Event Handling

Applets are event-driven programs. Thus, event handling is at the core of successful applet programming. Most events to which our applet will respond are generated by the user. These events are passed to our applet in a variety of ways, with the specific method depending upon the actual event. There are several types of events. The most commonly handled events are those generated by the mouse, the keyboard, and various controls, such as a push button. Events are supported by the **java.awt.event** package.

The Delegation Event Model

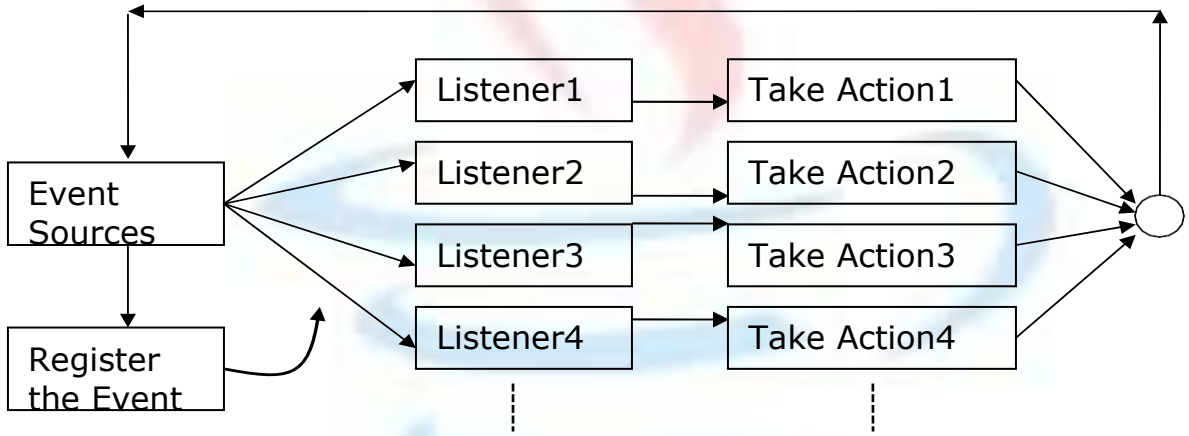


Fig. Delegation Event Model

The modern approach to handling events is based on the delegation event model, which defines standard and consistent mechanisms to generate and process events. Its concept is quite simple: a source generates an event and sends it to one or more listeners. In this scheme, the listener simply waits until it receives an event. Once received, the listener processes the event and then returns. The advantage of this design is that the application logic that processes events is cleanly separated from the user interface logic that generates those events. A user interface element is able to "delegate" the processing of an event to a separate piece of code.

In the delegation event model, listeners must register with a source in order to receive an event notification. This provides an important benefit: notifications are sent only to listeners that want to receive them. This is a more efficient way to handle events than the design used by the old Java 1.0 approach.

Java also allows us to process events without using the delegation event model. This can be done by extending an AWT component. However, the delegation event model is the preferred design for the reasons just cited.

Events

In the delegation model, an event is an object that describes a state change in a source. It can be generated as a consequence of a person interacting with the elements in a graphical user interface. Some of the activities that cause events to be generated are pressing a button, entering a character via the keyboard, selecting an item in a list, and clicking the mouse. Many other user operations could also be cited as examples. Events may also occur that are not directly caused by interactions with a user interface. For example, an event may be generated when a timer expires, a counter exceeds a value, software or hardware failure occurs, or an operation is completed. We are free to define events that are appropriate for your application.

Event Sources

A source is an object that generates an event. This occurs when the internal state of that object changes in some way. Sources may generate more than one type of event. A source must register listeners in order for the listeners to receive notifications about a specific type of event. Each type of event has its own registration method. Here is the general form:

```
public void add***Type***Listener(TypeListener el)
```

Here, *Type* is the name of the event and *el* is a reference to the event listener. For example, the method that registers a keyboard event listener is called addKeyListener( ). The method that registers a mouse motion listener is called addMouseMotionListener( ). When an event occurs, all registered listeners are notified and receive a copy of the event object. This is known as multicasting the event. In all cases, notifications are sent only to listeners that register to receive them. Some sources may allow only one listener to register. The general form of such a method is this:

```
public void addTypeListener(TypeListener el)
     throws java.util.TooManyListenersException
```

Here, *Type* is the name of the event and el is a reference to the event listener. When such an event occurs, the registered listener is notified. This is known as unicasting the event. A source must also provide a method that allows a listener to un-register an interest in a specific type of event. The general form of such a method is this:

```
public void remove***Type***Listener(TypeListener el)
```

Here, *Type* is the name of the event and *el* is a reference to the event listener. For example, to remove a keyboard listener, we would call removeKeyListener( ). The methods that add or remove listeners are provided by the source that generates events. For example, the Component class provides methods to add and remove keyboard and mouse event listeners.

Event Listeners

A listener is an object that is notified when an event occurs. It has two major requirements. First, it must have been registered with one or more sources to receive notifications about specific types of events. Second, it must implement methods to receive and process these notifications. The methods that receive and process events are defined in a set of interfaces found in java.awt.event. For example, the MouseMotionListener interface defines two methods to receive notifications when the mouse is dragged or moved. Any object may receive and process one or both of these events if it provides an implementation of this interface.

Event Classes

The classes that represent events are at the core of Java's event handling mechanism. At the root of the Java event class hierarchy is **EventObject**, which is in java.util. It is the superclass for all events. EventObject contains two methods: getSource( ) and toString( ). The getSource( ) method returns the source of the event. Its general form is shown here:

```
Object getSource( )
```

As expected, toString( ) returns the string equivalent of the event. The class AWTEvent, defined within the java.awt package, is a subclass of EventObject. It is the superclass (either directly or indirectly) of all AWT-based events used by the delegation event model.

- EventObject is a superclass of all events.
- AWTEvent is a superclass of all AWT events that are handled by the delegation event model.

The package java.awt.event defines several types of events that are generated by various user interface elements.

Event Class	Description
ActionEvent	Generated when a button is pressed, a list item is double-clicked, or a menu item is selected.
AdjustmentEvent	Generated when a scroll bar is manipulated.
ComponentEvent	Generated when a component is hidden, moved, resized, or becomes visible.
ContainerEvent	Generated when a component is added to or removed from a container.
FocusEvent	Generated when a component gains or loses keyboard focus.
InputEvent	Abstract super class for all component input event classes.
ItemEvent	Generated when a check box or list item is clicked; also occurs when a choice selection is made or a checkable menu item is selected or deselected.
KeyEvent	Generated when input is received from the keyboard.

MouseEvent	Generated when the mouse is dragged, moved, clicked, pressed, or released; also generated when the mouse enters or exits a component.
MouseWheelEvent	Generated when the mouse wheel is moved.
TextEvent	Generated when the value of a text area or text field is changed.
WindowEvent	Generated when a window is activated, closed, deactivated, deiconified, iconified, opened, or quit.

ActionEvent

An *ActionEvent* is generated when a button is pressed, a list item is double-clicked, or a menu item is selected. The ActionEvent class defines four integer constants that can be used to identify any modifiers associated with an action event: ALT_MASK, CTRL_MASK, META_MASK, and SHIFT_MASK. In addition, there is an integer constant, ACTION_PERFORMED, which can be used to identify action events. We can obtain the command name for the invoking ActionEvent object by using the getActionCommand( ) method, shown here:

```
String getActionCommand( )
```

For example, when a button is pressed, an action event is generated that has a command name equal to the label on that button. The getModifiers( ) method returns a value that indicates which modifier keys (ALT, CTRL, META, and/or SHIFT) were pressed when the event was generated. Its form is shown here:

```
int getModifiers( )
```

The method getWhen( ) that returns the time at which the event took place. This is called the event's timestamp. The getWhen( ) method is shown here.

```
long getWhen( )
```

AdjustmentEvent

An AdjustmentEvent is generated by a scroll bar. There are five types of adjustment events. The AdjustmentEvent class defines integer constants that can be used to identify them. The constants and their meanings are shown here:

BLOCK_DECREMENT	The user clicked inside the scroll bar to decrease its value.

BLOCK_INCREMENT	The user clicked inside the scroll bar to increase its value.
TRACK	The slider was dragged.
UNIT_DECREMENT	The button at the end of the scroll bar was clicked to decrease its value.
UNIT_INCREMENT	The button at the end of the scroll bar was clicked to increase its value.

The type of the adjustment event may be obtained by the getAdjustmentType( ) method. It returns one of the constants defined by AdjustmentEvent. The general form is shown here:

```
int getAdjustmentType( )
```

The amount of the adjustment can be obtained from the getValue( ) method, shown here:

```
int getValue( )
```

For example, when a scroll bar is manipulated, this method returns the value represented by that change.

