlider` *or* `JProgressBar`	Although Swing has a `JScrollBar` class, you don't usually use it directly.
`ScrollPane`	`JScrollPane`	You can add custom decorations, including row and column headers, to Swing scroll panes.
`TextArea`	`JTextArea`	Typically requires some re-coding to convert. See Converting Text Components for information and examples.

`TextField`	`JTextField`	For simple uses, `JTextField` is source-compatible with `TextField`. If you use text listeners you need to modify your code to use a custom document or document listener instead. If you need a password field, use `JPasswordField` instead. See Converting Text Components for information about non-trivial conversions and examples.
`Window`	`JWindow` *or* `JToolTip`	You might be able to substitute a non-window component, such as a `JLabel`, and use a layered pane.

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Component-Specific Conversion Tips

This section has tips for converting AWT applet, canvas, choice, list, and text components to the Swing equivalents.

Converting Applets

As mentioned in Step 7 of the conversion instructions, AWT programs add components directly to the `Applet` object and directly set the applet's layout manager. Swing applets, on the other hand, add components to and set the layout manager on the `JApplet`'s *content pane*. So to convert an applet, you must make the source code changes described in that section.

Furthermore, while `FlowLayout` is the default layout manager for AWT applets, `BorderLayout` is the default layout manager for Swing applets. This has two repercussions:

1. If you want to use a `FlowLayout`, the Swing version of your program must use `setLayout` on the content pane to specify it.
2. If you specified `BorderLayout` in your AWT applet, you can remove the `setLayout` statement from the Swing version.

As Step 8 says, don't paint directly in a `JApplet` because it will be covered by the applet's content pane. Instead of seeing your painting, you'll just see a blank area. The solution is to have a custom component do the painting, and add it to the content pane. See the instructions for converting canvases for tips on choosing a class for the custom component, and moving the paint code to the appropriate method.

Be very aware of thread issues when converting your applet. Because the `stop` and `start` methods aren't called from the event-dispatching thread, you should use `SwingUtilities.invokeLater` in those methods whenever you make a change that might result on a call upon a component. See Threads and Swing◆ and How to Use Threads◆ for more information.

Lastly, your applet's users will probably use Java Plug-in to run your applet. So you will need to convert the `<APPLET>` tag to an `OBJECT`/`EMBED` tag. An automatic HTML converter can be found at the Java Plug-in◆ site.

Converting Canvases (Custom Components)

Before converting a custom component, check whether you can use a standard Swing component. For example, if your custom component simply displays an image, perhaps with some text, then you can use a Swing label◆. If your custom component implements a button with an image, you can use a Swing button◆ instead. If you've implemented a tree or grid, consider using a Swing tree◆ or table◆.

If no Swing component has the functionality you need, then we recommend that you change the superclass of your custom component from `Canvas` to `JPanel`. Then move the drawing code from `paint` or `update` to a method named `paintComponent`. At the top of that method, you should insert `super.paintComponent(g)`. Remove all code related to double buffering, since Swing provides that automatically. For more information about implementing painting in custom Swing components, refer to Working with Graphics◆.

`JPanel` is not the only possible superclass for custom components. You can use a more specialized superclass, such as `JLabel` or `AbstractToggleButton`. Or you can use a less specialized superclass, such as `Component`, `Container`, or `JComponent`◆. Extending `JComponent` instead of `Component` or `Container` gives you automatic double buffering and access to Swing features such as borders. Extending `JPanel` instead of `JComponent` buys you automatic background painting, which you can turn off if you like with `setOpaque(false)`.

Converting Choices

AWT choices are equivalent to uneditable Swing combo boxes. Although both choices and combo boxes fire item events, the conditions under which the events are fired differ. A choice fires one item event each time the user selects an item from its menu. The Swing combo box component fires one item event each time the state of an item changes. Thus a combo box fires two item events when the user chooses a new item from the combo box: one because the currently selected item's state changed to deselected and one because the chosen item's state changed to selected. Furthermore, although a choice fires an item event when the user chooses the already selected item, a combo box fires no events in this case.

You have a couple of options:

- If you want to be notified when the user chooses an already selected item, use an action listener instead of an item listener. Although choices fire only item events, combo boxes fire action events as well.
- If you're interested in item events, but only care about one per selection, use the event object's `getStateChanged` method to determine whether you're interested in a particular event.

Converting Lists

AWT lists and Swing lists differ in many ways:

- Populating a Swing list is different than populating an AWT list because a standard Swing list is immutable--you cannot add or remove items from it. To populate a Swing list, create a vector, array, or data model with the initial items in it.

AWT Code	**Swing Code**

List spanish = new List();
spanish.addItem("uno");
spanish.addItem("dos");
spanish.addItem("tres");
spanish.addItem("cuatro");
	String[] listData = { "uno",
	"dos",
	"tres",
	"cuatro" };
	JList spanish = new JList(listData);

  If you want a mutable list, you need to provide the list with a custom `ListModel` that is mutable. Refer to Modifying a List◆ for details and an example.

- AWT lists provide scroll bars automatically. If you want scrolling capability for a Swing list, you need to put the list in a scroll pane. Remember to change the arguments to the `add` method so that it adds the scroll pane, rather than the actual list, to the container. If you are using a `GridBagLayout`, make sure that you then apply the constraints to the scroll pane rather than to the list.

AWT Code	**Swing Code**

List spanish = new List();
somecontainer.add(spanish);
	JList spanish = new JList(listData);
	JScrollPane scrollPane = new JScrollPane(spanish);
	somecontainer.add(scrollPane);

- Although `List` generates action events, `JList` doesn't. To listen for changes to the selection on a `JList` use a `ListSelectionListener`. To listen for single, double, or triple clicks, use a mouse listener.

- A Swing list supports three selection modes, not two.

For an example of converting a program that contains a list, refer to Converting ListDemo.

Converting Text Components

The Swing text components have much richer functionality than the AWT text components. You can easily display styled text, such as HTML text, using a editor pane or text pane◆. For information on what Swing text components have to offer, see Using Text Components◆.

When converting a text area, be aware that Swing text areas aren't automatically placed in scroll panes. You normally should put the Swing text area in a scroll pane and set the scroll pane's preferred size. If you forget to set the preferred size of the scroll pane, then depending on the layout manager you use, the scroll pane might grow each time a line of text is added to the text area -- and the user won't see scroll bars. When you add a text area to a scroll pane, remember to make these other changes to your program:

- Change the `add` call to add the scroll pane, instead of the text area, to the container.
- If you are using a `GridBagLayout` make sure that you then apply the constraints to the scroll pane rather than to the text area.

Swing text components support different listeners than AWT text components. For example, Swing text components don't have an `addTextListener` method. Instead you should use a custom document or register a document listener. If you have a key event listener registered on an AWT text component, then you should probably replace it with a custom document. Documents and document listeners are discussed in General Rules for Using Text Components◆, and examples of implementing custom documents are in Creating a Validated Text Field◆.

For an example of converting an AWT text component to a Swing text component, including how to convert text listeners, refer to Converting TextEventDemo.

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General Conversion Tips

This section gives you conversion tips for dealing with empty space, painting, and images.

Empty Space

If you use the Java Look & Feel, your Swing program might have less space between components than the previous version. If you want to add more space, you can do it using any combination of layout managers, empty borders, and invisible spacer components. See Putting Space Between Components◆ for more information. You can also use the `setMargin` method for text components.

Converting Painting Code

AWT components perform painting in the `paint` and `update` methods. Swing components use the `paintComponent` method instead. To take advantage of automatic background painting, your implementation of `paintComponent` should call `super.paintComponent`, first thing. See Overview of Custom Painting◆ for details.

Note that Swing components automatically use double buffering to make their painting smooth. If the program that you're converting implements double buffering explicitly, this is a unique opportunity to delete some code! For example the AWT-based animation program `ImageSequence.java`◆ paints to an off-screen image and then paints the image to the screen all at once. Its Swing counterpart, `ImageSequenceTimer.java`◆, simply puts its paint code in the custom component's `paintComponent` method, and double buffering is handled automatically. During the conversion process, we removed `offImage`, `offGraphics`, and all code that referred to them.

If your painting code puts a title or edges around the component, consider replacing it with a border◆. For example, you can easily create a box around a group of components by adding the components to a `JPanel` and making the panel have a border. The AWT-based program `CoordinatesDemo`◆ uses a class called `FramedArea` that exists solely to put a frame around the coordinate area. The Swing version of this program, CoordinatesDemo, uses a border instead and deletes the `FramedArea` class.

Converting Images

Although you can use `Image` objects in Swing programs, you might want to convert some or all of them into `Icon` objects. The main reason is Swing components that can display images -- labels, buttons, cell renderers in tables and trees and lists, tabbed panes, menus, and so on -- do so using `Icon` objects. Another reason is that `Icon` objects have accessibility support built in.

You can convert an `Image` into an icon in one of two ways. The first way is to use `new ImageIcon(anImage)`. The second is to create an `ImageIcon` using the same data source that you used to create the `Image`. When you use the second way, the constructor automatically loads the image data, returning when the image is ready to use.

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Trail: Creating a GUI with JFC/Swing: End of Trail

You've reached the end of the "Creating a GUI with JFC/Swing" trail.

If you have comments or suggestions about this trail, use our feedback page to tell us about it.

Take a break -- have a cup of steaming hot java.

What next?

Once you've caught your breath, you have several choices of where to go next. You can go to the tutorial's front page or to the Trail Map to see all of your choices, or you can go directly to one of the following related trails:

Writing Applets: This is the starting point for learning everything about writing applets.

Essential Java Classes: By taking this trail, you can find out about strings, exceptions, threads, and other Java features that are used in all kinds of Java programs.

1.2 2D Graphics: If you are using JDK 1,2, you can use 2D graphics when writing Swing components that do custom painting.

1.2 Sound: You can use sound to enhance your program's user interface.

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```
/*
 * 1.1 version.
 */

import java.awt.*;
import java.awt.event.*;

/*
 * Based on Arthur van Hoff's animation examples, this application
 * can serve as a template for all animation applications.
 */
public class AnimatorApplication extends Frame
                                 implements Runnable {
    int frameNumber = -1;
    int delay;
    Thread animatorThread;
    boolean frozen = false;

    AnimatorApplication(int fps, String windowTitle) {
        super(windowTitle);
        delay = (fps > 0) ? (1000 / fps) : 100;

        addMouseListener(new MouseAdapter() {
            public void mousePressed(MouseEvent e) {
                if (frozen) {
                    frozen = false;
                    startAnimation();
                } else {
                    frozen = true;
                    stopAnimation();
                }
            }
        });

        addWindowListener(new WindowAdapter() {
            public void windowIconified(WindowEvent e) {
                stopAnimation();
            }
            public void windowDeiconified(WindowEvent e) {
                startAnimation();
            }
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });
    }

    public void startAnimation() {
        if (frozen) {
            //Do nothing.  The user has requested that we
            //stop changing the image.
        } else {
            //Start animating!
            if (animatorThread == null) {
                animatorThread = new Thread(this);
            }
            animatorThread.start();
        }
    }

    public void stopAnimation() {
        //Stop the animating thread.
        animatorThread = null;
    }

    public void run() {
        //Just to be nice, lower this thread's priority
        //so it can't interfere with other processing going on.
        Thread.currentThread().setPriority(Thread.MIN_PRIORITY);

        //Remember the starting time.
        long startTime = System.currentTimeMillis();

        //Remember which thread we are.
        Thread currentThread = Thread.currentThread();

        //This is the animation loop.
        while (currentThread == animatorThread) {
            //Advance the animation frame.
            frameNumber++;

            //Display it.
            repaint();

            //Delay depending on how far we are behind.
            try {
                startTime += delay;
                Thread.sleep(Math.max(0,
                             startTime-System.currentTimeMillis()));
            } catch (InterruptedException e) {
                break;
            }
        }
    }

    //Draw the current frame of animation.
    public void paint(Graphics g) {
        g.drawString("Frame " + frameNumber, 5, 50);
    }

    public static void main(String args[]) {
        AnimatorApplication animator = null;
        int fps = 10;

        // Get frames per second from the command line argument
        if (args.length > 0) {
            try {
                fps = Integer.parseInt(args[0]);
            } catch (Exception e) {}
        }
        animator = new AnimatorApplication(fps, "Animator");
        animator.setSize(200, 60);
        animator.setVisible(true);
        animator.startAnimation();
    }
}
```

