EE3206
Java Programming and Applications

Lecture 10
Event-Driven Programming

Mr. Van Ting, Dept. of EE, CityU HK

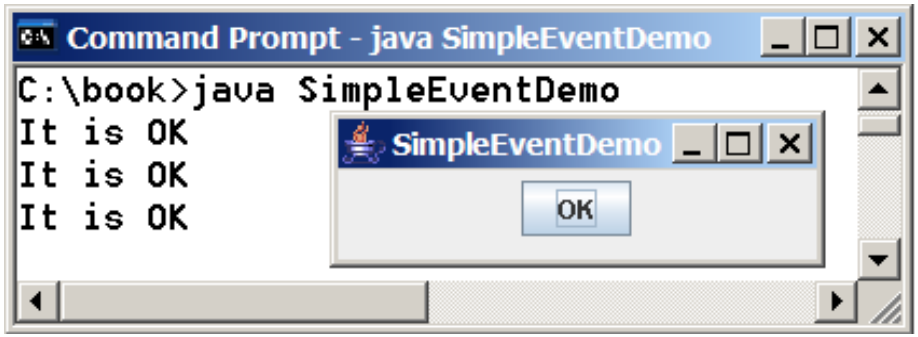
Intended Learning Outcomes

- To explain the concept of event-driven programming.
- To understand events, event sources, and event classes.
- To declare listener classes and write the code to handle events.
- To write programs to deal with ActionEvent, MouseEvent and KeyEvent.
- To understand the use of Adpaters.
- To use the Timer class to control animations.
- To create GUI with various user-interface components.
- To create listeners for various types of events.

Procedural vs. Event-Driven

- Procedural programming – a list of procedures is executed in the order as they are listed.
- In event-driven programming, code is executed upon activation of events.

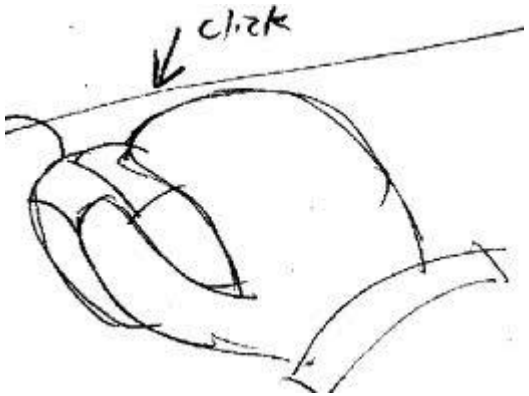
- The example displays a button in the frame. A message is displayed on the console when a button is clicked.

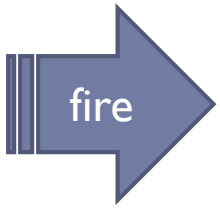


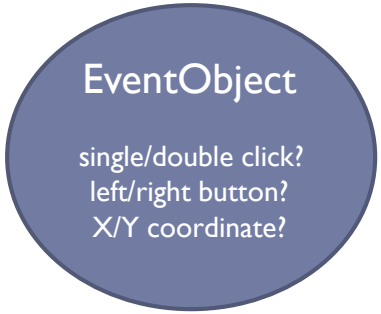
SimpleEventDemo

What are Events?

- An event can be defined as a type of signal to the program that something has happened.
- The event is generated/fired by external user actions such as mouse movements, mouse clicks, and keystrokes, or by the operating system, such as a timer.