ComponentEvent

A ComponentEvent is generated when the size, position, or visibility of a component is changed. There are four types of component events. The ComponentEvent class defines integer constants that can be used to identify them. The constants and their meanings are shown here:

COMPONENT_HIDDEN	The component was hidden.
COMPONENT_MOVED	The component was moved.
COMPONENT_RESIZED	The component was resized.
COMPONENT_SHOWN	The component became visible.

ComponentEvent is the super-class either directly or indirectly of ContainerEvent, FocusEvent, KeyEvent, MouseEvent, and WindowEvent. The getComponent( ) method returns the component that generated the event. It is shown here:

```
Component getComponent( )
```

ContainerEvent

A ContainerEvent is generated when a component is added to or removed from a container. There are two types of container events. The ContainerEvent class defines int constants that can be used to identify them:

COMPONENT_ADDED and COMPONENT_REMOVED. They indicate that a component has been added to or removed from the container.

FocusEvent

A FocusEvent is generated when a component gains or loses input focus. These events are identified by the integer constants FOCUS_GAINED and FOCUS_LOST. FocusEvent is a subclass of ComponentEvent.

If the user moves the mouse to adjust a scroll bar, the focus is temporarily lost.) The other component involved in the focus change, called the opposite component, is passed in other. Therefore, if a FOCUS_GAINED event occurred, other will refer to the component that lost focus. Conversely, if a FOCUS_LOST event occurred, other will refer to the component that gains focus.

InputEvent

The abstract class InputEvent is a subclass of ComponentEvent and is the superclass for component input events. Its subclasses are KeyEvent and MouseEvent. InputEvent defines several integer constants that represent any modifiers, such as the control key being pressed, that might be associated with the event. Originally, the InputEvent class defined the following eight values to represent the modifiers.

ALT_MASK	BUTTON2_MASK META_MASK
ALT_GRAPH_MASK	BUTTON3_MASK SHIFT_MASK
	BUTTON1_MASK CTRL_MASK

However, because of possible conflicts between the modifiers used by keyboard events and mouse events, and other issues, Java 2, version 1.4 added the following extended modifier values.

ALT_DOWN_MASK	ALT_GRAPH_DOWN_MASK
BUTTON1_DOWN_MASK	BUTTON2_DOWN_MASK
BUTTON3_DOWN_MASK	CTRL_DOWN_MASK
META_DOWN_MASK	SHIFT_DOWN_MASK

When writing new code, it is recommended that we use the new, extended modifiers rather than the original modifiers. To test if a modifier was pressed at the time an event is generated, use the isAltDown( ), isAltGraphDown( ), isControlDown( ), isMetaDown( ), and isShiftDown( ) methods. The forms of these methods are shown here:

```
boolean isAltDown( )
boolean isAltGraphDown( )
```

```
boolean isControlDown( )
boolean isMetaDown( )
boolean isShiftDown( )
```

We can obtain a value that contains all of the original modifier flags by calling the getModifiers( ) method. It is shown here:

```
int getModifiers( )
```

We can obtain the extended modifiers by called getModifiersEx( ), which is shown here.

```
int getModifiersEx( )
```

ItemEvent

An ItemEvent is generated when a check box or a list item is clicked or when a checkable menu item is selected or deselected. There are two types of item events, which are identified by the following integer constants:

DESELECTED	The user deselected an item.
SELECTED	The user selected an item.

In addition, ItemEvent defines one integer constant, ITEM_STATE_CHANGED, that signifies a change of state.

The getItem( ) method can be used to obtain a reference to the item that generated an event. Its signature is shown here:

```
Object getItem( )
```

The getItemSelectable( ) method can be used to obtain a reference to the ItemSelectable object that generated an event. Its general form is shown here:

```
ItemSelectable getItemSelectable( )
```

Lists and choices are examples of user interface elements that implement the ItemSelectable interface. The getStateChange( ) method returns the state change (i.e., SELECTED or DESELECTED) for the event. It is shown here:

```
int getStateChange( )
```

KeyEvent

A KeyEvent is generated when keyboard input occurs. There are three types of key events, which are identified by these integer constants: KEY_PRESSED, KEY_RELEASED, and KEY_TYPED. The first two events are

generated when any key is pressed or released. The last event occurs only when a character is generated. Remember, not all key presses result in characters. For example, pressing the SHIFT key does not generate a character. There are many other integer constants that are defined by KeyEvent. For example, VK_0 through VK_9 and VK_A through VK_Z define the ASCII equivalents of the numbers and letters. Here are some others:

VK_ENTER	VK_ESCAPE	VK_CANCEL	VK_UP
VK_DOWN	VK_LEFT	VK_RIGHT	VK_PAGE_DOWN
VK_PAGE_UP	VK_SHIFT	VK_ALT	VK_CONTROL

The VK constants specify virtual key codes and are independent of any modifiers, such as control, shift, or alt. KeyEvent is a subclass of InputEvent.

The KeyEvent class defines several methods, but the most commonly used ones are getKeyChar( ), which returns the character that was entered, and getKeyCode( ), which returns the key code. Their general forms are shown here:

```
char getKeyChar( )
int getKeyCode( )
```

If no valid character is available, then getKeyChar( ) returns CHAR_UNDEFINED. When a KEY_TYPED event occurs, getKeyCode( ) returns VK_UNDEFINED.

MouseEvent

There are eight types of mouse events. The MouseEvent class defines the following integer constants that can be used to identify them:

MOUSE_CLICKED	The user clicked the mouse.
MOUSE_DRAGGED	The user dragged the mouse.
MOUSE_ENTERED	The mouse entered a component.
MOUSE_EXITED	The mouse exited from a component.
MOUSE_MOVED	The mouse moved.
MOUSE_PRESSED	The mouse was pressed.
MOUSE_RELEASED	The mouse was released.
MOUSE_WHEEL	The mouse wheel was moved.

The most commonly used methods in this class are getX( ) and getY( ). These returns the X and Y coordinate of the mouse when the event occurred. Their forms are shown here:

```
int getX( )
int getY( )
```

Alternatively, we can use the getPoint( ) method to obtain the coordinates of the mouse. It is shown here:

```
Point getPoint( )
```

It returns a Point object that contains the X, Y coordinates in its integer members: x and y. The translatePoint( ) method changes the location of the event. Its form is shown here:

```
void translatePoint(int x, int y)
```

Here, the arguments x and y are added to the coordinates of the event. The getClickCount( ) method obtains the number of mouse clicks for this event. Its signature is shown here:

```
int getClickCount( )
```

The isPopupTrigger( ) method tests if this event causes a pop-up menu to appear on this platform. Its form is shown here:

```
boolean isPopupTrigger( )
```

Java 2, version 1.4 added the getButton( ) method, shown here.

```
int getButton( )
```

It returns a value that represents the button that caused the event. The return value will be one of these constants defined by MouseEvent.

NOBUTTON BUTTON1 BUTTON2 BUTTON3

The NOBUTTON value indicates that no button was pressed or released.

MouseWheelEvent

The MouseWheelEvent class encapsulates a mouse wheel event. It is a subclass of MouseEvent and was added by Java 2, version 1.4. Not all mice have wheels. If a mouse has a wheel, it is located between the left and right buttons. Mouse wheels are used for scrolling. MouseWheelEvent defines these two integer constants.

WHEEL_BLOCK_SCROLL	A page-up or page-down scroll event occurred.
WHEEL_UNIT_SCROLL	A line-up or line-down scroll event occurred.

MouseWheelEvent defines methods that give us access to the wheel event. For obtaining the number of rotational units, call getWheelRotation( ), shown here.

```
int getWheelRotation( )
```

It returns the number of rotational units. If the value is positive, the wheel moved counterclockwise. If the value is negative, the wheel moved clockwise. For obtaining the type of scroll, call getScrollType( ), shown next.

```
int getScrollType( )
```

It returns either WHEEL_UNIT_SCROLL or WHEEL_BLOCK_SCROLL. If the scroll type is WHEEL_UNIT_SCROLL, we can obtain the number of units to scroll by calling getScrollAmount( ). It is shown here.

```
int getScrollAmount( )
```

TextEvent

Instances of this class describe text events. These are generated by text fields and text areas when characters are entered by a user or program. TextEvent defines the integer constant TEXT_VALUE_CHANGED.

The TextEvent object does not include the characters currently in the text component that generated the event. Instead, our program must use other methods associated with the text component to retrieve that information. This operation differs from other event objects discussed in this section. For this reason, no methods are discussed here for the TextEvent class. Think of a text event notification as a signal to a listener that it should retrieve information from a specific text component.