```
/*
 * 1.1 version.
 */

import java.awt.*;
import java.awt.event.ActionListener;
import java.awt.event.ActionEvent;
import java.applet.Applet;

public class ButtonDemoApplet extends Applet
                              implements ActionListener {

    protected Button b1, b2, b3;
    protected static final String DISABLE = "disable";
    protected static final String ENABLE = "enable";

    public void init() {
        b1 = new Button();
        b1.setLabel("Disable middle button");
        b1.setActionCommand(DISABLE);

        b2 = new Button("Middle button");

        b3 = new Button("Enable middle button");
        b3.setEnabled(false);
        b3.setActionCommand(ENABLE);

        //Listen for actions on buttons 1 and 3.
        b1.addActionListener(this);
        b3.addActionListener(this);

        //Add Components to the Applet, using the default FlowLayout.
        add(b1);
        add(b2);
        add(b3);
    }

    public void actionPerformed(ActionEvent e) {
        if (e.getActionCommand().equals(DISABLE)) {
            b2.setEnabled(false);
            b1.setEnabled(false);
            b3.setEnabled(true);
        } else {
            b2.setEnabled(true);
            b1.setEnabled(true);
            b3.setEnabled(false);
        }
    }
}
```

```
/*
 * 1.1 code.
 */

import java.applet.Applet;
import java.awt.*;
import java.awt.event.*;

public class TextEventDemo extends Applet
                           implements ActionListener {
    TextField textField;
    TextArea textArea;
    TextArea displayArea;

    public void init() {
        Button button = new Button("Clear");
        button.addActionListener(this);

        textField = new TextField(20);
        textField.addActionListener(new MyTextActionListener());
        textField.addTextListener(new MyTextListener("Text Field"));

        textArea = new TextArea(5, 20);
        textArea.addTextListener(new MyTextListener("Text Area"));

        displayArea = new TextArea(5, 20);
        displayArea.setEditable(false);

        GridBagLayout gridbag = new GridBagLayout();
        GridBagConstraints c = new GridBagConstraints();
        setLayout(gridbag);
        c.fill = GridBagConstraints.BOTH;
        c.weightx = 1.0;

        /*
         * Hack to get around gridbag's refusal to allow
         * multi-row components in anything but the left column.
         */
        Panel leftPanel = new Panel();
        leftPanel.setLayout(new BorderLayout());
        leftPanel.add("North", textField);
        leftPanel.add("Center", textArea);

        c.gridheight = 2;
        gridbag.setConstraints(leftPanel, c);
        add(leftPanel);

        c.weighty = 1.0;
        c.gridwidth = GridBagConstraints.REMAINDER;
        c.gridheight = 1;
        gridbag.setConstraints(displayArea, c);
        add(displayArea);

        c.weighty = 0.0;
        gridbag.setConstraints(button, c);
        add(button);

        textField.requestFocus();
    }

    class MyTextListener implements TextListener {
        String preface;
        String newline;
```

```java
        public MyTextListener(String source) {
            newline = System.getProperty("line.separator");
            preface = source
                      + " text value changed."
                      + newline
                      + "   First 10 characters: \"";
        }

        public void textValueChanged(TextEvent e) {
            TextComponent tc = (TextComponent)e.getSource();
            String s = tc.getText();
            try {
                s = s.substring(0, 10);
            } catch (StringIndexOutOfBoundsException ex) {
            }

            displayArea.append(preface + s + "\"" + newline);

            //Scroll down, unless the peer still needs to be created.
            if (displayArea.isValid()) {
                displayArea.setCaretPosition(java.lang.Integer.MAX_VALUE);
            }
        }
    }

    class MyTextActionListener implements ActionListener {
        /** Handle the text field Return. */
        public void actionPerformed(ActionEvent e) {
            int selStart = textArea.getSelectionStart();
            int selEnd = textArea.getSelectionEnd();

            textArea.replaceRange(textField.getText(),
                                  selStart, selEnd);
            textField.selectAll();
        }
    }

    /** Handle button click. */
    public void actionPerformed(ActionEvent e) {
        displayArea.setText("");
        textField.requestFocus();
    }
}
```

```
/*
 * 1.1 version.
 */

import java.awt.*;
import java.awt.event.*;
import java.util.*;
import java.applet.Applet;

public class Converter extends Applet {
    ConversionPanel metricPanel, usaPanel;
    Unit[] metricDistances = new Unit[3];
    Unit[] usaDistances = new Unit[4];

    /**
     * Create the ConversionPanels (one for metric, another for U.S.).
     * I used "U.S." because although Imperial and U.S. distance
     * measurements are the same, this program could be extended to
     * include volume measurements, which aren't the same.
     */
    public void init() {
        //Use a GridLayout with 2 rows, as many columns as necessary,
        //and 5 pixels of padding around all edges of each cell.
        setLayout(new GridLayout(2,0,5,5));

        //Create Unit objects for metric distances, and then
        //instantiate a ConversionPanel with these Units.
        metricDistances[0] = new Unit("Centimeters", 0.01);
        metricDistances[1] = new Unit("Meters", 1.0);
        metricDistances[2] = new Unit("Kilometers", 1000.0);
        metricPanel = new ConversionPanel(this, "Metric System",
                                          metricDistances);

        //Create Unit objects for U.S. distances, and then
        //instantiate a ConversionPanel with these Units.
        usaDistances[0] = new Unit("Inches", 0.0254);
        usaDistances[1] = new Unit("Feet", 0.305);
        usaDistances[2] = new Unit("Yards", 0.914);
        usaDistances[3] = new Unit("Miles", 1613.0);
        usaPanel = new ConversionPanel(this, "U.S. System", usaDistances);

        //Add both ConversionPanels to the Converter.
        add(metricPanel);
        add(usaPanel);
    }

    /**
     * Does the conversion from metric to U.S., or vice versa, and
     * updates the appropriate ConversionPanel.
     */
    void convert(ConversionPanel from) {
        ConversionPanel to;

        if (from == metricPanel)
            to = usaPanel;
        else
            to = metricPanel;

        double multiplier = from.getMultiplier() / to.getMultiplier();
        to.setValue(multiplier * from.getValue());
    }
```

```java
    /** Draws a box around this panel. */
    public void paint(Graphics g) {
        Dimension d = getSize();
        g.drawRect(0,0, d.width - 1, d.height - 1);
    }

    /**
     * Puts a little breathing space between
     * the panel and its contents, which lets us draw a box
     * in the paint() method.
     */
    public Insets getInsets() {
        return new Insets(5,5,5,5);
    }

    /** Executed only when this program runs as an application. */
    public static void main(String[] args) {
        //Create a new window.
        Frame f = new Frame("Converter Applet/Application");
        f.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });

        //Create a Converter instance.
        Converter converter = new Converter();

        //Initialize the Converter instance.
        converter.init();

        //Add the Converter to the window and display the window.
        f.add("Center", converter);
        f.pack();        //Resizes the window to its natural size.
        f.setVisible(true);
    }
}
```

```
/*
 * 1.1 version.
 */

import java.awt.*;
import java.awt.event.*;
import java.util.*;
import java.applet.Applet;

public class ConversionPanel extends Panel
                      implements ActionListener,
                                 AdjustmentListener,
                                 ItemListener {
    TextField textField;
    Choice unitChooser;
    Scrollbar slider;
    int max = 10000;
    int block = 100;
    Converter controller;
    Unit[] units;

    ConversionPanel(Converter myController, String myTitle, Unit[] myUnits) {
        //Initialize this ConversionPanel to use a GridBagLayout.
        GridBagConstraints c = new GridBagConstraints();
        GridBagLayout gridbag = new GridBagLayout();
        setLayout(gridbag);

        //Save arguments in instance variables.
        controller = myController;
        units = myUnits;

        //Set up default layout constraints.
        c.fill = GridBagConstraints.HORIZONTAL;

        //Add the label.  It displays this panel's title, centered.
        Label label = new Label(myTitle, Label.CENTER);
        c.gridwidth = GridBagConstraints.REMAINDER; //It ends a row.
        gridbag.setConstraints(label, c);
        add(label);

        //Add the text field.  It initially displays "0" and needs
        //to be at least 10 columns wide.
        textField = new TextField("0", 10);
        c.weightx = 1.0;  //Use maximum horizontal space...
        c.gridwidth = 1; //The default value.
        gridbag.setConstraints(textField, c);
        add(textField);
        textField.addActionListener(this);

        //Add the pop-up list (Choice).
        unitChooser = new Choice();
        for (int i = 0; i < units.length; i++) { //Populate it.
            unitChooser.add(units[i].description);
        }
        c.weightx = 0.0; //The default value.
        c.gridwidth = GridBagConstraints.REMAINDER; //End a row.
        gridbag.setConstraints(unitChooser, c);
        add(unitChooser);
        unitChooser.addItemListener(this);

        //Add the slider.  It's horizontal, and it has the maximum
        //value specified by the instance variable max.  Its initial
        //and minimum values are the default (0).  A click increments
        //the value by block units.
        slider = new Scrollbar(Scrollbar.HORIZONTAL);
        slider.setMaximum(max + 10);
        slider.setBlockIncrement(block);
        c.gridwidth = 1; //The default value.
        gridbag.setConstraints(slider, c);
        add(slider);
        slider.addAdjustmentListener(this);
    }

    /**
     * Returns the multiplier (units/meter) for the currently
     * selected unit of measurement.
     */
    double getMultiplier() {
        int i = unitChooser.getSelectedIndex();
        return units[i].multiplier;
    }

    /** Draws a box around this panel. */
    public void paint(Graphics g) {
        Dimension d = getSize();
        g.drawRect(0,0, d.width - 1, d.height - 1);
    }

    /**
     * Puts a little breathing space between
     * the panel and its contents, which lets us draw a box
     * in the paint() method.
     * We add more pixels to the right, to work around a
     * Choice bug.
     */
    public Insets getInsets() {
        return new Insets(5,5,5,8);
    }

    /**
     * Gets the current value in the text field.
     * It's guaranteed to be the same as the value
     * in the scroller (subject to rounding, of course).
     */
    double getValue() {
        double f;
        try {
            f = (double)Double.valueOf(textField.getText()).doubleValue();
        } catch (java.lang.NumberFormatException e) {
            f = 0.0;
        }
        return f;
    }

    public void actionPerformed(ActionEvent e) {
        setSliderValue(getValue());
        controller.convert(this);
    }

    public void itemStateChanged(ItemEvent e) {
        controller.convert(this);
    }

    /** Respond to the slider. */
    public void adjustmentValueChanged(AdjustmentEvent e) {
        textField.setText(String.valueOf(e.getValue()));
        controller.convert(this);
    }

    /** Set the values in the slider and text field. */
    void setValue(double f) {
        setSliderValue(f);
        textField.setText(String.valueOf((float)f));
    }

    /** Set the slider value. */
    void setSliderValue(double f) {
        int sliderValue = (int)f;

        if (sliderValue > max)
               sliderValue = max;
        if (sliderValue < 0)
            sliderValue = 0;
        slider.setValue(sliderValue);
    }
}
```

```java
/*
 * 1.1 version.
 */

public class Unit {
    String description;
    double multiplier;

    Unit(String description, double multiplier) {
        super();
        this.description = description;
        this.multiplier = multiplier;
    }

    public String toString() {
        String s = "Meters/" + description + " = " + multiplier;
        return s;
    }
}
```

```
/*
 * 1.1 version.
 */

import java.awt.*;
import java.awt.event.*;
import java.applet.Applet;

public class ListDemo extends Applet
                      implements ActionListener,
                                 ItemListener {
    TextArea output;
    List spanish, italian;
    String newline;

    public void init() {
        newline = System.getProperty("line.separator");

        //Build first list, which allows multiple selections.
        spanish = new List(4, true); //prefer 4 items visible
        spanish.add("uno");
        spanish.add("dos");
        spanish.add("tres");
        spanish.add("cuatro");
        spanish.add("cinco");
        spanish.add("seis");
        spanish.add("siete");
        spanish.addActionListener(this);
        spanish.addItemListener(this);

        //Build second list, which allows one selection at a time.
        italian = new List(); //Defaults to none visible, only one selectable
        italian.add("uno");
        italian.add("due");
        italian.add("tre");
        italian.add("quattro");
        italian.add("cinque");
        italian.add("sei");
        italian.add("sette");
        italian.addActionListener(this);
        italian.addItemListener(this);

        //Add lists to the Applet.
        GridBagLayout gridBag = new GridBagLayout();
        setLayout(gridBag);

        //Can't put text area on right due to GBL bug
        //(can't span rows in any column but the first).
        output = new TextArea(10, 40);
        output.setEditable(false);
        GridBagConstraints tc = new GridBagConstraints();
        tc.fill = GridBagConstraints.BOTH;
        tc.weightx = 1.0;
        tc.weighty = 1.0;
        tc.gridheight = 2;
        gridBag.setConstraints(output, tc);
        add(output);