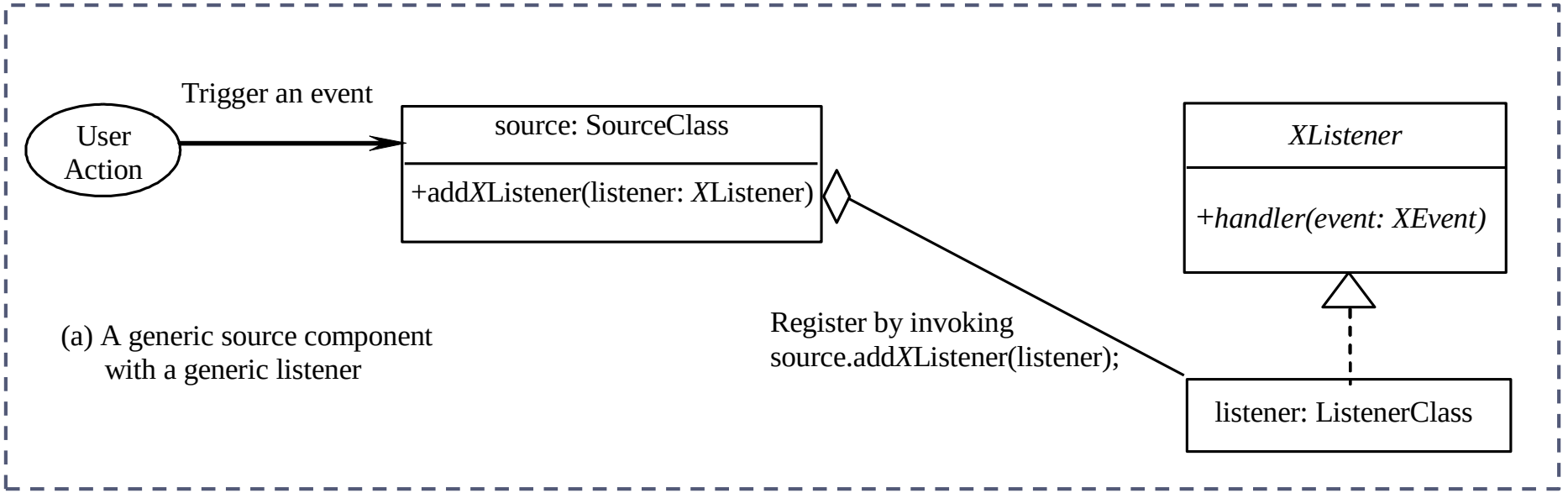
- An event object contains whatever properties are relevant to the event.
- You can identify the firing source object (e.g. a **JButton**) of the event using the **getSource()** instance method in the **EventObject** class. Its subclasses deal with special types of events, such as button actions, window events, component events, mouse movements, and keystrokes.

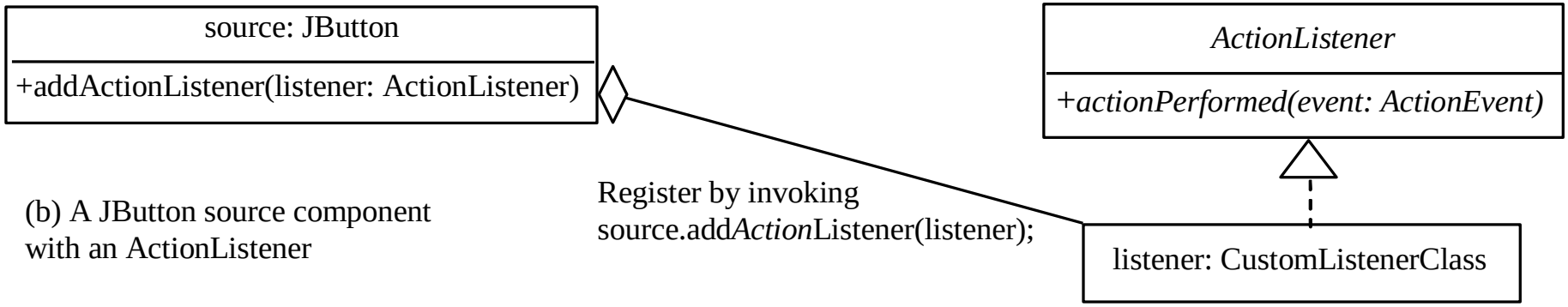
Common User Actions

Table below lists external user actions, source objects, and event types generated.