WindowEvent

There are ten types of window events. The WindowEvent class defines integer constants that can be used to identify them. The constants and their meanings are shown here:

WINDOW_ACTIVATED	The window was activated.
WINDOW_CLOSED	The window has been closed.
WINDOW_CLOSING	The user requested that the window be closed.
WINDOW_DEACTIVATED	The window was deactivated.
WINDOW_DEICONIFIED	The window was deiconified.
WINDOW_GAINED_FOCUS	The window gained input focus.
WINDOW_ICONIFIED	The window was iconified.
WINDOW_LOST_FOCUS	The window lost input focus.
WINDOW_OPENED	The window was opened.

WINDOW_STATE_CHANGED The state of the window changed.

WindowEvent is a subclass of ComponentEvent. The most commonly used method in this class is getWindow( ). It returns the Window object that generated the event. Its general form is shown here:

```
Window getWindow( )
```

Java 2, version 1.4, adds methods that return the opposite window (when a focus event has occurred), the previous window state, and the current window state. These methods are shown here:

```
Window getOppositeWindow()
int getOldState()
int getNewState()
```

Sources of Events

Following is list of some of the user interface components that can generate the events described in the previous section. In addition to these graphical user interface elements, other components, such as an applet, can generate events. For example, we receive key and mouse events from an applet. (We may also build our own components that generate events.)

Event Source	*Description*
Button	Generates action events when the button is pressed.
Checkbox	Generates item events when the check box is selected or deselected.
Choice	Generates item events when the choice is changed.
List	Generates action events when an item is double-clicked; Generates item events when an item is selected or deselected.
Menu Item	Generates action events when a menu item is selected; generates item events when a checkable menu item is selected or deselected.
Scrollbar	Generates adjustment events when the scroll bar is manipulated.
Text components	Generates text events when the user enters a character.
Window	Generates window events when a window is activated, closed,deactivated, deiconified, iconified, opened, or quit.

Event Listener Interfaces

The delegation event model has two parts: sources and listeners. Listeners are created by implementing one or more of the interfaces defined by the java.awt.event package. When an event occurs, the event source invokes the appropriate method defined by the listener and provides an event object as its argument.

ActionListener Interface

This interface defines the actionPerformed( ) method that is invoked when an action event occurs. Its general form is shown here:

```
void actionPerformed(ActionEvent ae)
```

AdjustmentListener Interface

This interface defines the adjustmentValueChanged( ) method that is invoked when an adjustment event occurs. Its general form is shown here:

```
void adjustmentValueChanged(AdjustmentEvent ae)
```

ComponentListener Interface

This interface defines four methods that are invoked when a component is resized, moved, shown, or hidden. Their general forms are shown here:

```
void componentResized(ComponentEvent ce)
void componentMoved(ComponentEvent ce)
void componentShown(ComponentEvent ce)
void componentHidden(ComponentEvent ce)
```

The AWT processes the resize and move events. The componentResized() and componentMoved( ) methods are provided for notification purposes only.

ContainerListener Interface

This interface contains two methods. When a component is added to a container, componentAdded( ) is invoked. When a component is removed from a container, componentRemoved( ) is invoked. Their general forms are shown here:

```
void componentAdded(ContainerEvent ce)
void componentRemoved(ContainerEvent ce)
```

FocusListener Interface

This interface defines two methods. When a component obtains keyboard focus, focusGained( ) is invoked. When a component loses keyboard focus, focusLost( ) is called. Their general forms are shown here:

```
void focusGained(FocusEvent fe)
void focusLost(FocusEvent fe)
```

ItemListener Interface

This interface defines the itemStateChanged( ) method that is invoked when the state of an item changes. Its general form is shown here:

```
void itemStateChanged(ItemEvent ie)
```

KeyListener Interface

This interface defines three methods. The keyPressed( ) and keyReleased( ) methods are invoked when a key is pressed and released, respectively. The keyTyped( ) method is invoked when a character has been entered. For example, if a user presses and releases the A key, three events are generated in sequence: key pressed, typed, and released. If a user presses and releases the HOME key, two key events are generated in sequence: key pressed and released. The general forms of these methods are shown here:

```
void keyPressed(KeyEvent ke)
void keyReleased(KeyEvent ke)
void keyTyped(KeyEvent ke)
```

MouseListener Interface

This interface defines five methods. If the mouse is pressed and released at the same point, mouseClicked( ) is invoked. When the mouse enters a component, the mouseEntered( ) method is called. When it leaves, mouseExited( ) is called. The mousePressed( ) and mouseReleased( ) methods are invoked when the mouse is pressed and released, respectively. The general forms of these methods are shown here:

```
void mouseClicked(MouseEvent me)
void mouseEntered(MouseEvent me)
void mouseExited(MouseEvent me)
void mousePressed(MouseEvent me)
void mouseReleased(MouseEvent me)
```

MouseMotionListener Interface

This interface defines two methods. The mouseDragged( ) method is called multiple times as the mouse is dragged. The mouseMoved( ) method is called multiple times as the mouse is moved. Their general forms are shown here:

```
void mouseDragged(MouseEvent me)
void mouseMoved(MouseEvent me)
```

MouseWheelListener Interface

This interface defines the mouseWheelMoved( ) method that is invoked when the mouse wheel is moved. Its general form is shown here.

```
void mouseWheelMoved(MouseWheelEvent mwe)
```

MouseWheelListener was added by Java 2, version 1.4.

TextListener Interface

This interface defines the textChanged( ) method that is invoked when a change occurs in a text area or text field. Its general form is shown here:

```
void textChanged(TextEvent te)
```

WindowFocusListener Interface

This interface defines two methods: windowGainedFocus( ) and windowLostFocus( ). These are called when a window gains or losses input focus. Their general forms are shown here.

```
void windowGainedFocus(WindowEvent we)
void windowLostFocus(WindowEvent we)
```

WindowFocusListener was added by Java 2, version 1.4.

WindowListener Interface

This interface defines seven methods. The windowActivated( ) and windowDeactivated( ) methods are invoked when a window is activated or deactivated, respectively. If a window is iconified, the windowIconified( ) method is called. When a window is deiconified, the windowDeiconified( ) method is called. When a window is opened or closed, the windowOpened( ) or windowClosed( ) methods are called, respectively. The windowClosing( ) method is called when a window is being closed. The general forms of these methods are:

```
 void windowActivated(WindowEvent we)
 void windowClosed(WindowEvent we)
 void windowClosing(WindowEvent we)
 void windowDeactivated(WindowEvent we)
 void windowDeiconified(WindowEvent we)
 void windowIconified(WindowEvent we)
 void windowOpened(WindowEvent we)
```

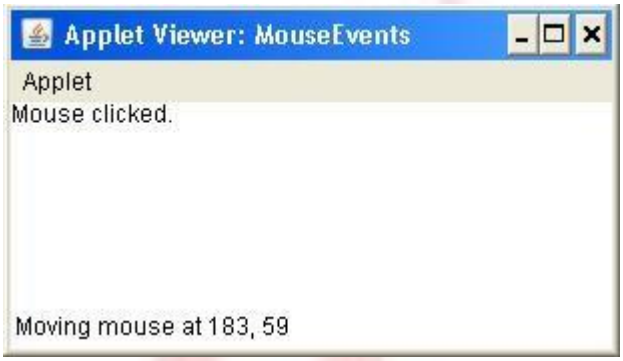
Handling Mouse Events

In order to handle mouse events, we must implement the MouseListener and the MouseMotionListener interfaces.

```
import java.awt.*;
import java.awt.event.*;
import java.applet.*;
/*
<applet code="MouseEvents" width=300 height=100>
</applet>
*/
public class MouseEvents extends Applet
implements MouseListener, MouseMotionListener
{
    String msg = "";
    int mouseX = 0, mouseY = 0; // coordinates of mouse
    public void init()
    {
        addMouseListener(this);
        addMouseMotionListener(this);
    }
    public void mouseClicked(MouseEvent me)
    {
        // save coordinates
        mouseX = 0;
        mouseY = 10;
        msg = "Mouse clicked.";
        repaint();
    }
    // Handle mouse entered.
    public void mouseEntered(MouseEvent me)
    {
        // save coordinates
        mouseX = 0;
        mouseY = 10;
        msg = "Mouse entered.";
        repaint();
    }
    // Handle mouse exited.
```

```
public void mouseExited(MouseEvent me)
{
    // save coordinates
    mouseX = 0;
    mouseY = 10;
    msg = "Mouse exited.";
    repaint();
}
// Handle button pressed.
public void mousePressed(MouseEvent me)
{
    // save coordinates
    mouseX = me.getX();
    mouseY = me.getY();
    msg = "Down";
    repaint();
}
// Handle button released.
public void mouseReleased(MouseEvent me)
{
    // save coordinates
    mouseX = me.getX();
    mouseY = me.getY();
    msg = "Up";
    repaint();
}
// Handle mouse dragged.
public void mouseDragged(MouseEvent me)
{
    // save coordinates
    mouseX = me.getX();
    mouseY = me.getY();
    msg = "*";
    showStatus("Dragging mouse at " + mouseX + ", " + mouseY);
    repaint();
}
// Handle mouse moved.
public void mouseMoved(MouseEvent me)
{
    // show status
    showStatus("Moving mouse at " + me.getX() + ", " +
      me.getY());
}
// Display msg in applet window at current X,Y location.
public void paint(Graphics g)
{
    g.drawString(msg, mouseX, mouseY);
}
```

```
}
```



Here, the MouseEvents class extends Applet and implements both the MouseListener and MouseMotionListener interfaces. These two interfaces contain methods that receive and process the various types of mouse events. Notice that the applet is both the source and the listener for these events. This works because Component, which supplies the addMouseListener( ) and addMouseMotionListener( ) methods, is a superclass of Applet. Being both the source and the listener for events is a common situation for applets.