        GridBagConstraints lc = new GridBagConstraints();
        lc.fill = GridBagConstraints.VERTICAL;
        lc.gridwidth = GridBagConstraints.REMAINDER; //end row
        gridBag.setConstraints(spanish, lc);
        add(spanish);
        gridBag.setConstraints(italian, lc);
        add(italian);
    }

    public void actionPerformed(ActionEvent e) {
        List list = (List)(e.getSource());
        String language = (list == spanish) ?
                          "Spanish" : "Italian";
        output.append("Action event occurred on \""
                          + list.getSelectedItem()  + "\" in "
                          + language + "." + newline);
    }

    public void itemStateChanged(ItemEvent e) {
        List list = (List)(e.getItemSelectable());
        String language = (list == spanish) ?
                          "Spanish" : "Italian";

        int index = ((Integer)(e.getItem())).intValue();
        if (e.getStateChange() == ItemEvent.SELECTED) {
            output.append("Select event occurred on item #"
                          + index + " (\""
                          + list.getItem(index) + "\") in "
                          + language + "." + newline);
        } else { //the item was deselected
            output.append("Deselect event occurred on item #"
                          + index + " (\""
                          + list.getItem(index) + "\") in "
                          + language + "." + newline);
        }
    }
}
```

```
import javax.swing.*;
import javax.swing.event.*;
import javax.swing.table.*;

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

public class SharedModelDemo extends JPanel {
    JTextArea output;
    JList list;
    JTable table;
    String newline = "\n";
    ListSelectionModel listSelectionModel;

    public SharedModelDemo() {
        super(new BorderLayout());

        Vector data = new Vector(7);
        String[] columnNames = { "French", "Spanish", "Italian" };
        String[] oneData =     { "un",     "uno",     "uno"     };
        String[] twoData =     { "deux",   "dos",     "due"     };
        String[] threeData =   { "trois",  "tres",    "tre"     };
        String[] fourData =    { "quatre", "cuatro",  "quattro" };
        String[] fiveData =    { "cinq",   "cinco",   "cinque"  };
        String[] sixData =     { "six",    "seis",    "sei"     };
        String[] sevenData =   { "sept",   "siete",   "sette"   };

        //Build the model.
        SharedDataModel dataModel = new SharedDataModel(columnNames);
        dataModel.addElement(oneData);
        dataModel.addElement(twoData);
        dataModel.addElement(threeData);
        dataModel.addElement(fourData);
        dataModel.addElement(fiveData);
        dataModel.addElement(sixData);
        dataModel.addElement(sevenData);

        list = new JList(dataModel);
        list.setCellRenderer(new DefaultListCellRenderer() {
            public Component getListCellRendererComponent(JList l,
                                                          Object value,
                                                          int i,
                                                          boolean s,
                                                          boolean f) {
                String[] array = (String[])value;
                return super.getListCellRendererComponent(l,
                                                          array[0],
                                                          i, s, f);
            }
        });

        listSelectionModel = list.getSelectionModel();
        listSelectionModel.addListSelectionListener(
                                new SharedListSelectionHandler());
        JScrollPane listPane = new JScrollPane(list);

        table = new JTable(dataModel);
        table.setSelectionModel(listSelectionModel);
        JScrollPane tablePane = new JScrollPane(table);

        //Build control area (use default FlowLayout).
        JPanel controlPane = new JPanel();
        String[] modes = { "SINGLE_SELECTION",
                           "SINGLE_INTERVAL_SELECTION",
                           "MULTIPLE_INTERVAL_SELECTION" };

        final JComboBox comboBox = new JComboBox(modes);
        comboBox.setSelectedIndex(2);
        comboBox.addActionListener(new ActionListener() {
            public void actionPerformed(ActionEvent e) {
                String newMode = (String)comboBox.getSelectedItem();
                if (newMode.equals("SINGLE_SELECTION")) {
                    listSelectionModel.setSelectionMode(
                        ListSelectionModel.SINGLE_SELECTION);
                } else if (newMode.equals("SINGLE_INTERVAL_SELECTION")) {
                    listSelectionModel.setSelectionMode(
                        ListSelectionModel.SINGLE_INTERVAL_SELECTION);
                } else {
                    listSelectionModel.setSelectionMode(
                        ListSelectionModel.MULTIPLE_INTERVAL_SELECTION);
                }
                output.append("----------"
                              + "Mode: " + newMode
                              + "----------" + newline);
            }
        });
        controlPane.add(new JLabel("Selection mode:"));
        controlPane.add(comboBox);

        //Build output area.
        output = new JTextArea(10, 40);
        output.setEditable(false);
        JScrollPane outputPane = new JScrollPane(output,
                         ScrollPaneConstants.VERTICAL_SCROLLBAR_ALWAYS,
                         ScrollPaneConstants.HORIZONTAL_SCROLLBAR_ALWAYS);

        //Do the layout.
        JSplitPane splitPane = new JSplitPane(JSplitPane.VERTICAL_SPLIT);
        add(splitPane, BorderLayout.CENTER);

        JPanel topHalf = new JPanel();
        topHalf.setLayout(new BoxLayout(topHalf, BoxLayout.X_AXIS));
        JPanel listContainer = new JPanel(new GridLayout(1,1));
        listContainer.setBorder(BorderFactory.createTitledBorder(
                                                "List"));
        listContainer.add(listPane);
        JPanel tableContainer = new JPanel(new GridLayout(1,1));
        tableContainer.setBorder(BorderFactory.createTitledBorder(
                                                "Table"));
        tableContainer.add(tablePane);
        tablePane.setPreferredSize(new Dimension(300, 100));
        topHalf.setBorder(BorderFactory.createEmptyBorder(5,5,0,5));
        topHalf.add(listContainer);
        topHalf.add(tableContainer);

        topHalf.setMinimumSize(new Dimension(400, 50));
        topHalf.setPreferredSize(new Dimension(400, 110));
        splitPane.add(topHalf);

        JPanel bottomHalf = new JPanel(new BorderLayout());
        bottomHalf.add(controlPane, BorderLayout.NORTH);
        bottomHalf.add(outputPane, BorderLayout.CENTER);
        //XXX: next line needed if bottomHalf is a scroll pane:
```

```
        //bottomHalf.setMinimumSize(new Dimension(400, 50));
        bottomHalf.setPreferredSize(new Dimension(450, 135));
        splitPane.add(bottomHalf);
    }

    public static void main(String[] args) {
        JFrame frame = new JFrame("SharedModelDemo");
        frame.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });

        frame.setContentPane(new SharedModelDemo());
        frame.pack();
        frame.setVisible(true);
    }

    class SharedListSelectionHandler implements ListSelectionListener {
        public void valueChanged(ListSelectionEvent e) {
            ListSelectionModel lsm = (ListSelectionModel)e.getSource();

            int firstIndex = e.getFirstIndex();
            int lastIndex = e.getLastIndex();
            boolean isAdjusting = e.getValueIsAdjusting();
            output.append("Event for indexes "
                          + firstIndex + " - " + lastIndex
                          + "; isAdjusting is " + isAdjusting
                          + "; selected indexes:");

            if (lsm.isSelectionEmpty()) {
                output.append(" <none>");
            } else {
                // Find out which indexes are selected.
                int minIndex = lsm.getMinSelectionIndex();
                int maxIndex = lsm.getMaxSelectionIndex();
                for (int i = minIndex; i <= maxIndex; i++) {
                    if (lsm.isSelectedIndex(i)) {
                        output.append(" " + i);
                    }
                }
            }
            output.append(newline);
        }
    }

    class SharedDataModel extends DefaultListModel
                          implements TableModel {
        public String[] columnNames;

        public SharedDataModel(String[] columnNames) {
            super();
            this.columnNames = columnNames;
        }

        public void rowChanged(int row) {
            fireContentsChanged(this, row, row);
        }

        private TableModel tableModel = new AbstractTableModel() {
            public String getColumnName(int column) {
                return columnNames[column];
            }
            public int getRowCount() {
                return size();
            }
            public int getColumnCount() {
                return columnNames.length;
            }
            public Object getValueAt(int row, int column) {
                String[] rowData = (String [])elementAt(row);
                return rowData[column];
            }
            public boolean isCellEditable(int row, int column) {
                return true;
            }
            public void setValueAt(Object value, int row, int column) {
                String newValue = (String)value;
                String[] rowData = (String [])elementAt(row);
                rowData[column] = newValue;
                fireTableCellUpdated(row, column); //table event
                rowChanged(row);                   //list event
            }
        };

        //Implement the TableModel interface.
        public int getRowCount() {
            return tableModel.getRowCount();
        }
        public int getColumnCount() {
            return tableModel.getColumnCount();
        }
        public String getColumnName(int columnIndex) {
            return tableModel.getColumnName(columnIndex);
        }
        public Class getColumnClass(int columnIndex) {
            return tableModel.getColumnClass(columnIndex);
        }
        public boolean isCellEditable(int rowIndex, int columnIndex) {
            return tableModel.isCellEditable(rowIndex, columnIndex);
        }
        public Object getValueAt(int rowIndex, int columnIndex) {
            return tableModel.getValueAt(rowIndex, columnIndex);
        }
        public void setValueAt(Object aValue, int rowIndex, int columnIndex) {
            tableModel.setValueAt(aValue, rowIndex, columnIndex);
        }
        public void addTableModelListener(TableModelListener l) {
            tableModel.addTableModelListener(l);
        }
        public void removeTableModelListener(TableModelListener l) {
            tableModel.removeTableModelListener(l);
        }
    }
}
```

Trail: Creating a GUI with JFC/Swing
Lesson: Getting Started with Swing

Platform-Specific Details: Setting Environment Variables

The directory paths used below assume that you have installed both the JDK and Swing releases under `/home/me` (for Solaris) or on drive C (for Windows). You should adjust the directory paths to reflect your installation.

Solaris

Set the environment variables with commands like the following:

```
setenv JAVA_HOME /home/me/jdk1.1.8
setenv SWING_HOME /home/me/swing-1.1.1
```

Windows 95

Open your favorite text editor and add the following to your system's `AUTOEXEC.BAT` file:

```
set JAVA_HOME=C:\JDK1.1.8
set SWING_HOME=C:\swing-1.1.1
set CLASSPATH=.;%JAVA_HOME%\lib\classes.zip;%SWING_HOME%\swing.jar
set PATH=%PATH%;%JAVA_HOME%\bin
```

Windows NT

Double-click the System icon inside the Control Panel. When the System Properties dialog box opens, choose the Environment tab and then place the following in the lower list box, which is labeled "User Variables":