User Action		Source Object		Event Type Generated
Click a button		`JButton`		`ActionEvent`
Click a check box		`JCheckBox`		`ItemEvent`, `ActionEvent`
Click a radio button		`JRadioButton`		`ItemEvent`, `ActionEvent`
Press return on a text field	Act On	`JTextField`	Fire	`ActionEvent`
Select a new item		`JComboBox`		`ItemEvent`, `ActionEvent`
Window opened, closed, etc.		`Window`		`WindowEvent`
Mouse pressed, released, etc.		`Component`		`MouseEvent`
Key released, pressed, etc.		`Component`		`KeyEvent`

The Delegation Model

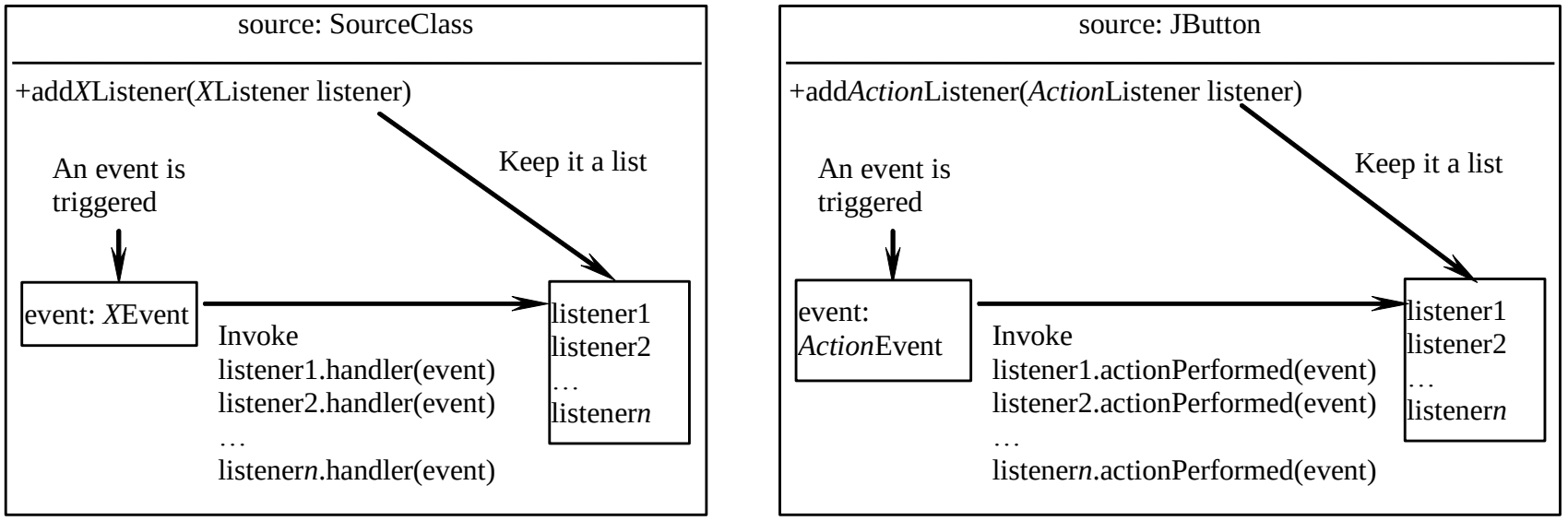




The Delegation Model: Example

```
JButton jbt = new JButton("OK");
ActionListener listener = new CustomListenerClass();
jbt.addActionListener(listener);
```

The internal function of a source component:



(a) Internal function of a generic source object

(b) Internal function of a JButton object

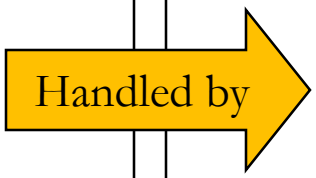
Selected Event Handlers

Event Class	Listener Interface	Listener Methods (Handlers)
`ActionEvent`	`ActionListener`	`actionPerformed(ActionEvent)`
`ItemEvent`	`ItemListener`	`itemStateChanged(ItemEvent)`

`WindowEvent`	`WindowListener`	`windowClosing(WindowEvent)`
		`windowOpened(WindowEvent)`
		`windowIconified(WindowEvent)`
		`windowDeiconified(WindowEvent)`
		`windowClosed(WindowEvent)`
		`windowActivated(WindowEvent)`
		`windowDeactivated(WindowEvent)`