Inside init( ), the applet registers itself as a listener for mouse events. This is done by using addMouseListener( ) and addMouseMotionListener( ), which, as mentioned, are members of Component. They are shown here:

```
void addMouseListener(MouseListener ml)
void addMouseMotionListener(MouseMotionListener mml)
```

Here, *ml* is a reference to the object receiving mouse events, and *mml* is a reference to the object receiving mouse motion events. In this program, the same object is used for both. The applet then implements all of the methods defined by the MouseListener and MouseMotionListener interfaces. These are the event handlers for the various mouse events. Each method handles its event and then returns.

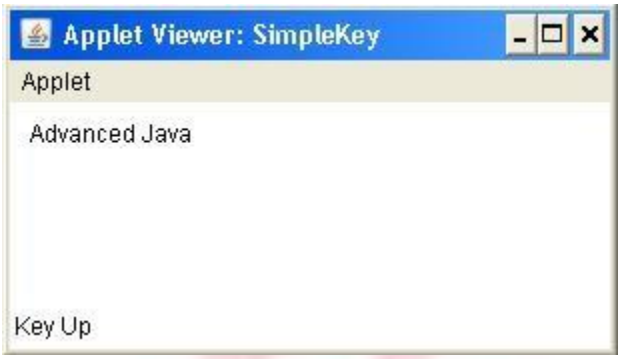
Handling Keyboard Events

We will be implementing the KeyListener interface for handling keyboard events. Before looking at an example, it is useful to review how key events are generated. When a key is pressed, a KEY_PRESSED event is generated. This results in a call to the keyPressed( ) event handler. When the key is released, a KEY_RELEASED event is generated and the keyReleased( ) handler is executed. If a character is generated by the keystroke, then a KEY_TYPED event is sent and the keyTyped( ) handler is invoked. Thus, each time the user presses a key, at least two and often three events are generated. If all we care about are actual characters, then we can ignore the information passed by the key press and release events. However, if our program needs to handle special keys, such

as the arrow or function keys, then it must watch for them through the keyPressed( ) handler.

There is one other requirement that our program must meet before it can process keyboard events: it must request input focus. To do this, call requestFocus( ), which is defined by Component. If we don't, then our program will not receive any keyboard events. The following program demonstrates keyboard input. It echoes keystrokes to the applet window and shows the pressed/released status of each key in the status window.

```
import java.awt.*;
import java.awt.event.*;
import java.applet.*;
/*
<applet code="SimpleKey" width=300 height=100>
</applet>
*/
public class SimpleKey extends Applet
implements KeyListener
{
    String msg = "";
    int X = 10, Y = 20; // output coordinates
    public void init()
    {
        addKeyListener(this);
        requestFocus(); // request input focus
    }
    public void keyPressed(KeyEvent ke)
    {
        showStatus("Key Down");
    }
    public void keyReleased(KeyEvent ke)
    {
        showStatus("Key Up");
    }
    public void keyTyped(KeyEvent ke)
    {
        msg += ke.getKeyChar();
        repaint();
    }
    // Display keystrokes.
    public void paint(Graphics g)
    {
        g.drawString(msg, X, Y);
    }
}
```



If we want to handle the special keys, such as the arrow or function keys, we need to respond to them within the keyPressed( ) handler. They are not available through keyTyped( ). To identify the keys, we use their virtual key codes. For example, the next method shows the use of special keys:

```
public void keyPressed(KeyEvent ke)
{
     showStatus("Key Down");
     int key = ke.getKeyCode();
     switch(key)
     {
          case KeyEvent.VK_F1:
               msg += "<F1>";
               break;
          case KeyEvent.VK_F2:
               msg += "<F2>";
               break;
          case KeyEvent.VK_F3:
               msg += "<F3>";
               break;
          case KeyEvent.VK_PAGE_DOWN:
               msg += "<PgDn>";
               break;
          case KeyEvent.VK_PAGE_UP:
               msg += "<PgUp>";
               break;
          case KeyEvent.VK_LEFT:
               msg += "<Left Arrow>";
               break;
          case KeyEvent.VK_RIGHT:
               msg += "<Right Arrow>";
               break;
     }
     repaint();
}
```

Adapter Classes

Java provides a special feature, called an adapter class that can simplify the creation of event handlers in certain situations. An adapter class provides an empty implementation of all methods in an event listener interface. Adapter classes are useful when we want to receive and process only some of the events that are handled by a particular event listener interface. We can define a new class to act as an event listener by extending one of the adapter classes and implementing only those events in which we are interested. For example, the MouseMotionAdapter class has two methods, mouseDragged( ) and mouseMoved( ). The signatures of these empty methods are exactly as defined in the MouseMotionListener interface. If you were interested in only mouse drag events, then you could simply extend MouseMotionAdapter and implement mouseDragged( ). The empty implementation of mouseMoved( ) would handle the mouse motion events for you.

List below shows the commonly used adapter classes in java.awt.event and notes the interface that each implements. The following example demonstrates an adapter. It displays a message in the status bar of an applet viewer or browser when the mouse is clicked or dragged. However, all other mouse events are silently ignored. The program has three classes. AdapterDemo extends Applet. Its init( ) method creates an instance of MyMouseAdapter and registers that object to receive notifications of mouse events. It also creates an instance of MyMouseMotionAdapter and registers that object to receive notifications of mouse motion events. Both of the constructors take a reference to the applet as an argument. MyMouseAdapter implements the mouseClicked( ) method. The other mouse events are silently ignored by code inherited from the MouseAdapter class. MyMouseMotionAdapter implements the mouseDragged( ) method. The other mouse motion event is silently ignored by code inherited from the MouseMotionAdapter class.

Adapter Class	**Listener Interface**
ComponentAdapter	ComponentListener
ContainerAdapter	ContainerListener
FocusAdapter	FocusListener
KeyAdapter	KeyListener
MouseAdapter	MouseListener
MouseMotionAdapter	MouseMotionListener
WindowAdapter	WindowListener

```
import java.awt.*;
import java.awt.event.*;
import java.applet.*;
/*
<applet code="AdapterDemo" width=300 height=100>
</applet>
*/
```

```
public class AdapterDemo extends Applet
{
    public void init()
    {
        addMouseListener(new MyMouseAdapter(this));
        addMouseMotionListener(new MyMouseMotionAdapter(this));
    }
}
class MyMouseAdapter extends MouseAdapter
{
    AdapterDemo adapterDemo;
    public MyMouseAdapter(AdapterDemo adapterDemo)
    {
        this.adapterDemo = adapterDemo;
    }
    // Handle mouse clicked.
    public void mouseClicked(MouseEvent me)
    {
        adapterDemo.showStatus("Mouse clicked");
    }
}
class MyMouseMotionAdapter extends MouseMotionAdapter
{
    AdapterDemo adapterDemo;
    public MyMouseMotionAdapter(AdapterDemo adapterDemo)
    {
        this.adapterDemo = adapterDemo;
    }
    // Handle mouse dragged.
    public void mouseDragged(MouseEvent me)
    {
        adapterDemo.showStatus("Mouse dragged");
    }
}
```

As we can see by looking at the program, not having to implement all of the methods defined by the MouseMotionListener and MouseListener interfaces saves our considerable amount of effort and prevents our code from becoming cluttered with empty methods.