```
JAVA_HOME     C:\JDK1.1.8
SWING_HOME    C:\swing-1.1.1
CLASSPATH     .;%JAVA_HOME%\lib\classes.zip;%SWING_HOME%\swing.jar
PATH          %PATH%;%JAVA_HOME%\bin
```

Note: Be careful not to change your system environment variables, which appear in the upper list box.

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```
//v 1.3
import javax.swing.*;

public class HelloWorldSwing {
    public static void main(String[] args) {
        JFrame frame = new JFrame("HelloWorldSwing");
        final JLabel label = new JLabel("Hello World");
        frame.getContentPane().add(label);

        frame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
        frame.pack();
        frame.setVisible(true);
    }
}
```

```java
//v 1.3
import javax.swing.*;
import java.awt.*;
import java.awt.event.*;

public class SwingApplication {
    private static String labelPrefix = "Number of button clicks: ";
    private int numClicks = 0;

    public Component createComponents() {
        final JLabel label = new JLabel(labelPrefix + "0    ");

        JButton button = new JButton("I'm a Swing button!");
        button.setMnemonic(KeyEvent.VK_I);
        button.addActionListener(new ActionListener() {
            public void actionPerformed(ActionEvent e) {
                numClicks++;
                label.setText(labelPrefix + numClicks);
            }
        });
        label.setLabelFor(button);

        /*
         * An easy way to put space between a top-level container
         * and its contents is to put the contents in a JPanel
         * that has an "empty" border.
         */
        JPanel pane = new JPanel();
        pane.setBorder(BorderFactory.createEmptyBorder(
                                        30, //top
                                        30, //left
                                        10, //bottom
                                        30) //right
                                        );
        pane.setLayout(new GridLayout(0, 1));
        pane.add(button);
        pane.add(label);

        return pane;
    }

    public static void main(String[] args) {
        try {
            UIManager.setLookAndFeel(
                UIManager.getCrossPlatformLookAndFeelClassName());
        } catch (Exception e) {}

        //Create the top-level container and add contents to it.
        JFrame frame = new JFrame("SwingApplication");
        SwingApplication app = new SwingApplication();
        Component contents = app.createComponents();
        frame.getContentPane().add(contents, BorderLayout.CENTER);

        frame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
        frame.pack();
        frame.setVisible(true);
    }
}
```

```
/*
 * @(#)SimpleExample.java       1.23 99/04/23
 *
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 */

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

/**
 * An application that displays a JButton and several JRadioButtons.
 * The JRadioButtons determine the look and feel used by the application.
 */
public class SimpleExample extends JPanel {
    static JFrame frame;

    static String metal= "Metal";
    static String metalClassName = "javax.swing.plaf.metal.MetalLookAndFeel";

    static String motif = "Motif";
    static String motifClassName =
            "com.sun.java.swing.plaf.motif.MotifLookAndFeel";

    static String windows = "Windows";
    static String windowsClassName =
            "com.sun.java.swing.plaf.windows.WindowsLookAndFeel";

    JRadioButton metalButton, motifButton, windowsButton;

    public SimpleExample() {
        // Create the buttons.
        JButton button = new JButton("Hello, world");
        button.setMnemonic('h'); //for looks only; button does nada

        metalButton = new JRadioButton(metal);
        metalButton.setMnemonic('o');
        metalButton.setActionCommand(metalClassName);
        motifButton = new JRadioButton(motif);
        motifButton.setMnemonic('m');
        motifButton.setActionCommand(motifClassName);

        windowsButton = new JRadioButton(windows);
        windowsButton.setMnemonic('w');
        windowsButton.setActionCommand(windowsClassName);

        // Group the radio buttons.
        ButtonGroup group = new ButtonGroup();
        group.add(metalButton);
        group.add(motifButton);
        group.add(windowsButton);

        // Register a listener for the radio buttons.
        RadioListener myListener = new RadioListener();
        metalButton.addActionListener(myListener);
        motifButton.addActionListener(myListener);
        windowsButton.addActionListener(myListener);

        add(button);
        add(metalButton);
        add(motifButton);
        add(windowsButton);
    }


    /** An ActionListener that listens to the radio buttons. */
    class RadioListener implements ActionListener {
        public void actionPerformed(ActionEvent e) {
            String lnfName = e.getActionCommand();

            try {
                UIManager.setLookAndFeel(lnfName);
                SwingUtilities.updateComponentTreeUI(frame);
                frame.pack();
            }
            catch (Exception exc) {
                JRadioButton button = (JRadioButton)e.getSource();
                button.setEnabled(false);
                updateState();
                System.err.println("Could not load LookAndFeel: " + lnfName);
            }

        }
    }

    public void updateState() {
         String lnfName = UIManager.getLookAndFeel().getClass().getName();
         if (lnfName.indexOf(metal) >= 0) {
             metalButton.setSelected(true);
         } else if (lnfName.indexOf(windows) >= 0) {
             windowsButton.setSelected(true);
         } else if (lnfName.indexOf(motif) >= 0) {
             motifButton.setSelected(true);
         } else {
             System.err.println("SimpleExample is using an unknown L&F: " + lnfName);
         }
    }

    public static void main(String s[]) {
        /*
           NOTE: By default, the look and feel will be set to the
           Cross Platform Look and Feel (which is currently Metal).
           The user may someday be able to override the default
           via a system property. If you as the developer want to
           be sure that a particular L&F is set, you can do so
           by calling UIManager.setLookAndFeel(). For example, the
           first code snippet below forcibly sets the UI to be the
           System Look and Feel. The second code snippet forcibly
           sets the look and feel to the Cross Platform L&F.

           Snippet 1:
              try {
                  UIManager.setLookAndFeel(UIManager.getSystemLookAndFeelClassName());
              } catch (Exception exc) {
                  System.err.println("Error loading L&F: " + exc);
              }

           Snippet 2:
              try {
                  UIManager.setLookAndFeel(UIManager.getCrossPlatformLookAndFeelClassName());
              } catch (Exception exc) {
                  System.err.println("Error loading L&F: " + exc);
              }
        */

        SimpleExample panel = new SimpleExample();

        frame = new JFrame("SimpleExample");
        frame.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {System.exit(0);}
        });
        frame.getContentPane().add("Center", panel);
        frame.pack();
        frame.setVisible(true);

        panel.updateState();
    }
}
```

```
//v 1.3
import java.awt.*;
import java.awt.event.*;
import javax.swing.*;

// This example demonstrates the use of JButton, JTextField
// and JLabel.
public class CelsiusConverter implements ActionListener {
    JFrame converterFrame;
    JPanel converterPanel;
    JTextField tempCelsius;
    JLabel celsiusLabel, fahrenheitLabel;
    JButton convertTemp;

    // Constructor
    public CelsiusConverter() {
        // Create the frame and container.
        converterFrame = new JFrame("Convert Celsius to Fahrenheit");
        converterFrame.setSize(40, 40);
        converterPanel = new JPanel();
        converterPanel.setLayout(new GridLayout(2, 2));

        // Add the widgets.
        addWidgets();

        // Add the panel to the frame.
        converterFrame.getContentPane().add(converterPanel, BorderLayout.CENTER);

        // Exit when the window is closed.
        converterFrame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);

        // Show the converter.
        converterFrame.pack();
        converterFrame.setVisible(true);
    }

    // Create and add the widgets for converter.
    private void addWidgets() {
        // Create widgets.
        tempCelsius = new JTextField(2);
        celsiusLabel = new JLabel("Celsius", SwingConstants.LEFT);
        convertTemp = new JButton("Convert...");
        fahrenheitLabel = new JLabel("Fahrenheit", SwingConstants.LEFT);

        // Listen to events from Convert button.
        convertTemp.addActionListener(this);

        // Add widgets to container.
        converterPanel.add(tempCelsius);
        converterPanel.add(celsiusLabel);
        converterPanel.add(convertTemp);
        converterPanel.add(fahrenheitLabel);

        celsiusLabel.setBorder(BorderFactory.createEmptyBorder(5,5,5,5));
        fahrenheitLabel.setBorder(BorderFactory.createEmptyBorder(5,5,5,5));

    }

    // Implementation of ActionListener interface.
    public void actionPerformed(ActionEvent event) {
        // Parse degrees Celsius as a double and convert to Fahrenheit.
        int tempFahr = (int)((Double.parseDouble(tempCelsius.getText()))
                             * 1.8 + 32);
```

```java
        fahrenheitLabel.setText(tempFahr + " Fahrenheit");
    }

    // main method
    public static void main(String[] args) {
        // Set the look and feel.
        try {
            UIManager.setLookAndFeel(
                UIManager.getCrossPlatformLookAndFeelClassName());
        } catch(Exception e) {}

        CelsiusConverter converter = new CelsiusConverter();
    }
}
```

```
//v 1.3 import java.awt.*; import java.awt.event.*; import javax.swing.*; // This example demonstrates
the use of JButton, JTextField // and JLabel. public class CelsiusConverter2 implements ActionListener {
JFrame converterFrame; JPanel converterPanel; JTextField tempCelsius; JLabel celsiusLabel,
fahrenheitLabel; JButton convertTemp; // Constructor public CelsiusConverter2() { // Create the frame
and container. converterFrame = new JFrame("Convert Celsius to Fahrenheit");
converterFrame.setSize(40, 40); converterPanel = new JPanel(); converterPanel.setLayout(new
GridLayout(2, 2)); // Add the widgets. addWidgets(); // Add the panel to the frame.
converterFrame.getContentPane().add(converterPanel, BorderLayout.CENTER); // Exit when the
window is closed. converterFrame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE); // Show the
converter. converterFrame.pack(); converterFrame.setVisible(true); } // Create and add the widgets for
converter. private void addWidgets() { // Create widgets. ImageIcon icon = new
ImageIcon("images/convert.gif", "Convert temperature"); tempCelsius = new JTextField(2); celsiusLabel
= new JLabel("Celsius", SwingConstants.LEFT); convertTemp = new JButton(icon); fahrenheitLabel =
new JLabel("Fahrenheit", SwingConstants.LEFT);
celsiusLabel.setBorder(BorderFactory.createEmptyBorder(5,5,5,5));
fahrenheitLabel.setBorder(BorderFactory.createEmptyBorder(5,5,5,5)); // Listen to events from Convert
button. convertTemp.addActionListener(this); // Add widgets to container.
converterPanel.add(tempCelsius); converterPanel.add(celsiusLabel); converterPanel.add(convertTemp);
converterPanel.add(fahrenheitLabel); } // Implementation of ActionListener interface. public void
actionPerformed(ActionEvent event) { // Parse degrees Celsius as a double and convert to Fahrenheit. int
tempFahr = (int)((Double.parseDouble(tempCelsius.getText())) * 1.8 + 32); // Set fahrenheitLabel to new
value and set font color based on the temperature. if (tempFahr <= 32) { fahrenheitLabel.setText("" +
tempFahr + "° Fahrenheit"); } else if (tempFahr <= 80) { fahrenheitLabel.setText("" + tempFahr + "°
Fahrenheit "); } else { fahrenheitLabel.setText("" + tempFahr + "° Fahrenheit"); } } // main method
public static void main(String[] args) { // set the look and feel try { UIManager.setLookAndFeel(
UIManager.getCrossPlatformLookAndFeelClassName()); } catch(Exception e) {} CelsiusConverter2
converter = new CelsiusConverter2(); } }
```

```
//v 1.3
import java.awt.*;
import java.awt.event.*;
import javax.swing.*;
import java.net.URL;

// This example demonstrates the use of JButton, JTextField
// and JLabel.
public class LunarPhases implements ActionListener {
    final static int NUM_IMAGES = 8;
    final static int START_INDEX = 3;

    ImageIcon[] images = new ImageIcon[NUM_IMAGES];
    JPanel mainPanel, selectPanel, displayPanel;

    JComboBox phaseChoices = null;
    JLabel phaseIconLabel = null;

    // Constructor
    public LunarPhases() {
        // Create the phase selection and display panels.
        selectPanel = new JPanel();
        displayPanel = new JPanel();

        // Add various widgets to the sub panels.
        addWidgets();

        // Create the main panel to contain the two sub panels.
        mainPanel = new JPanel();
        mainPanel.setLayout(new GridLayout(2,1,5,5));
        mainPanel.setBorder(BorderFactory.createEmptyBorder(5,5,5,5));

        // Add the select and display panels to the main panel.
        mainPanel.add(selectPanel);
        mainPanel.add(displayPanel);
    }

    // Create and the widgets to select and display the phases of the moon.
    private void addWidgets() {
        // Get the images and put them into an array of ImageIcon.
        for (int i = 0; i < NUM_IMAGES; i++) {
            String imageName = "images/image" + i + ".jpg";
            System.out.println("getting image: " + imageName);
            URL iconURL = ClassLoader.getSystemResource(imageName);

            ImageIcon icon = new ImageIcon(iconURL);
            images[i] = icon;
        }

        // Create label for displaying moon phase images and put a border around it.
        phaseIconLabel = new JLabel();
        phaseIconLabel.setHorizontalAlignment(JLabel.CENTER);
        phaseIconLabel.setVerticalAlignment(JLabel.CENTER);
        phaseIconLabel.setVerticalTextPosition(JLabel.CENTER);
        phaseIconLabel.setHorizontalTextPosition(JLabel.CENTER);
        phaseIconLabel.setBorder(BorderFactory.createCompoundBorder(
                            BorderFactory.createLoweredBevelBorder(),
                            BorderFactory.createEmptyBorder(5,5,5,5)));

        phaseIconLabel.setBorder(BorderFactory.createCompoundBorder(
                            BorderFactory.createEmptyBorder(0,0,10,0),
                            phaseIconLabel.getBorder()));
        // Create combo box with lunar phase choices.
        String[] phases = { "New", "Waxing Crescent", "First Quarter",
                            "Waxing Gibbous", "Full", "Waning Gibbous",
                            "Third Quarter", "Waning Crescent" };
        phaseChoices = new JComboBox(phases);
        phaseChoices.setSelectedIndex(START_INDEX);

        // Display the first image.
        phaseIconLabel.setIcon(images[START_INDEX]);
        phaseIconLabel.setText("");

        // Add border around the select panel.
        selectPanel.setBorder(BorderFactory.createCompoundBorder(
                BorderFactory.createTitledBorder("Select Phase"),
                BorderFactory.createEmptyBorder(5,5,5,5)));

        // Add border around the display panel.
        displayPanel.setBorder(BorderFactory.createCompoundBorder(
            BorderFactory.createTitledBorder("Display Phase"),
            BorderFactory.createEmptyBorder(5,5,5,5)));

        // Add moon phases combo box to select panel and image label to displayPanel.
        selectPanel.add(phaseChoices);
        displayPanel.add(phaseIconLabel);

        // Listen to events from combo box.
        phaseChoices.addActionListener(this);
    }

    // Implementation of ActionListener interface.
    public void actionPerformed(ActionEvent event) {
        if ("comboBoxChanged".equals(event.getActionCommand())) {
            // update the icon to display the new phase
            phaseIconLabel.setIcon(images[phaseChoices.getSelectedIndex()]);
        }
    }

    // main method
    public static void main(String[] args) {
        // create a new instance of LunarPhases
        LunarPhases phases = new LunarPhases();

        // Create a frame and container for the panels.
        JFrame lunarPhasesFrame = new JFrame("Lunar Phases");

        // Set the look and feel.
        try {
            UIManager.setLookAndFeel(
                UIManager.getCrossPlatformLookAndFeelClassName());
        } catch(Exception e) {}

        lunarPhasesFrame.setContentPane(phases.mainPanel);

        // Exit when the window is closed.
        lunarPhasesFrame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);

        // Show the converter.
        lunarPhasesFrame.pack();
        lunarPhasesFrame.setVisible(true);
    }
}
```

```
import javax.swing.*; import java.awt.*; import java.awt.event.*; public class VoteDialog extends
JPanel { JLabel label; JFrame frame; String simpleDialogDesc = "The candidates"; public
VoteDialog(JFrame frame) { this.frame = frame; JLabel title; // Create the components. JPanel
choicePanel = createSimpleDialogBox(); System.out.println("passed createSimpleDialogBox"); title =
new JLabel("Click the \"Vote\" button" + " once you have selected a candidate.", JLabel.CENTER); label
= new JLabel("Vote now!", JLabel.CENTER);
label.setBorder(BorderFactory.createEmptyBorder(10,10,10,10));
choicePanel.setBorder(BorderFactory.createEmptyBorder(20,20,5,20)); // Set the layout. setLayout(new
BorderLayout()); add(title, BorderLayout.NORTH); add(label, BorderLayout.SOUTH); add(choicePanel,
BorderLayout.CENTER); } void setLabel(String newText) { label.setText(newText); } private JPanel
createSimpleDialogBox() { final int numButtons = 4; JRadioButton[] radioButtons = new
JRadioButton[numButtons]; final ButtonGroup group = new ButtonGroup(); JButton voteButton = null;
final String defaultMessageCommand = "default"; final String yesNoCommand = "yesno"; final String
yeahNahCommand = "yeahnah"; final String yncCommand = "ync"; radioButtons[0] = new
JRadioButton("Candidate 1: Sparky the Dog");
radioButtons[0].setActionCommand(defaultMessageCommand); radioButtons[1] = new
JRadioButton("Candidate 2: Shady Sadie"); radioButtons[1].setActionCommand(yesNoCommand);
radioButtons[2] = new JRadioButton("Candidate 3: R.I.P. McDaniels");
radioButtons[2].setActionCommand(yeahNahCommand); radioButtons[3] = new
JRadioButton("Candidate 4: Duke the Java™ Platform Mascot");
radioButtons[3].setActionCommand(yncCommand); for (int i = 0; i < numButtons; i++) {
group.add(radioButtons[i]); } // Select the first button by default. radioButtons[0].setSelected(true);
voteButton = new JButton("Vote"); voteButton.addActionListener(new ActionListener() { public void
actionPerformed(ActionEvent e) { String command = group.getSelection().getActionCommand(); // ok
dialog if (command == defaultMessageCommand) { JOptionPane.showMessageDialog(frame, "This
candidate is a dog. Invalid vote."); // yes/no dialog } else if (command == yesNoCommand) { int n =
JOptionPane.showConfirmDialog( frame, "This candidate is a convicted felon. \nDo you still want to
vote for her?", "A Follow-up Question", JOptionPane.YES_NO_OPTION); if (n ==
JOptionPane.YES_OPTION) { setLabel("OK. Keep an eye on your wallet."); } else if (n ==
JOptionPane.NO_OPTION) { setLabel("Whew! Good choice."); } else { setLabel("It is your civic duty
to cast your vote."); } // yes/no (with customized wording) } else if (command == yeahNahCommand) {
Object[] options = {"Yes, please", "No, thanks"}; int n = JOptionPane.showOptionDialog(frame, "This
candidate is deceased. \nDo you still want to vote for him?", "A Follow-up Question",
JOptionPane.YES_NO_OPTION, JOptionPane.QUESTION_MESSAGE, null, options, options[0]); if (n
== JOptionPane.YES_OPTION) { setLabel("I hope you don't expect much from your candidate."); } else
if (n == JOptionPane.NO_OPTION) { setLabel("Whew! Good choice."); } else { setLabel("It is your
civic duty to cast your vote."); } // yes/no/cancel (with customized wording) } else if (command ==
yncCommand) { Object[] options = {"Yes!", "No, I'll pass", "Well, if I must"}; int n =
JOptionPane.showOptionDialog(frame, "Duke is a cartoon mascot. \nDo you " + "still want to cast your
vote?", "A Follow-up Question", JOptionPane.YES_NO_CANCEL_OPTION,
JOptionPane.QUESTION_MESSAGE, null, options, options[2]); if (n == JOptionPane.YES_OPTION)
{ setLabel("Excellent choice."); } else if (n == JOptionPane.NO_OPTION) { setLabel("Whatever you
say. It's your vote."); } else if (n == JOptionPane.CANCEL_OPTION) { setLabel("Well, I'm certainly
not going to make you vote."); } else { setLabel("It is your civic duty to cast your vote."); } } return; }
}); System.out.println("calling createPane"); return createPane(simpleDialogDesc + ":", radioButtons,
voteButton); } private JPanel createPane(String description, JRadioButton[] radioButtons, JButton
showButton) { int numChoices = radioButtons.length; JPanel box = new JPanel(); JLabel label = new
JLabel(description); box.setLayout(new BoxLayout(box, BoxLayout.Y_AXIS)); box.add(label); for (int i
= 0; i < numChoices; i++) { box.add(radioButtons[i]); } JPanel pane = new JPanel(); pane.setLayout(new
BorderLayout()); pane.add(box, BorderLayout.NORTH); pane.add(showButton, BorderLayout.SOUTH);
System.out.println("returning pane"); return pane; } public static void main(String[] args) { JFrame
frame = new JFrame("VoteDialog"); Container contentPane = frame.getContentPane();
contentPane.setLayout(new GridLayout(1,1)); contentPane.add(new VoteDialog(frame)); // Exit when
the window is closed. frame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE); frame.pack();
frame.setVisible(true); } }
```