`MouseEvent`	`MouseListener`	`mousePressed(MouseEvent)`
		`mouseReleased(MouseEvent)`
		`mouseClicked(MouseEvent)`
		`mouseExited(MouseEvent)`
		`mouseEntered(MouseEvent)`

`KeyEvent`	`KeyListener`	`keyPressed(KeyEvent)`
		`keyReleased(KeyEvent)`
		`keyTyped(KeyEvent)`



Inner Classes Listener

- A listener class is designed specifically to create a listener object for a GUI component (e.g., a button). It will not be shared by other applications. So, it is appropriate to define the listener class inside the frame class as an inner class.
  - The inner class is considered as a member of its outer class
  - The inner class *InnerClass* in *OuterClass* is compiled into *OuterClass*$*InnerClass*.*class*

- Advantages:
  - In some applications, you can use an inner class to make programs more simple.
  - An inner class can reference the data and methods defined in the outer class in which it nests, so you do not need to pass the reference of the outer class to the constructor of the inner class (see next page).

Inner Classes Pseudo Code

```
public class Test {
  ...
}

public class A {
  ...
}
```

(a)

```
public class Test {
  ...

  // Inner class
  public class A {
    ...
  }
}
```

(b)

```
// OuterClass.java: inner class demo
public class OuterClass {
  private int data;

  /** A method in the outer class */
  public void m() {
    // Do something
  }

  // An inner class
  class InnerClass {
    /** A method in the inner class */
    public void mi() {
      // Directly reference data and method
      // defined in its outer class
      data++;
      m();
    }
  }
}
```

(c)

SimpleEventDemoInnerClass

Anonymous Class and Object

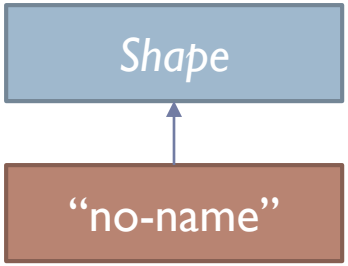
- Anonymous class/object is a mechanism for defining class/object without explicitly stating the name of the class/object. For example,

```
Circle c = new Circle();       // give an identifier c to the object explicitly
doSomething(c);
// create anonymous object and immediately pass to method
doSomething(new Circle());     // no name is given to the circle instance
```

- To create an anonymous class, you always extend a superclass or implement an interface. Any abstract methods must be implemented so as to instantiate the anonymous class.
- An anonymous class always uses the no-arg constructor from its superclass to create an instance. If an anonymous class implements an interface, the corresponding constructor is Object().

```
Shape s = new Shape() {
  // Implement or override all methods
  // in superclass or interface
  // Other methods if necessary
};
```