Inner Classes

For understanding the benefit provided by inner classes, consider the applet shown in the following listing. It does not use an inner class. Its goal is to display the string “Mouse Pressed” in the status bar of the applet viewer or browser when the mouse is pressed. There are two top-level classes in this program. MousePressedDemo extends Applet, and MyMouseAdapter extends

MouseAdapter. The init( ) method of MousePressedDemo instantiates MyMouseAdapter and provides this object as an argument to the addMouseListener( ) method. Notice that a reference to the applet is supplied as an argument to the MyMouseAdapter constructor. This reference is stored in an instance variable for later use by the mousePressed( ) method. When the mouse is pressed, it invokes the showStatus( ) method of the applet through the stored applet reference. In other words, showStatus( ) is invoked relative to the applet reference stored by MyMouseAdapter.

```
// This applet does NOT use an inner
class. import java.applet.*;
import java.awt.event.*;
/*
<applet code="MousePressedDemo" width=200 height=100>
</applet>
*/
public class MousePressedDemo extends Applet
{
     public void init()
     {
          addMouseListener(new MyMouseAdapter(this));
     }
}
class MyMouseAdapter extends MouseAdapter
{
     MousePressedDemo mousePressedDemo;
     public MyMouseAdapter(MousePressedDemo mousePressedDemo)
     {
          this.mousePressedDemo = mousePressedDemo;
     }
     public void mousePressed(MouseEvent me)
     {
          mousePressedDemo.showStatus("Mouse Pressed.");
     }
}
```

The following listing shows how the preceding program can be improved by using an inner class. Here, InnerClassDemo is a top-level class that extends Applet. MyMouseAdapter is an inner class that extends MouseAdapter. Because MyMouseAdapter is defined within the scope of InnerClassDemo, it has access to all of the variables and methods within the scope of that class. Therefore, the mousePressed( ) method can call the showStatus( ) method directly. It no longer needs to do this via a stored reference to the applet. Thus, it is no longer necessary to pass MyMouseAdapter( ) a reference to the invoking object.

```
// Inner class demo.
import java.applet.*;
```

```
import java.awt.event.*;
/*
<applet code="InnerClassDemo" width=200 height=100>
</applet>
*/
public class InnerClassDemo extends Applet
{
     public void init()
     {
          addMouseListener(new MyMouseAdapter());
     }
     class MyMouseAdapter extends MouseAdapter
     {
          public void mousePressed(MouseEvent me)
          {
               showStatus("Mouse Pressed");
          }
     }
}
```

Anonymous Inner Classes

An anonymous inner class is one that is not assigned a name. Consider the applet shown in the following listing. As before, its goal is to display the string "Mouse Pressed" in the status bar of the applet viewer or browser when the mouse is pressed.

```
// Anonymous inner class demo.
import java.applet.*;
import java.awt.event.*;
/*
<applet code="AnonymousInnerClassDemo" width=200 height=100>
</applet>
*/
public class AnonymousInnerClassDemo extends Applet
{
     public void init()
     {
          addMouseListener(new MouseAdapter() {
               public void mousePressed(MouseEvent me) {
               showStatus("Mouse Pressed");
               }
          });
     }
}
```

There is one top-level class in this program: AnonymousInnerClassDemo. The init( ) method calls the addMouseListener( ) method. Its argument is an

expression that defines and instantiates an anonymous inner class. Let's analyze this expression carefully. The syntax new MouseAdapter( ) { ... } indicates to the compiler that the code between the braces defines an anonymous inner class. Furthermore, that class extends MouseAdapter. This new class is not named, but it is automatically instantiated when this expression is executed. Because this anonymous inner class is defined within the scope of AnonymousInnerClassDemo, it has access to all of the variables and methods within the scope of that class. Therefore, it can call the showStatus( ) method directly. As just illustrated, both named and anonymous inner classes solve some annoying problems in a simple yet effective way. They also allow us to create more efficient code.

Handling Buttons

```
// Demonstrate Buttons
import java.awt.*;
import java.awt.event.*;
import java.applet.*;
/*
<applet code="ButtonDemo" width=250 height=150>
</applet>
*/
public class ButtonDemo extends Applet implements ActionListener
{
     String msg = "";
     Button yes, no, maybe;
     public void init()
     {
          yes = new Button("Yes");
          no = new Button("No");
          maybe = new Button("Undecided");
          add(yes);
          add(no);
          add(maybe);
          yes.addActionListener(this);
          no.addActionListener(this);
          maybe.addActionListener(this);
     }
     public void actionPerformed(ActionEvent ae)
     {
          String str = ae.getActionCommand();
          if(str.equals("Yes"))
          {
               msg = "You pressed Yes.";
          }
          else if(str.equals("No"))
          {
```

```
                msg = "You pressed No.";
            }
                else
                {
                    msg = "You pressed Undecided.";
                }
            repaint();
        }
        public void paint(Graphics g)
        {
            g.drawString(msg, 6, 100);
        }
}
```

Handling Checkboxes

```
// Demonstrate check boxes.
import java.awt.*;
import java.awt.event.*;
import java.applet.*;
/*
<applet code="CheckboxDemo" width=250 height=200>
</applet>
*/
public class CheckboxDemo extends Applet implements ItemListener
{
    String msg = "";
    Checkbox Win98, winNT, solaris, mac;
    public void init()
    {
        Win98 = new Checkbox("Windows 98/XP", null, true);
        winNT = new Checkbox("Windows NT/2000");
        solaris = new Checkbox("Solaris");
        mac = new Checkbox("MacOS");
        add(Win98);
        add(winNT);
        add(solaris);
        add(mac);
        Win98.addItemListener(this);
        winNT.addItemListener(this);
        solaris.addItemListener(this);
        mac.addItemListener(this);
    }
    public void itemStateChanged(ItemEvent ie)
    {
        repaint();
    }
    // Display current state of the check boxes.
```

```
    public void paint(Graphics g)
    {
        msg = "Current state: ";
        g.drawString(msg, 6, 80);
        msg = " Windows 98/XP: " + Win98.getState();
        g.drawString(msg, 6, 100);
        msg = " Windows NT/2000: " + winNT.getState();
        g.drawString(msg, 6, 120);
        msg = " Solaris: " + solaris.getState();
        g.drawString(msg, 6, 140);
        msg = " MacOS: " + mac.getState();
        g.drawString(msg, 6, 160);
    }
}
```

Handling Radio Buttons

```
// Demonstrate check box group.
import java.awt.*;
import java.awt.event.*;
import java.applet.*;
/*
<applet code="CBGroup" width=250 height=200>
</applet>
*/
public class CBGroup extends Applet implements ItemListener
{
    String msg = "";
    Checkbox Win98, winNT, solaris, mac;
    CheckboxGroup cbg;
    public void init()
    {
        cbg = new CheckboxGroup();
        Win98 = new Checkbox("Windows 98/XP", cbg, true);
        winNT = new Checkbox("Windows NT/2000", cbg, false);
        solaris = new Checkbox("Solaris", cbg, false);
        mac = new Checkbox("MacOS", cbg, false);
        add(Win98);
        add(winNT);
        add(solaris);
        add(mac);
        Win98.addItemListener(this);
        winNT.addItemListener(this);
        solaris.addItemListener(this);
        mac.addItemListener(this);
    }
    public void itemStateChanged(ItemEvent ie)
    {
```

```
            repaint();
        }
        // Display current state of the check boxes.
        public void paint(Graphics g)
        {
            msg = "Current selection: ";
            msg += cbg.getSelectedCheckbox().getLabel();
            g.drawString(msg, 6, 100);
        }
}
```

Handling Choice Controls

```
// Demonstrate Choice lists.
import java.awt.*;
import java.awt.event.*;
import java.applet.*;
/*
<applet code="ChoiceDemo" width=300 height=180>
</applet>
*/
public class ChoiceDemo extends Applet implements ItemListener
{
    Choice os, browser;
    String msg = "";
    public void init()
    {
        os = new Choice();
        browser = new Choice();
        // add items to os list
        os.add("Windows 98/XP");
        os.add("Windows NT/2000");
        os.add("Solaris");
        os.add("MacOS");
        // add items to browser list
        browser.add("Netscape 3.x");
        browser.add("Netscape 4.x");
        browser.add("Netscape 5.x");
        browser.add("Netscape 6.x");
        browser.add("Internet Explorer 4.0");
        browser.add("Internet Explorer 5.0");
        browser.add("Internet Explorer 6.0");
        browser.add("Lynx 2.4");
        browser.select("Netscape 4.x");
        // add choice lists to window
        add(os);
        add(browser);
        // register to receive item events
```

```
            os.addItemListener(this);
            browser.addItemListener(this);
      }
      public void itemStateChanged(ItemEvent ie)
      {
            repaint();
      }
      // Display current selections.
      public void paint(Graphics g)
      {
            msg = "Current OS: ";
            msg += os.getSelectedItem();
            g.drawString(msg, 6, 120);
            msg = "Current Browser: ";
            msg += browser.getSelectedItem();
            g.drawString(msg, 6, 140);
      }
}
```