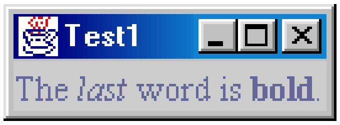
Trail: Creating a GUI with JFC/Swing
Lesson: Getting Started with Swing

Answers to Questions and Exercises: User Interfaces That Swing

Questions

Use the API documentation to answer these questions.

Question 1: Show the code that creates a label displaying the following text, with the italics and boldface as shown in this screenshot:



The *last* word is **bold**.

Answer 1:

```
label = new JLabel("<html>The <em>last</em> word is <b>bold</b>.");
```

Question 2: Use the API documentation or online tutorial, if necessary, to answer the following questions:

Question 2a: Assume that you have a Swing label that tends to have more horizontal space than it needs to display its text. What code would you use to make the text within a label (`Jlabel`) be centered instead of left-aligned?
Answer 2a: Here are two ways:

```
new JLabel(labelText, JLabel.CENTER);
```

or

```
label.setHorizontalAlignment(JLabel.CENTER);
```

Question 2b: What method do you use to enable and disable such components as Swing buttons?
Answer 2b: The `Component setEnabled` method.

Question 2c: How do you add a component to the rightmost (east) cell in a container that uses `BorderLayout`?
Answer 2c: Here's one way:

```
container.add(component, BorderLayout.EAST);
```

Question 3: Is the following code thread-safe? If so, why? If not, what can you do to make it thread-safe?

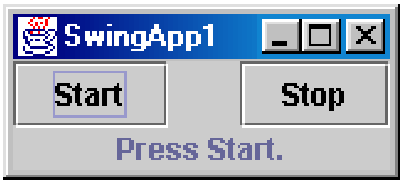
```
JLabel label;

Container createGUI() {
    ...
      //create a JPanel; add components to it, including label
     ...
     return panel;
}

public static void main(String[] args) {
    JFrame f = new JFrame("A Frame");
    f.setContentPane(createGUI());
    f.pack();
    f.setVisible(true);
    String labelText = findTextFromSomewhere();
    label.setText(labelText);
}
```

Answer 3: It's not thread-safe because the main thread updates the label after the label is visible. You can use `SwingUtilities.invokeLater` to make `label.setText` be executed on the event-dispatching thread.

Exercises

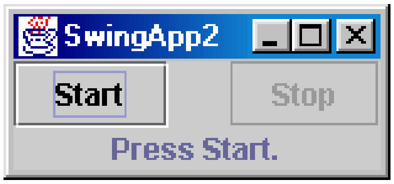
You'll need to work on these exercises in order, as they build upon each other. *Hint:* Your answer to question 2 will be useful.

Question 1: Write an application called `SwingApp1` that has two buttons and one label, arranged as shown in the following screenshot:



Hint: You can use the content pane's default `BorderLayout` to manage the buttons and label.
Answer 1: See `SwingApp1`◆.

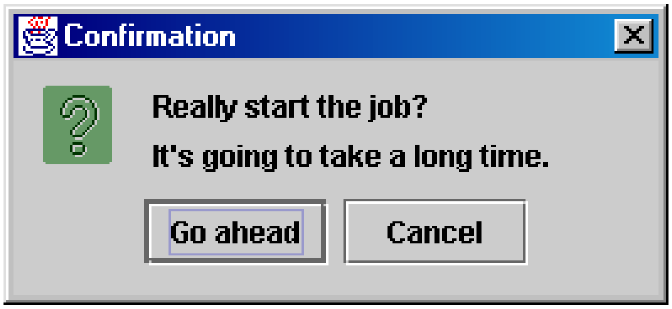
Question 2: Copy `SwingApp1.java` to `SwingApp2.java`, and modify `SwingApp2` so that the Stop button is initially disabled. Implement and register one or two action listeners so that when the user clicks either button, the clicked button is disabled, the other button is enabled, and the label is updated appropriately. Your application should look like this:



Press Start.

Answer 2: See `SwingApp2`◆.

Question 3: Copy `SwingApp2.java` to `SwingApp3.java`, and modify `SwingApp3` so that its Start button brings up a dialog that looks like this:



Really start the job?
It's going to take a long time.

If the user chooses the Go ahead button, the Start button should do exactly what it did in `SwingApp2`. If the user does anything else, the application should update the label to report the cancellation and leave the buttons in their existing state.
Answer 3: See `SwingApp3`◆.

```java
/*
 * This is a 1.3 version (thanks to JFrame.EXIT_ON_CLOSE)
 * but could easily be converted to work in earlier releases.
 * There are many valid ways to implement the exercise.
 */

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

public class SwingApp1 {
    JButton startButton, stopButton;
    JLabel label;

    public SwingApp1() {
        JFrame f = new JFrame("SwingApp1");
        f.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE); //1.3+
        createGUI(f);
        f.pack();
        f.setVisible(true);
    }

    void createGUI(JFrame f) {
        startButton = new JButton("Start");
        stopButton = new JButton("Stop");
        label = new JLabel("Press Start.", JLabel.CENTER);

        Container c = f.getContentPane();
        //Use the content pane's default BorderLayout layout manager.
        c.add(startButton, BorderLayout.WEST);
        c.add(stopButton, BorderLayout.EAST);
        c.add(label, BorderLayout.SOUTH);
    }

    public static void main(String[] args) {
        new SwingApp1();
    }
}
```

```java
/*
 * This is a 1.3 version (thanks to JFrame.EXIT_ON_CLOSE)
 * but could easily be converted to work in earlier releases.
 * There are many valid ways to implement the exercise.
 */

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

public class SwingApp2 {
    JButton startButton, stopButton;
    JLabel label;

    public SwingApp2() {
        JFrame f = new JFrame("SwingApp2");
        f.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE); //1.3+
        createGUI(f);
        initListeners();
        f.pack();
        f.setVisible(true);
    }

    void initListeners() {
        ActionListener al = new MyActionListener();
        startButton.addActionListener(al);
        stopButton.addActionListener(al);
    }

    class MyActionListener implements ActionListener {
        public void actionPerformed(ActionEvent e) {
            if (e.getSource() == startButton) {
                startButton.setEnabled(false);
                stopButton.setEnabled(true);
                label.setText("Press Stop.");
            } else {
                // e.getSource() == stopButton
                stopButton.setEnabled(false);
                startButton.setEnabled(true);
                label.setText("Press Start.");
            }
        }
    }

    void createGUI(JFrame f) {
        startButton = new JButton("Start");
        stopButton = new JButton("Stop");
        stopButton.setEnabled(false);
        label = new JLabel("Press Start.", JLabel.CENTER);

        Container c = f.getContentPane();
        //Use the content pane's default BorderLayout layout manager.
        c.add(startButton, BorderLayout.WEST);
        c.add(stopButton, BorderLayout.EAST);
        c.add(label, BorderLayout.SOUTH);
    }

    public static void main(String[] args) {
        new SwingApp2();
    }
}
```

```
/*
 * This is a 1.3 version (thanks to JFrame.EXIT_ON_CLOSE)
 * but could easily be converted to work in earlier releases.
 * There are many valid ways to implement the exercise.
 */

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

public class SwingApp3 {
    JFrame f;
    JButton startButton, stopButton;
    JLabel label;

    public SwingApp3() {
        f = new JFrame("SwingApp3");
        f.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE); //1.3+
        createGUI(f);
        initListeners();
        f.pack();
        f.setVisible(true);
    }

    void initListeners() {
        ActionListener al = new MyActionListener();
        startButton.addActionListener(al);
        stopButton.addActionListener(al);
    }

    class MyActionListener implements ActionListener {
        public void actionPerformed(ActionEvent e) {
            if (e.getSource() == startButton) {
                if (userOKs()) {
                    startButton.setEnabled(false);
                    stopButton.setEnabled(true);
                    label.setText("Press Stop.");
                } else {
                    label.setText("Start canceled.");
                }
            } else {
                // e.getSource() == stopButton
                stopButton.setEnabled(false);
                startButton.setEnabled(true);
                label.setText("Press Start.");
            }
        }

        boolean userOKs() {
            Object[] options = {"Go ahead", "Cancel"};
            int n = JOptionPane.showOptionDialog(
                      f,
                      "Really start the job?\n"
                      + "It's going to take a long time.",
                      "Confirmation",
                      JOptionPane.YES_NO_OPTION,
                      JOptionPane.QUESTION_MESSAGE,
                      null,
                      options,
                      options[0]);
            if (n == JOptionPane.YES_OPTION) {
                return true;
            }
            return false;
        }
    }

    void createGUI(JFrame f) {
        startButton = new JButton("Start");
        stopButton = new JButton("Stop");
        stopButton.setEnabled(false);
        label = new JLabel("Press Start.", JLabel.CENTER);

        Container c = f.getContentPane();
        //Use the content pane's default BorderLayout layout manager.
        c.add(startButton, BorderLayout.WEST);
        c.add(stopButton, BorderLayout.EAST);
        c.add(label, BorderLayout.SOUTH);
    }

    public static void main(String[] args) {
        new SwingApp3();
    }
}
```

```
/*
 * 1.1 version.
 */

import java.awt.*;
import java.awt.event.*;
import java.applet.Applet;

/*
 * This applet displays several images in a row.  It prevents
 * flashing by double buffering.  However, it doesn't wait
 * for the images to fully load before drawing them, which
 * causes the weird effect of the animation appearing from
 * the top down.
 */

public class ImageSequence extends Applet
                           implements Runnable {
    int frameNumber = -1;
    int delay;
    Thread animatorThread;
    boolean frozen = false;

    Image images[];

    Dimension offDimension;
    Image offImage;
    Graphics offGraphics;

    public void init() {
        String str;
        int fps = 10;

        //How many milliseconds between frames?
        str = getParameter("fps");
        try {
            if (str != null) {
                fps = Integer.parseInt(str);
            }
        } catch (Exception e) {}
        delay = (fps > 0) ? (1000 / fps) : 100;

        //Get the images.
        images = new Image[10];
        for (int i = 1; i <= 10; i++) {
            images[i-1] = getImage(getCodeBase(),
                                   "T"+i+".gif");
        }

        addMouseListener(new MouseAdapter() {
            public void mousePressed(MouseEvent e) {
                if (frozen) {
                    frozen = false;
                    start();
                } else {
                    frozen = true;

                    //Instead of calling stop(), which destroys the
                    //backbuffer, just stop the animating thread.
                    animatorThread = null;
                }
            }
        });
    }

    public void start() {
        if (frozen) {
            //Do nothing.  The user has requested that we
            //stop changing the image.
        } else {
            //Start animating!
            if (animatorThread == null) {
                animatorThread = new Thread(this);
            }
            animatorThread.start();
        }
    }

    public void stop() {
        //Stop the animating thread.
        animatorThread = null;

        //Get rid of the objects necessary for double buffering.
        offGraphics = null;
        offImage = null;
    }

    public void run() {
        //Just to be nice, lower this thread's priority
        //so it can't interfere with other processing going on.
        Thread.currentThread().setPriority(Thread.MIN_PRIORITY);

        //Remember the starting time.
        long startTime = System.currentTimeMillis();

        //Remember which thread we are.
        Thread currentThread = Thread.currentThread();

        //This is the animation loop.
        while (currentThread == animatorThread) {
            //Advance the animation frame.
            frameNumber++;

            //Display it.
            repaint();

            //Delay depending on how far we are behind.
            try {
                startTime += delay;
                Thread.sleep(Math.max(0,
                             startTime-System.currentTimeMillis()));
            } catch (InterruptedException e) {
                break;
            }
        }
    }

    //Draw the current frame of animation.
    public void paint(Graphics g) {
        update(g);
    }

    public void update(Graphics g) {
        Dimension d = getSize();
        //Create the offscreen graphics context,
        //if no good one exists.
        if ( (offGraphics == null)
          || (d.width != offDimension.width)
          || (d.height != offDimension.height) ) {
            offDimension = d;
            offImage = createImage(d.width, d.height);
            offGraphics = offImage.getGraphics();
        }

        //Erase the previous image.
        offGraphics.setColor(getBackground());
        offGraphics.fillRect(0, 0, d.width, d.height);
        offGraphics.setColor(Color.black);

        //Paint the frame into the image.
        try {
            offGraphics.drawImage(images[frameNumber%10],
                                  0, 0, this);
        } catch(ArrayIndexOutOfBoundsException e) {
            //On rare occasions, this method can be called
            //when frameNumber is still -1.  Do nothing.
            return;
        }

        //Paint the image onto the screen.
        g.drawImage(offImage, 0, 0, this);
    }
}
```

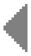
```java
/*
 * 1.1 version.
 */

import java.awt.*;
import java.awt.event.*;
import java.applet.Applet;

/*
 * This displays a framed area.  When the user clicks within
 * the area, this program displays a dot and a string indicating
 * the coordinates where the click occurred.
 */

public class CoordinatesDemo extends Applet {
    FramedArea framedArea;
    Label label;

    public void init() {
        GridBagLayout gridBag = new GridBagLayout();
        GridBagConstraints c = new GridBagConstraints();

        setLayout(gridBag);

        framedArea = new FramedArea(this);
        c.fill = GridBagConstraints.BOTH;
        c.weighty = 1.0;
        c.gridwidth = GridBagConstraints.REMAINDER; //end row
        gridBag.setConstraints(framedArea, c);
        add(framedArea);

        label = new Label("Click within the framed area.");
        c.fill = GridBagConstraints.HORIZONTAL;
        c.weightx = 1.0;
        c.weighty = 0.0;
        gridBag.setConstraints(label, c);
        add(label);
    }

    public void updateLabel(Point point) {
        label.setText("Click occurred at coordinate ("
                      + point.x + ", " + point.y + ").");
    }
}

/* This class exists solely to put a frame around the coordinate area. */
class FramedArea extends Panel {
    public FramedArea(CoordinatesDemo controller) {
        super();

        //Set layout to one that makes its contents as big as possible.
        setLayout(new GridLayout(1,0));

        add(new CoordinateArea(controller));
    }

    public Insets getInsets() {
        return new Insets(4,4,5,5);
    }

    public void paint(Graphics g) {
        Dimension d = getSize();
        Color bg = getBackground();
        g.setColor(bg);
        g.draw3DRect(0, 0, d.width - 1, d.height - 1, true);
        g.draw3DRect(3, 3, d.width - 7, d.height - 7, false);
    }
}

class CoordinateArea extends Canvas {
    Point point = null;
    CoordinatesDemo controller;

    public CoordinateArea(CoordinatesDemo controller) {
        super();
        this.controller = controller;

        addMouseListener(new MouseAdapter() {
            public void mousePressed(MouseEvent e) {
                int x = e.getX();
                int y = e.getY();
                if (point == null) {
                    point = new Point(x, y);
                } else {
                    point.x = x;
                    point.y = y;
                }
                repaint();
            }
        });
    }

    public void paint(Graphics g) {
        //If user has chosen a point, paint a tiny rectangle on top.
        if (point != null) {
            controller.updateLabel(point);
            g.fillRect(point.x - 1, point.y - 1, 2, 2);
        }
    }
}
```

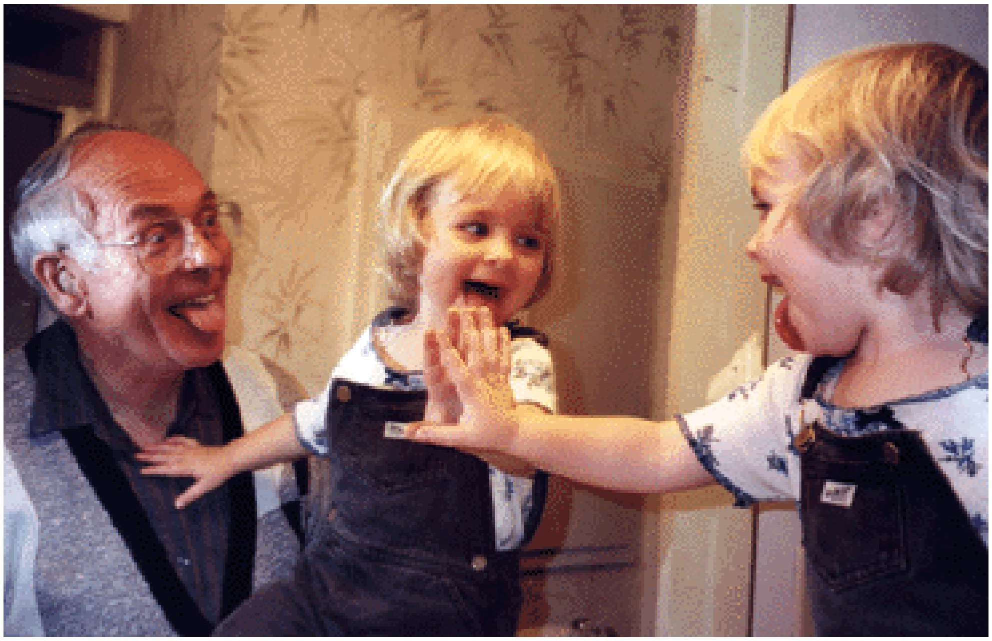
```
import java.awt.*;
import javax.swing.*;
import javax.accessibility.*;
import java.util.Locale;

public class Rule extends JComponent implements Accessible {
    public static final int INCH = Toolkit.getDefaultToolkit().
            getScreenResolution();
    public static final int HORIZONTAL = 0;
    public static final int VERTICAL = 1;
    public static final int SIZE = 35;

    public int orientation;
    public boolean isMetric;
    private int increment;
    private int units;

    public Rule(int o, boolean m) {
        orientation = o;
        isMetric = m;
        setIncrementAndUnits();
    }

    public void setIsMetric(boolean isMetric) {
        if (accessibleContext != null && this.isMetric != isMetric) {
            if (isMetric) {
                accessibleContext.firePropertyChange(
                    AccessibleContext.ACCESSIBLE_STATE_PROPERTY,
                    AccessibleRulerState.INCHES,
                    AccessibleRulerState.CENTIMETERS);
            } else {
                accessibleContext.firePropertyChange(
                    AccessibleContext.ACCESSIBLE_STATE_PROPERTY,
                    AccessibleRulerState.CENTIMETERS,
                    AccessibleRulerState.INCHES);
            }
        }
        this.isMetric = isMetric;
        setIncrementAndUnits();
        repaint();
    }

    private void setIncrementAndUnits() {
        if (isMetric) {
            units = (int)((double)INCH / (double)2.54); // dots per centimeter
            increment = units;
        } else {
            units = INCH;
            increment = units / 2;
        }
    }

    public boolean isMetric() {
        return this.isMetric;
    }

    public int getIncrement() {
        return increment;
    }

    public void setPreferredHeight(int ph) {
        setPreferredSize(new Dimension(SIZE, ph));
    }

    public void setPreferredWidth(int pw) {
        setPreferredSize(new Dimension(pw, SIZE));
    }

    public void paintComponent(Graphics g) {
        Rectangle drawHere = g.getClipBounds();

        // Fill clipping area with dirty brown/orange.
        g.setColor(new Color(230, 163, 4));
        g.fillRect(drawHere.x, drawHere.y, drawHere.width, drawHere.height);

        // Do the ruler labels in a small font that's black.
        g.setFont(new Font("SansSerif", Font.PLAIN, 10));
        g.setColor(Color.black);

        // Some vars we need.
        int end = 0;
        int start = 0;
        int tickLength = 0;
        String text = null;

        // Use clipping bounds to calculate first tick
        // and last tick location.
        if (orientation == HORIZONTAL) {
            start = (drawHere.x / increment) * increment;
            end = (((drawHere.x + drawHere.width) / increment) + 1)
                  * increment;
        } else {
            start = (drawHere.y / increment) * increment;
            end = (((drawHere.y + drawHere.height) / increment) + 1)
                  * increment;
        }

        // Make a special case of 0 to display the number
        // within the rule and draw a units label.
        if (start == 0) {
            text = Integer.toString(0) + (isMetric ? " cm" : " in");
            tickLength = 10;
            if (orientation == HORIZONTAL) {
                g.drawLine(0, SIZE-1, 0, SIZE-tickLength-1);
                g.drawString(text, 2, 21);
            } else {
                g.drawLine(SIZE-1, 0, SIZE-tickLength-1, 0);
                g.drawString(text, 9, 10);
            }
            text = null;
            start = increment;
        }

        // ticks and labels
        for (int i = start; i < end; i += increment) {
            if (i % units == 0)  {
                tickLength = 10;
                text = Integer.toString(i/units);
            } else {
                tickLength = 7;
                text = null;
            }

            if (tickLength != 0) {
                if (orientation == HORIZONTAL) {
                    g.drawLine(i, SIZE-1, i, SIZE-tickLength-1);
                    if (text != null)
                        g.drawString(text, i-3, 21);
                } else {
                    g.drawLine(SIZE-1, i, SIZE-tickLength-1, i);
                    if (text != null)
                        g.drawString(text, 9, i+3);
                }
            }
        }
    }

    public AccessibleContext getAccessibleContext() {
        if (accessibleContext == null) {
            accessibleContext = new AccessibleRuler();
        }
        return accessibleContext;
    }

    protected class AccessibleRuler extends AccessibleJComponent {
        public AccessibleRole getAccessibleRole() {
            return AccessibleRuleRole.RULER;
        }

        public AccessibleStateSet getAccessibleStateSet() {
            AccessibleStateSet states = super.getAccessibleStateSet();
            if (orientation == VERTICAL) {
                states.add(AccessibleState.VERTICAL);
            } else {
                states.add(AccessibleState.HORIZONTAL);
            }
            if (isMetric) {
                states.add(AccessibleRulerState.CENTIMETERS);
            } else {
                states.add(AccessibleRulerState.INCHES);
            }
            return states;
        }
    }
}

class AccessibleRuleRole extends AccessibleRole {
    public static final AccessibleRuleRole RULER
        = new AccessibleRuleRole("ruler");

    protected AccessibleRuleRole(String key) {
        super(key);
    }

    //Should really provide localizable versions of these names.
    public String toDisplayString(String resourceBundleName,
                                  Locale locale) {
        return key;
    }
}

class AccessibleRulerState extends AccessibleState {
    public static final AccessibleRulerState INCHES
        = new AccessibleRulerState("inches");
    public static final AccessibleRulerState CENTIMETERS
        = new AccessibleRulerState("centimeters");
    protected AccessibleRulerState(String key) {
        super(key);
    }

    //Should really provide localizable versions of these names.
    public String toDisplayString(String resourceBundleName,
                                  Locale locale) {
        return key;
    }
}
```