Handling Lists

```
// Demonstrate Lists.
import java.awt.*;
import java.awt.event.*;
import java.applet.*;
/*
<applet code="ListDemo" width=300 height=180>
</applet>
*/
public class ListDemo extends Applet implements ActionListener
{
      List os, browser;
      String msg = "";
      public void init()
      {
            os = new List(4, true);
            browser = new List(4, false);
            // add items to os list
            os.add("Windows 98/XP");
            os.add("Windows NT/2000");
            os.add("Solaris");
            os.add("MacOS");
            // add items to browser list
            browser.add("Netscape 3.x");
            browser.add("Netscape 4.x");
            browser.add("Netscape 5.x");
            browser.add("Netscape 6.x");
            browser.add("Internet Explorer 4.0");
```

```
            browser.add("Internet Explorer 5.0");
            browser.add("Internet Explorer 6.0");
            browser.add("Lynx 2.4");
            browser.select(1);
            // add lists to window
            add(os);
            add(browser);
            // register to receive action events
            os.addActionListener(this);
            browser.addActionListener(this);
      }
      public void actionPerformed(ActionEvent ae)
      {
            repaint();
      }
      // Display current selections.
      public void paint(Graphics g)
      {
            int idx[];
            msg = "Current OS: ";
            idx = os.getSelectedIndexes();
            for(int i=0; i<idx.length; i++)
            msg += os.getItem(idx[i]) + " ";
            g.drawString(msg, 6, 120);
            msg = "Current Browser: ";
            msg += browser.getSelectedItem();
            g.drawString(msg, 6, 140);
      }
}
```

Handling Scrollbars

```
// Demonstrate scroll bars.
import java.awt.*;
import java.awt.event.*;
import java.applet.*;
/*
<applet code="SBDemo" width=300 height=200>
</applet>
*/
public class SBDemo extends Applet
implements AdjustmentListener, MouseMotionListener
{
      String msg = "";
      Scrollbar vertSB, horzSB;
      public void init()
      {
            int width = Integer.parseInt(getParameter("width"));
```

```
            int height = Integer.parseInt(getParameter("height"));
            vertSB = new Scrollbar(Scrollbar.VERTICAL,
                 0, 1, 0, height);
            horzSB = new Scrollbar(Scrollbar.HORIZONTAL,
                 0, 1, 0, width);
            add(vertSB);
            add(horzSB);
            // register to receive adjustment events
            vertSB.addAdjustmentListener(this);
            horzSB.addAdjustmentListener(this);
            addMouseMotionListener(this);
      }
      public void adjustmentValueChanged(AdjustmentEvent ae)
      {
            repaint();
      }
      // Update scroll bars to reflect mouse dragging.
      public void mouseDragged(MouseEvent me)
      {
            int x = me.getX();
            int y = me.getY();
            vertSB.setValue(y);
            horzSB.setValue(x);
            repaint();
      }
      // Necessary for MouseMotionListener
      public void mouseMoved(MouseEvent me)
      {
      }
      // Display current value of scroll bars.
      public void paint(Graphics g)
      {
            msg = "Vertical: " + vertSB.getValue();
            msg += ", Horizontal: " + horzSB.getValue();
            g.drawString(msg, 6, 160);
            // show current mouse drag position
            g.drawString("*", horzSB.getValue(),
            vertSB.getValue());
      }
}
```

Handling Text field

```
// Demonstrate text field.
import java.awt.*;
import java.awt.event.*;
import java.applet.*;
/*
```

```
<applet code="TextFieldDemo" width=380 height=150>
</applet>
*/
public class TextFieldDemo extends Applet
implements ActionListener
{
     TextField name, pass;
     public void init()
     {
          Label namep = new Label("Name: ", Label.RIGHT);
          Label passp = new Label("Password: ", Label.RIGHT);
          name = new TextField(12);
          pass = new TextField(8);
          pass.setEchoChar('?');
          add(namep);
          add(name);
          add(passp);
          add(pass);
          // register to receive action events
          name.addActionListener(this);
          pass.addActionListener(this);
     }
     // User pressed Enter.
     public void actionPerformed(ActionEvent ae)
     {
          repaint();
     }
     public void paint(Graphics g)
     {
          g.drawString("Name: " + name.getText(), 6, 60);
          g.drawString("Selected text in name: "
               + name.getSelectedText(), 6, 80);
          g.drawString("Password: " + pass.getText(), 6, 100);
     }
}
```

Handling Menus

```
// Illustrate menus.
import java.awt.*;
import java.awt.event.*;
import java.applet.*;
/*
  <applet code="MenuDemo1" width=250 height=250>
  </applet>
*/

// Create a subclass of Frame
```

```
class MenuFrame extends Frame {
  String msg = "";
  CheckboxMenuItem debug, test;

  MenuFrame(String title) {
    super(title);

    // create menu bar and add it to frame
    MenuBar mbar = new MenuBar();
    setMenuBar(mbar);

    // create the menu items
    Menu file = new Menu("File");
    MenuItem item1, item2, item3, item4, item5;
    file.add(item1 = new MenuItem("New..."));
    file.add(item2 = new MenuItem("Open..."));
    file.add(item3 = new MenuItem("Close"));
    file.add(item4 = new MenuItem("-"));
    file.add(item5 = new MenuItem("Quit..."));
    mbar.add(file);

    Menu edit = new Menu("Edit");
    MenuItem item6, item7, item8, item9;
    edit.add(item6 = new MenuItem("Cut"));
    edit.add(item7 = new MenuItem("Copy"));
    edit.add(item8 = new MenuItem("Paste"));
    edit.add(item9 = new MenuItem("-"));
    Menu sub = new Menu("Special");
    MenuItem item10, item11, item12;
    sub.add(item10 = new MenuItem("First"));
    sub.add(item11 = new MenuItem("Second"));
    sub.add(item12 = new MenuItem("Third"));
    edit.add(sub);

    // these are checkable menu items
    debug = new CheckboxMenuItem("Debug");
    edit.add(debug);
    test = new CheckboxMenuItem("Testing");
    edit.add(test);

    mbar.add(edit);

    // create an object to handle action and item events
    MyMenuHandler handler = new MyMenuHandler(this);
    // register it to receive those events
    item1.addActionListener(handler);
    item2.addActionListener(handler);
    item3.addActionListener(handler);
```

```
    item4.addActionListener(handler);
    item5.addActionListener(handler);
    item6.addActionListener(handler);
    item7.addActionListener(handler);
    item8.addActionListener(handler);
    item9.addActionListener(handler);
    item10.addActionListener(handler);
    item11.addActionListener(handler);
    item12.addActionListener(handler);
    debug.addItemListener(handler);
    test.addItemListener(handler);

    // create an object to handle window events
    MyWindowAdapter adapter = new MyWindowAdapter(this);
     // register it to receive those events
    addWindowListener(adapter);
  }

  public void paint(Graphics g) {
    g.drawString(msg, 10, 200);

    if(debug.getState())
      g.drawString("Debug is on.", 10, 220);
    else
      g.drawString("Debug is off.", 10, 220);

    if(test.getState())
      g.drawString("Testing is on.", 10, 240);
    else
      g.drawString("Testing is off.", 10, 240);
  }
}

class MyWindowAdapter extends WindowAdapter {
  MenuFrame menuFrame;
  public MyWindowAdapter(MenuFrame menuFrame) {
    this.menuFrame = menuFrame;
  }
  public void windowClosing(WindowEvent we) {
    menuFrame.setVisible(false);
  }
}

class MyMenuHandler implements ActionListener, ItemListener {
  MenuFrame menuFrame;
  public MyMenuHandler(MenuFrame menuFrame) {
    this.menuFrame = menuFrame;
  }
```

```
  // Handle action events
  public void actionPerformed(ActionEvent ae) {
      String msg = "You selected ";
      String arg = (String)ae.getActionCommand();
      if(arg.equals("New..."))
        msg += "New.";
      else if(arg.equals("Open..."))
        msg += "Open.";
      else if(arg.equals("Close"))
        msg += "Close.";
      else if(arg.equals("Quit..."))
        msg += "Quit.";
      else if(arg.equals("Edit"))
        msg += "Edit.";
      else if(arg.equals("Cut"))
        msg += "Cut.";
      else if(arg.equals("Copy"))
        msg += "Copy.";
      else if(arg.equals("Paste"))
        msg += "Paste.";
      else if(arg.equals("First"))
        msg += "First.";
      else if(arg.equals("Second"))
        msg += "Second.";
      else if(arg.equals("Third"))
        msg += "Third.";
      else if(arg.equals("Debug"))
        msg += "Debug.";
      else if(arg.equals("Testing"))
        msg += "Testing.";
      menuFrame.msg = msg;
      menuFrame.repaint();
  }
  // Handle item events
  public void itemStateChanged(ItemEvent ie) {
    menuFrame.repaint();
  }
}
// Create frame window.
public class MenuDemo1 extends Applet {
  Frame f;

  public void init() {
    f = new MenuFrame("Menu Demo");
    int width = Integer.parseInt(getParameter("width"));
    int height = Integer.parseInt(getParameter("height"));

    setSize(new Dimension(width, height));
```

```
    f.setSize(width, height);
    f.setVisible(true);
  }

  public void start() {
    f.setVisible(true);
  }

  public void stop() {
    f.setVisible(false);
  }
}
```