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

public class Corner extends JComponent
                    implements Accessible {

    public void paintComponent(Graphics g) {
        // Fill me with dirty brown/orange.
        g.setColor(new Color(230, 163, 4));
        g.fillRect(0, 0, getWidth(), getHeight());
    }

    public AccessibleContext getAccessibleContext() {
        if (accessibleContext == null) {
            accessibleContext = new AccessibleCorner();
        }
        return accessibleContext;
    }

    protected class AccessibleCorner extends AccessibleJComponent {
        //Inherit everything, override nothing.
    }
}
```

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

public class ScrollablePicture extends JLabel implements Scrollable {

    private int maxUnitIncrement = 1;

    public ScrollablePicture(ImageIcon i, int m) {
        super(i);
        maxUnitIncrement = m;
    }

    public Dimension getPreferredScrollableViewportSize() {
        return getPreferredSize();
    }

    public int getScrollableUnitIncrement(Rectangle visibleRect, int orientation, int direction) {

        int currentPosition = 0;
        if (orientation == SwingConstants.HORIZONTAL)
            currentPosition = visibleRect.x;
        else
            currentPosition = visibleRect.y;

        if (direction < 0) {
            int newPosition = currentPosition - (currentPosition / maxUnitIncrement) *
maxUnitIncrement;
            return (newPosition == 0) ? maxUnitIncrement : newPosition;
        } else {
            return ((currentPosition / maxUnitIncrement) + 1) * maxUnitIncrement -
currentPosition;
        }
    }

    public int getScrollableBlockIncrement(Rectangle visibleRect, int orientation, int direction)
{
        if (orientation == SwingConstants.HORIZONTAL)
            return visibleRect.width - maxUnitIncrement;
        else
            return visibleRect.height - maxUnitIncrement;
    }

    public boolean getScrollableTracksViewportWidth() {
        return false;
    }

    public boolean getScrollableTracksViewportHeight() {
        return false;
    }

    public void setMaxUnitIncrement(int pixels) {
        maxUnitIncrement = pixels;
    }
}
```

```java
import javax.swing.ImageIcon;

public class Photo {
    public String filename;
    public String caption;
    public int width;
    public int height;
    public ImageIcon icon;

    public Photo(String filename, String caption, int w, int h) {
        this.filename = filename;
        if (caption == null)
            this.caption = filename;
        else
            this.caption = caption;
        width = w;
        height = h;
        icon = null;
    }

    public void setIcon(ImageIcon i) {
        icon = i;
    }

    public ImageIcon getIcon() {
        return icon;
    }
}
```



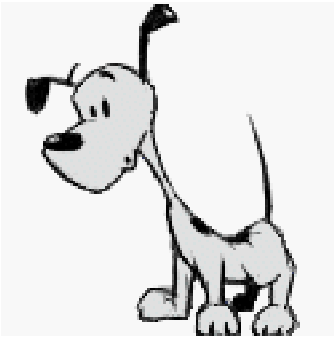


```
<applet code="IconDemoApplet.class"
        codebase="example-swing/"
        archive="icon.jar"
        width="400"
        height="360"
>
    <param NAME="IMAGEDIR" VALUE="images">

    <param NAME="IMAGE0" VALUE="stickerface.gif">
    <param NAME="CAPTION0" VALUE="Sticker Face">
    <param NAME="WIDTH0" VALUE="230">
    <param NAME="HEIGHT0" VALUE="238">

    <param NAME="IMAGE1" VALUE="lainesTongue.gif">
    <param NAME="CAPTION1" VALUE="Study of Laine's Tongue">
    <param NAME="WIDTH1" VALUE="369">
    <param NAME="HEIGHT1" VALUE="237">

    <param NAME="IMAGE2" VALUE="kathyCosmo.gif">
    <param NAME="CAPTION2" VALUE="Kathy & Cosmo">
    <param NAME="WIDTH2" VALUE="288">
    <param NAME="HEIGHT2" VALUE="200">

    <param NAME="IMAGE3" VALUE="ewanPumpkin.gif">
    <param NAME="CAPTION3" VALUE="Ewan Dinkins">
    <param NAME="WIDTH3" VALUE="278">
    <param NAME="HEIGHT3" VALUE="237">

</applet>
```

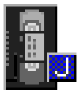
red

green

blue



```
import java.io.*;
import java.awt.*;
import java.awt.event.*;
import javax.swing.*;
import javax.swing.filechooser.*;

public class FileChooserDemo2 extends JFrame {
    static private String newline = "\n";

    public FileChooserDemo2() {
        super("FileChooserDemo2");

        //Create the log first, because the action listener
        //needs to refer to it.
        final JTextArea log = new JTextArea(5,20);
        log.setMargin(new Insets(5,5,5,5));
        log.setEditable(false);
        JScrollPane logScrollPane = new JScrollPane(log);

        JButton sendButton = new JButton("Attach...");
        sendButton.addActionListener(new ActionListener() {
            public void actionPerformed(ActionEvent e) {
                JFileChooser fc = new JFileChooser();
                fc.addChoosableFileFilter(new ImageFilter());
                fc.setFileView(new ImageFileView());
                fc.setAccessory(new ImagePreview(fc));

                int returnVal = fc.showDialog(FileChooserDemo2.this,
                                              "Attach");

                if (returnVal == JFileChooser.APPROVE_OPTION) {
                    File file = fc.getSelectedFile();
                    log.append("Attaching file: " + file.getName()
                               + "." + newline);
                } else {
                    log.append("Attachment cancelled by user." + newline);
                }
            }
        });

        Container contentPane = getContentPane();
        contentPane.add(sendButton, BorderLayout.NORTH);
        contentPane.add(logScrollPane, BorderLayout.CENTER);
    }

    public static void main(String[] args) {
        JFrame frame = new FileChooserDemo2();
        frame.addWindowListener(new WindowAdapter() {
            public void windowClosing(WindowEvent e) {
                System.exit(0);
            }
        });

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



GIF

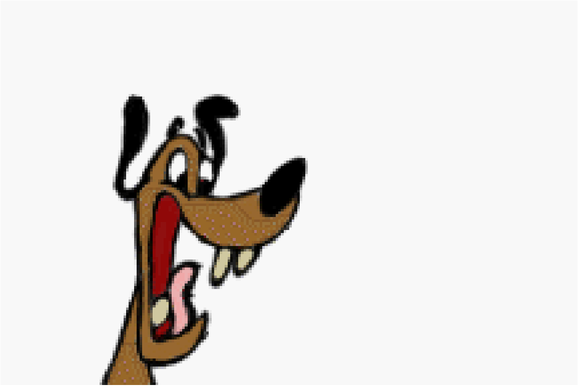
TIF

```java
import javax.swing.JFrame;
import javax.swing.JMenuBar;
import javax.swing.JMenu;
import javax.swing.JMenuItem;

import javax.swing.JOptionPane;

import java.awt.*;
import java.awt.event.*;

public class Framework extends WindowAdapter {
    public int numWindows = 0;
    private Point lastLocation = null;
    private int maxX = 500;
    private int maxY = 500;

    public Framework() {
        Dimension screenSize = Toolkit.getDefaultToolkit().getScreenSize();
        maxX = screenSize.width - 50;
        maxY = screenSize.height - 50;
        makeNewWindow();
    }

    public void makeNewWindow() {
        JFrame frame = new MyFrame(this);
        numWindows++;
        System.out.println("Number of windows: " + numWindows);

        if (lastLocation != null) {
            //Move the window over and down 40 pixels.
            lastLocation.translate(40, 40);
            if ((lastLocation.x > maxX) || (lastLocation.y > maxY)) {
                lastLocation.setLocation(0, 0);
            }
            frame.setLocation(lastLocation);
        } else {
            lastLocation = frame.getLocation();
        }

        System.out.println("Frame location: " + lastLocation);
        frame.setVisible(true);
    }

    //This method must be evoked from the event-dispatching thread.
    public void quit(JFrame frame) {
        if (quitConfirmed(frame)) {
            System.out.println("Quitting.");
            System.exit(0);
        }
        System.out.println("Quit operation not confirmed; staying alive.");
    }

    private boolean quitConfirmed(JFrame frame) {
        String s1 = "Quit";
        String s2 = "Cancel";
        Object[] options = {s1, s2};
        int n = JOptionPane.showOptionDialog(frame,
                "Windows are still open.\nDo you really want to quit?",
                "Quit Confirmation",
                JOptionPane.YES_NO_OPTION,
                JOptionPane.QUESTION_MESSAGE,
                null,
                options,
                s1);
        if (n == JOptionPane.YES_OPTION) {
            return true;
        } else {
            return false;
        }
    }

    public void windowClosed(WindowEvent e) {
        numWindows--;
        System.out.println("Number of windows = " + numWindows);
        if (numWindows <= 0) {
            System.out.println("All windows gone.  Bye bye!");
            System.exit(0);
        }
    }

    public static void main(String[] args) {
        Framework framework = new Framework();
    }
}

class MyFrame extends JFrame {
    protected Dimension defaultSize = new Dimension(200, 200);
    protected Framework framework = null;

    public MyFrame(Framework controller) {
        super("New Frame");
        framework = controller;
        setDefaultCloseOperation(DISPOSE_ON_CLOSE);
        addWindowListener(framework);