CardLayout

The CardLayout class is unique among the other layout managers in that it stores several different layouts. Each layout can be thought of as being on a separate index card in a deck that can be shuffled so that any card is on top at a given time. This can be useful for user interfaces with optional components that can be dynamically enabled and disabled upon user input. We can prepare the other layouts and have them hidden, ready to be activated when needed. CardLayout provides these two constructors:

```
CardLayout( )
CardLayout(int horz, int vert)
```

The first form creates a default card layout. The second form allows us to specify the horizontal and vertical space left between components in *horz* and *vert*, respectively. Use of a card layout requires a bit more work than the other layouts. The cards are typically held in an object of type Panel. This panel must have CardLayout selected as its layout manager. The cards that form the deck are also typically objects of type Panel. Thus, we must create a panel that contains the deck and a panel for each card in the deck. Next, we add to the appropriate panel the components that form each card. We then add these panels to the panel for which CardLayout is the layout manager. Finally, we add this panel to the main applet panel. Once these steps are complete, we must provide some way for the user to select between cards. One common approach is to include one push button for each card in the deck. When card panels are added to a panel, they are usually given a name. Thus, most of the time, we will use this form of add( ) when adding cards to a panel:

```
void add(Component panelObj, Object name);
```

Here, name is a string that specifies the name of the card whose panel is specified by *panelObj*. After we have created a deck, our program activates a card by calling one of the following methods defined by CardLayout:

```
void first(Container deck)
void last(Container deck)
void next(Container deck)
void previous(Container deck)
void show(Container deck, String cardName)
```

Here, *deck* is a reference to the container (usually a panel) that holds the cards, and *cardName* is the name of a card. Calling first( ) causes the first card in the deck to be shown. For showing the last card, call last( ) and for the next card, call next( ). To show the previous card, call previous( ). Both next( ) and previous( ) automatically cycle back to the top or bottom of the deck, respectively. The show( ) method displays the card whose name is passed in cardName. The following example creates a two-level card deck that allows the user to select an operating system. Windows-based operating systems are displayed in one card. Macintosh and Solaris are displayed in the other card.

The process of creating a card layout is visualized as below:

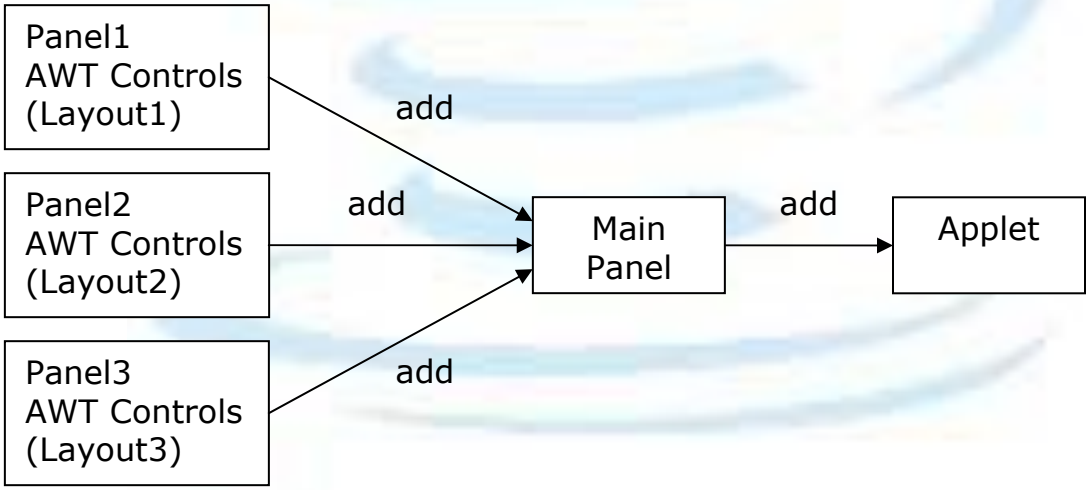


Fig. Creation of card layout

```
// Demonstrate CardLayout.
import java.awt.*;
import java.awt.event.*;
import java.applet.*;
/*
  <applet code="CardLayoutDemo" width=300 height=100>
  </applet>
*/

public class CardLayoutDemo extends Applet
  implements ActionListener, MouseListener
```

```
{

Checkbox Win98, winNT, solaris, mac;
Panel osCards;
CardLayout cardLO;
Button Win, Other;

public void init()
{
  Win = new Button("Windows");
  Other = new Button("Other");
  add(Win);
  add(Other);

  cardLO = new CardLayout();
  osCards = new Panel();
  osCards.setLayout(cardLO); // set panel layout to card layout

  Win98 = new Checkbox("Windows 98/XP", null, true);
  winNT = new Checkbox("Windows NT/2000");
  solaris = new Checkbox("Solaris");
  mac = new Checkbox("MacOS");

  // add Windows check boxes to a panel
  Panel winPan = new Panel();
  winPan.setLayout(new BorderLayout());
  winPan.add(Win98,BorderLayout.NORTH);
  winPan.add(winNT,BorderLayout.SOUTH);

  // Add other OS check boxes to a panel
  Panel otherPan = new Panel();
  otherPan.add(solaris);
  otherPan.add(mac);
  otherPan.setLayout(new GridLayout(2,2));

  // add panels to card deck panel
  osCards.add(winPan, "Windows");
  osCards.add(otherPan, "Other");

  // add cards to main applet panel
  add(osCards);

  // register to receive action events
  Win.addActionListener(this);
  Other.addActionListener(this);

  // register mouse events
  addMouseListener(this);
```

```
  }

  // Cycle through panels.
  public void mousePressed(MouseEvent me)
  {
    cardLO.next(osCards);
  }

  public void mouseClicked(MouseEvent me) {
  }
  public void mouseEntered(MouseEvent me) {
  }
  public void mouseExited(MouseEvent me) {
  }
  public void mouseReleased(MouseEvent me) {
  }

  public void actionPerformed(ActionEvent ae)
  {
    if(ae.getSource() == Win)
      cardLO.show(osCards, "Windows");
    else
      cardLO.show(osCards, "Other");
  }
}
```

Handling Events by Extending AWT Components

Java also allows us to handle events by subclassing AWT components. Doing so allows us to handle events in much the same way as they were handled under the original 1.0 version of Java. Of course, this technique is discouraged, because it has the same disadvantages of the Java 1.0 event model, the main one being inefficiency. In order to extend an AWT component, we must call the enableEvents( ) method of Component. Its general form is shown here:

```
protected final void enableEvents(long eventMask)
```

The eventMask argument is a bit mask that defines the events to be delivered to this component. The AWTEvent class defines int constants for making this mask. Several are shown here:

ACTION_EVENT_MASK	KEY_EVENT_MASK
ADJUSTMENT_EVENT_MASK	MOUSE_EVENT_MASK
COMPONENT_EVENT_MASK	MOUSE_MOTION_EVENT_MASK
CONTAINER_EVENT_MASK	MOUSE_WHEEL_EVENT_MASK
FOCUS_EVENT_MASK	TEXT_EVENT_MASK

INPUT_METHOD_EVENT_MASK WINDOW_EVENT_MASK
ITEM_EVENT_MASK

We must also override the appropriate method from one of our superclasses in order to process the event. Methods listed below most commonly used and the classes that provide them.

Event Processing Methods

Class	**Processing Methods**
Button	processActionEvent( )
Checkbox	processItemEvent( )
CheckboxMenuItem	processItemEvent( )
Choice	processItemEvent( )
Component	processComponentEvent( ), processFocusEvent( ), processKeyEvent( ), processMouseEvent( ), processMouseMotionEvent( ), processMouseWheelEvent ( )
List	processActionEvent( ), processItemEvent( )
MenuItem	processActionEvent( )
Scrollbar	processAdjustmentEvent( )
TextComponent	processTextEvent( )

Extending Button

The following program creates an applet that displays a button labeled "Test Button". When the button is pressed, the string "action event: " is displayed on the status line of the applet viewer or browser, followed by a count of the number of button presses. The program has one top-level class named ButtonDemo2 that extends Applet. A static integer variable named **i** is defined and initialized to zero. It records the number of button pushes. The init() method instantiates MyButton and adds it to the applet. MyButton is an inner class that extends Button. Its constructor uses super to pass the label of the button to the superclass constructor. It calls enableEvents( ) so that action events may be received by this object. When an action event is generated, processActionEvent( ) is called. That method displays a string on the status line and calls processActionEvent( ) for the superclass. Because MyButton is an inner class, it has direct access to the showStatus( ) method of ButtonDemo2.

```
/*
* <applet code=ButtonDemo2 width=200 height=100>
* </applet>
*/
import java.awt.*;
import java.awt.event.*;
import java.applet.*;
```

```
public class ButtonDemo2 extends Applet
{
     MyButton myButton;
     static int i = 0;
     public void init()
     {
          myButton = new MyButton("Test Button");
          add(myButton);
     }
     class MyButton extends Button
     {
          public MyButton(String label)
          {
               super(label);
               enableEvents(AWTEvent.ACTION_EVENT_MASK);
          }
          protected void processActionEvent(ActionEvent ae)
          {
               showStatus("action event: " + i++);
               super.processActionEvent(ae);
          }
     }
}
```

Extending Checkbox

The following program creates an applet that displays three check boxes labeled "Item 1", "Item 2", and "Item 3". When a check box is selected or deselected, a string containing the name and state of that check box is displayed on the status line of the applet viewer or browser.

The program has one top-level class named CheckboxDemo2 that extends Applet. Its init( ) method creates three instances of MyCheckbox and adds these to the applet. MyCheckbox is an inner class that extends Checkbox. Its constructor uses super to pass the label of the check box to the superclass constructor. It calls enableEvents( ) so that item events may be received by this object. When an item event is generated, processItemEvent( ) is called. That method displays a string on the status line and calls processItemEvent( ) for the superclass.

```
/*
* <applet code=CheckboxDemo2 width=300 height=100>
* </applet>
*/
import java.awt.*;
import java.awt.event.*;
import java.applet.*;
public class CheckboxDemo2 extends Applet
```

```
{
     MyCheckbox myCheckbox1, myCheckbox2, myCheckbox3;
     public void init()
     {
          myCheckbox1 = new MyCheckbox("Item 1");
          add(myCheckbox1);
          myCheckbox2 = new MyCheckbox("Item 2");
          add(myCheckbox2);
          myCheckbox3 = new MyCheckbox("Item 3");
          add(myCheckbox3);
     }
     class MyCheckbox extends Checkbox
     {
          public MyCheckbox(String label)
          {
               super(label);
               enableEvents(AWTEvent.ITEM_EVENT_MASK);
          }
          protected void processItemEvent(ItemEvent ie)
          {
               showStatus("Checkbox name/state: " + getLabel() +
               "/" + getState());
               super.processItemEvent(ie);
          }
     }
}
```

Extending a Check Box Group

The following program reworks the preceding check box example so that the check boxes form a check box group. Thus, only one of the check boxes may be selected at any time.

```
/*
* <applet code=CheckboxGroupDemo2 width=300 height=100>
* </applet>
*/
import java.awt.*;
import java.awt.event.*;
import java.applet.*;
public class CheckboxGroupDemo2 extends Applet
{
     CheckboxGroup cbg;
     MyCheckbox myCheckbox1, myCheckbox2, myCheckbox3;
     public void init()
     {
          cbg = new CheckboxGroup();
          myCheckbox1 = new MyCheckbox("Item 1", cbg, true);
```

```
            add(myCheckbox1);
            myCheckbox2 = new MyCheckbox("Item 2", cbg, false);
            add(myCheckbox2);
            myCheckbox3 = new MyCheckbox("Item 3", cbg, false);
            add(myCheckbox3);
      }
      class MyCheckbox extends Checkbox
      {
            public   MyCheckbox(String   label,   CheckboxGroup   cbg,
            boolean flag)
            {
                  super(label, cbg, flag);
                  enableEvents(AWTEvent.ITEM_EVENT_MASK);
            }
            protected void processItemEvent(ItemEvent ie)
            {
                  showStatus("Checkbox name/state: " + getLabel() +
                  "/" + getState());
                  super.processItemEvent(ie);
            }
      }
}
```

Extending Choice

The following program creates an applet that displays a choice list with items labeled "Red", "Green", and "Blue". When an entry is selected, a string that contains the name of the color is displayed on the status line of the applet viewer or browser. There is one top-level class named ChoiceDemo2 that extends Applet. Its init( ) method creates a choice element and adds it to the applet. MyChoice is an inner class that extends Choice. It calls enableEvents( ) so that item events may be received by this object. When an item event is generated, processItemEvent( ) is called. That method displays a string on the status line and calls processItemEvent( ) for the superclass.

```
/*
* <applet code=ChoiceDemo2 width=300 height=100>
* </applet>
*/
import java.awt.*;
import java.awt.event.*;
import java.applet.*;
public class ChoiceDemo2 extends Applet
{
      MyChoice choice;
      public void init()
      {
            choice = new MyChoice();
```

```
            choice.add("Red");
            choice.add("Green");
            choice.add("Blue");
            add(choice);
      }
      class MyChoice extends Choice
      {
            public MyChoice()
            {
                  enableEvents(AWTEvent.ITEM_EVENT_MASK);
            }
            protected void processItemEvent(ItemEvent ie)
            {
                  showStatus("Choice selection: " +
                  getSelectedItem());
                  super.processItemEvent(ie);
            }
      }
}
```

Extending List

The following program modifies the preceding example so that it uses a list instead of a choice menu. There is one top-level class named ListDemo2 that extends Applet. Its init( ) method creates a list element and adds it to the applet. MyList is an inner class that extends List. It calls enableEvents( ) so that both action and item events may be received by this object. When an entry is selected or deselected, processItemEvent( ) is called. When an entry is double-clicked, processActionEvent( ) is also called. Both methods display a string and then hand control to the superclass.

```
/*
* <applet code=ListDemo2 width=300 height=100>
* </applet>
*/
import java.awt.*;
import java.awt.event.*;
import java.applet.*;
public class ListDemo2 extends Applet
{
      MyList list;
      public void init()
      {
            list = new MyList();
            list.add("Red");
            list.add("Green");
            list.add("Blue");
```

```
        add(list);
    }
    class MyList extends List
    {
        public MyList()
        {
            enableEvents(AWTEvent.ITEM_EVENT_MASK |
            AWTEvent.ACTION_EVENT_MASK);
        }
        protected void processActionEvent(ActionEvent ae)
        {
            showStatus("Action event: " +
            ae.getActionCommand());
            super.processActionEvent(ae);
        }
        protected void processItemEvent(ItemEvent ie)
        {
            showStatus("Item event: " + getSelectedItem());
            super.processItemEvent(ie);
        }
    }
}
```

Extending Scrollbar

The following program creates an applet that displays a scroll bar. When this control is manipulated, a string is displayed on the status line of the applet viewer or browser. That string includes the value represented by the scroll bar. There is one top-level class named ScrollbarDemo2 that extends Applet. Its init( ) method creates a scroll bar element and adds it to the applet. MyScrollbar is an inner class that extends Scrollbar. It calls enableEvents( ) so that adjustment events may be received by this object. When the scroll bar is manipulated, processAdjustmentEvent( ) is called. When an entry is selected, processAdjustmentEvent( ) is called. It displays a string and then hands control to the superclass.

```
/*
* <applet code=ScrollbarDemo2 width=300 height=100>
* </applet>
*/
import java.awt.*;
import java.awt.event.*;
import java.applet.*;
public class ScrollbarDemo2 extends Applet
{
    MyScrollbar myScrollbar;
    public void init()
```

```
    {
        myScrollbar = new
        MyScrollbar(Scrollbar.HORIZONTAL, 0, 1, 0,
        100);
        add(myScrollbar);
    }
    class MyScrollbar extends Scrollbar
    {
        public MyScrollbar(int style, int initial, int
        thumb, int min, int max)
        {
            super(style, initial, thumb, min, max);
            enableEvents(AWTEvent.ADJUSTMENT_EVENT_MASK);
        }
        protected void processAdjustmentEvent(AdjustmentEvent
        ae)
        {
            showStatus("Adjustment event: " +
            ae.getValue()); setValue(getValue());
            super.processAdjustmentEvent(ae);
        }
    }
}
```

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