        JMenu menu = new JMenu("Window");
        menu.setMnemonic(KeyEvent.VK_W);
        JMenuItem item = null;
        //close
        item = new JMenuItem("Close");
        item.setMnemonic(KeyEvent.VK_C);
        item.addActionListener(new ActionListener() {
            public void actionPerformed(ActionEvent e) {
                System.out.println("Close window");
                MyFrame.this.setVisible(false);
                MyFrame.this.dispose();
            }
        });
        menu.add(item);

        //new
        item = new JMenuItem("New");
        item.setMnemonic(KeyEvent.VK_N);
        item.addActionListener(new ActionListener() {
            public void actionPerformed(ActionEvent e) {
                System.out.println("New window");
                framework.makeNewWindow();
            }
        });
        menu.add(item);

        //quit
        item = new JMenuItem("Quit");
        item.setMnemonic(KeyEvent.VK_Q);
        item.addActionListener(new ActionListener() {
            public void actionPerformed(ActionEvent e) {
                System.out.println("Quit request");
                framework.quit(MyFrame.this);
            }
        });
        menu.add(item);

        JMenuBar menuBar = new JMenuBar();
        menuBar.add(menu);
        setJMenuBar(menuBar);

        setSize(defaultSize);
    }
}
```

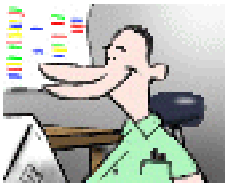
```
<applet code="TextDemo.class"
        codebase="example-swing/"
        archive="textfield.jar"
        width="250" height="125">

Since you can't run the applet,
here's a picture of it:

#usemacro UI_FIGURE (
    NAME TextDemoSwing.gif
    W 261
    H 206
    ALT A snapshot of TextDemo, which uses a standard text field and a standard text area.
)

</applet>
```

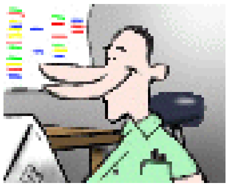
This is an uneditable `JEditorPane`, which was *initialized* with **HTML** text from a URL.

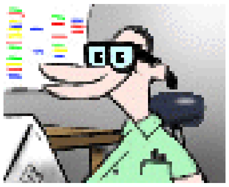
An editor pane uses specialized editor kits to read, write, display, and edit text of different formats. The Swing text package includes editor kits for plain text, HTML, and RTF. You can also develop custom editor kits for other formats.

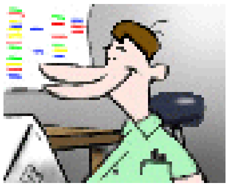


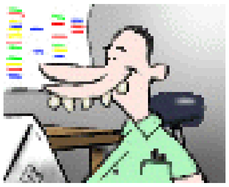
```
<applet code="TumbleItem.class"
        codebase="example-swing/"
        archive="tumble.jar"
        width="600" height="95">
    <param name="maxwidth" value="120">
    <param name="nimgs" value="17">
    <param name="offset" value="-57">
    <param name="img" value="images/tumble">

Your browser is completely ignoring the &lt;APPLET&gt; tag!

</applet>
```

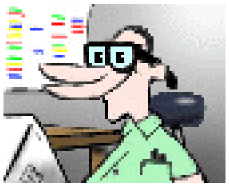


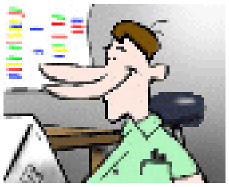


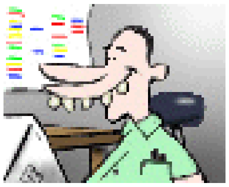


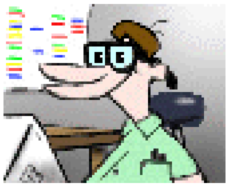


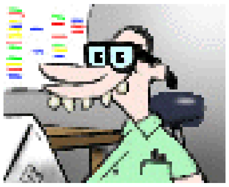


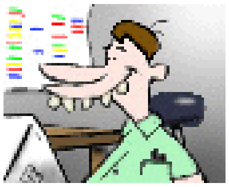


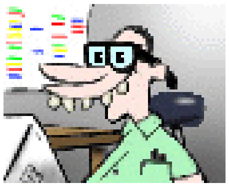


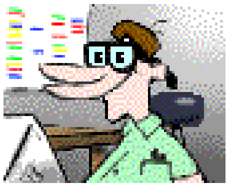


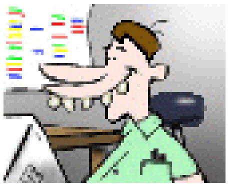


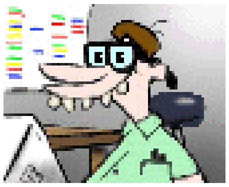


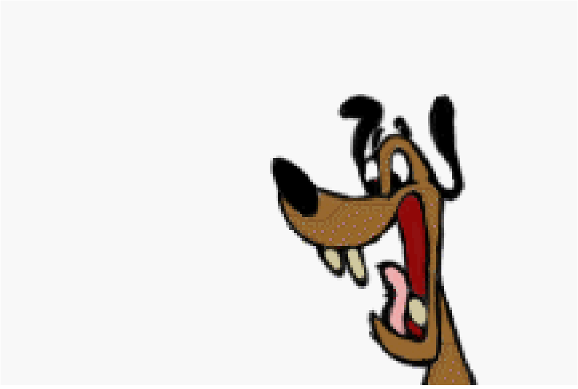


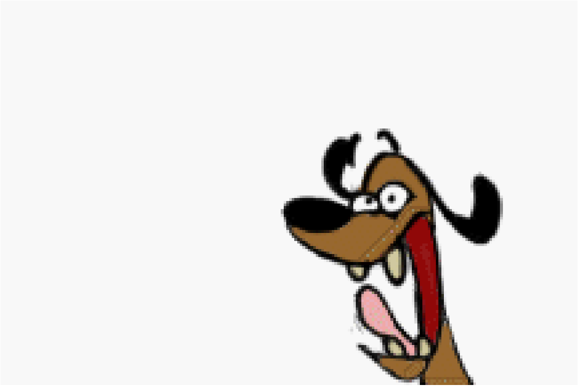


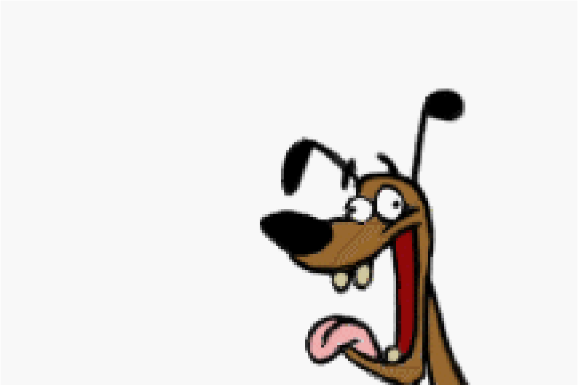


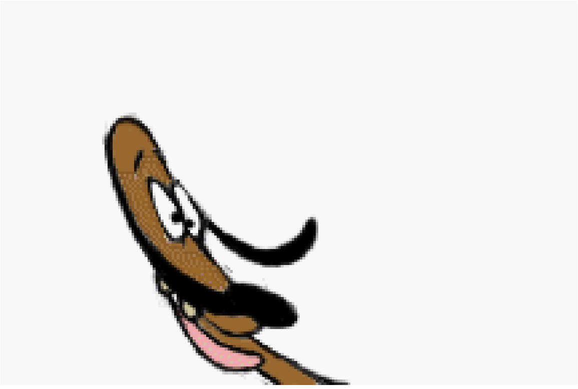


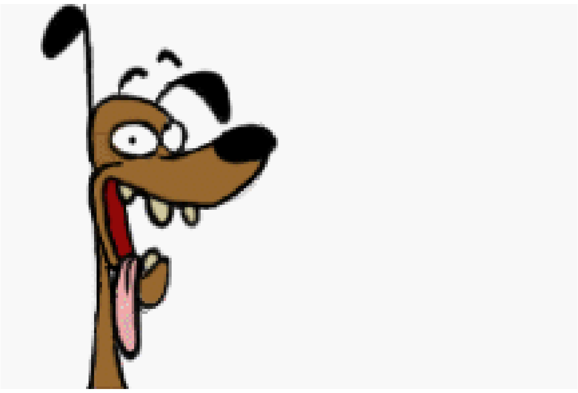


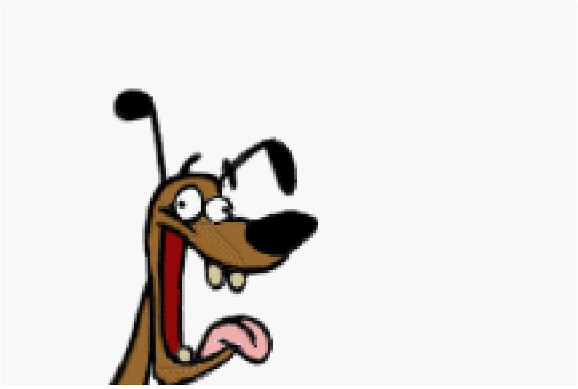


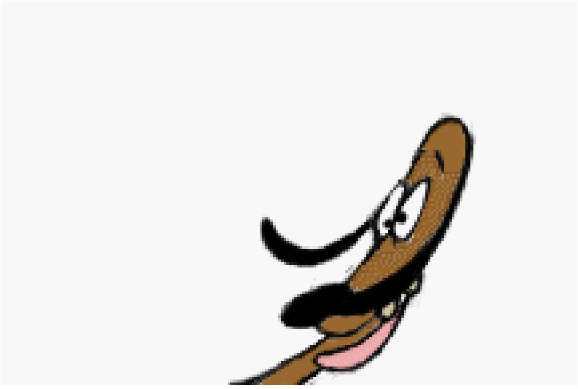


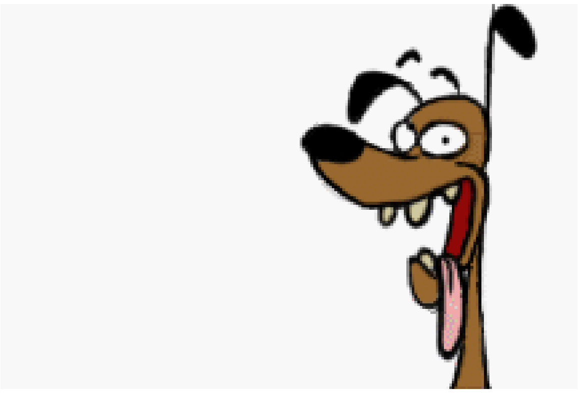


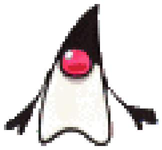


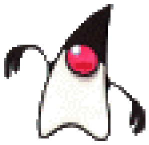


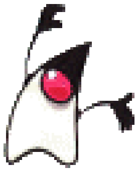


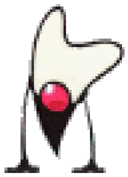


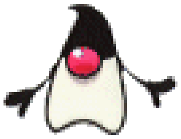


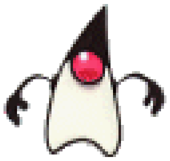


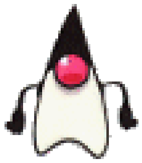












Mary Campione • Kathy Walrath
The Java™ Tutorial
Object-Oriented Programming for the Internet

Tree Demo

This is the help file (`TreeDemoHelp.html`) for the tree demo. Selecting any branch node in the tree results in this file being displayed. When you select a leaf node (a book), this pane displays an HTML file for that book.

This demo uses a split pane to separate the tree and this HTML view. Drag the divider up or down to change the space distribution.

The Java Tutorial

The one, the only. Well, not the only any more. This is the original Tutorial book. The second edition describes JDK 1.1 APIs -- but not Swing.

The Java Tutorial Continued

This book covers just about all the API that the other two books don't cover. The book is aimed at Java 2 (JDK 1.2) users, but it also covers many JDK 1.1 APIs.

The JFC Swing Tutorial

This is the UI trail from the original Tutorial, updated and expanded to reflect the Swing components. More fun than a barrel full of monkeys! Much more fun than a root canal!

The Java Programming Language

blah, blah, blah, blah, blah...

The Java FAQ

blah, blah, blah, blah, blah...

The Java Class Libraries

blah, blah, blah, blah, blah...

Concurrent Programming in Java

blah, blah, blah, blah, blah...

The Java Virtual Machine Specification

blah, blah, blah, blah, blah...

The Java Language Specification

blah, blah, blah, blah, blah...

```
<applet code="AppletDemo.class"
        codebase="example-swing"
        archive="applets.jar"
        width="570"
        height="65"
>
</applet>
```

```
<applet code="HelloSwingApplet.class"
        codebase="example-swing"
        archive="applets.jar"
        width=400
        height=50>
</applet>
```