* *s* is an instance of *"no-name" which extends Shape*



Anonymous Inner Classes

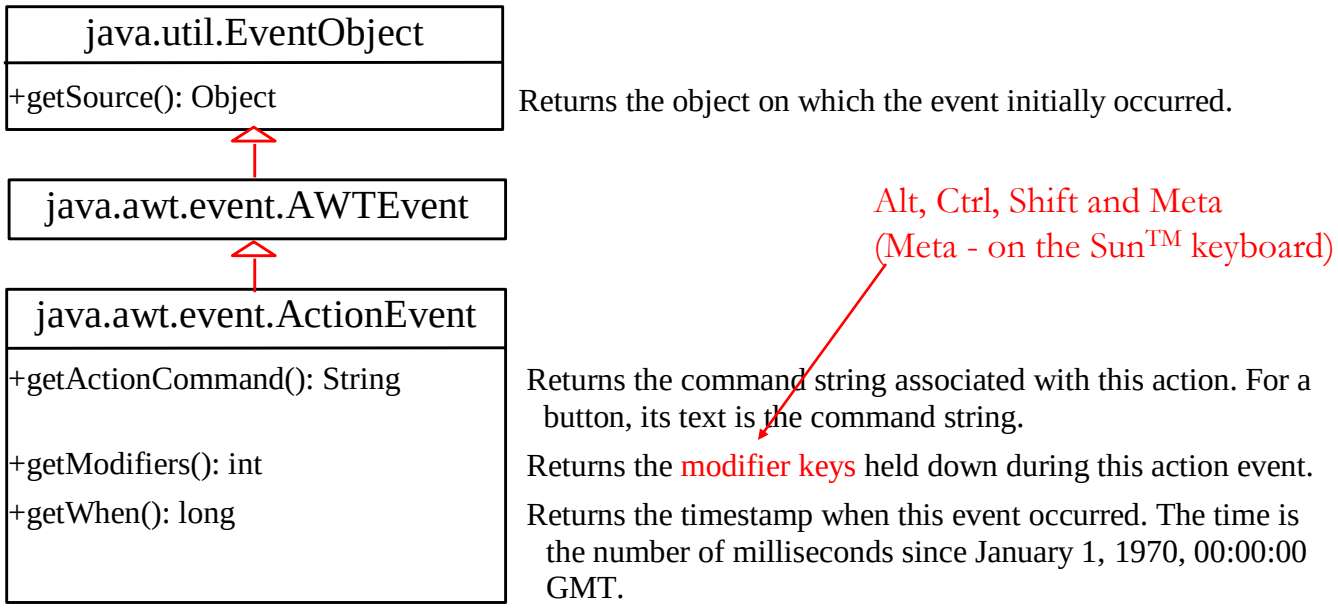
- Because without a name to reference, anonymous class must be declared and instantiated at the same time.

- Anonymous inner class is a special form of inner class that does not have a name.
- An anonymous inner class is compiled into a class named OuterClassName$n.class. For example, if the outer class Test has two anonymous inner classes, these two classes are compiled into Test$1.class and Test$2.class.

- Anonymous class is a convenient way for creating one-time class (e.g. listener class) without polluting the class namespace.

SimpleEventDemoAnonymousInnerClass

Handing ActionEvent



- Example 1: Display two buttons OK and Cancel in the window. A message is displayed on the console to indicate which button is clicked, when a button is clicked.

TestActionEvent

- Example 2: This example modifies TestActionEvent to add an additional listener for the action events on the buttons. When a button is clicked, both listeners respond to the action event.

TestMultipleListener

Handling Window Events

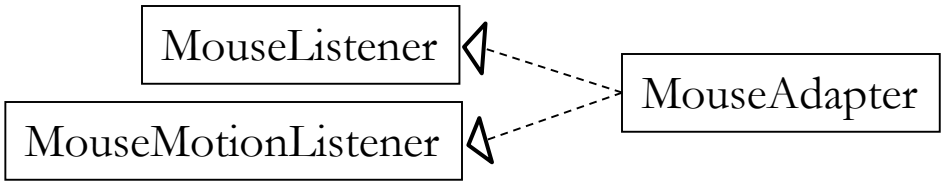
- Objective: Demonstrate handling the window events. Any subclass of the Window class can generate the following window events:
  - window opened, closing, closed, activated, deactivated, iconified, and deiconified.

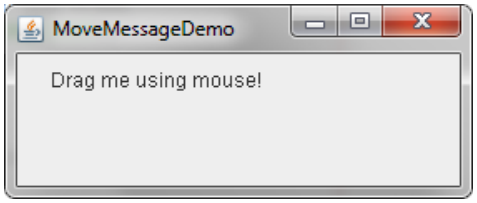
- This program creates a frame, listens to the window events, and displays a message to indicate the occurring event.

TestWindowEvent

Handling Mouse Events

- Java provides two listener interfaces to handle mouse events.
  - MouseListener - for actions such as when the mouse is pressed, released, entered, exited, or clicked
  - MouseMotionListener – for actions such as dragging or moving the mouse
- Because there are many abstract methods in these two interfaces, it is inconvenient to implement all handlers every time even you do not use all of them.
  - Java provides a class MouseAdapter which receives both mouse events and mouse motion events. The methods in this class are empty; this class is provided as a convenience for easily creating listeners by extending this class and overriding only the methods of interest.





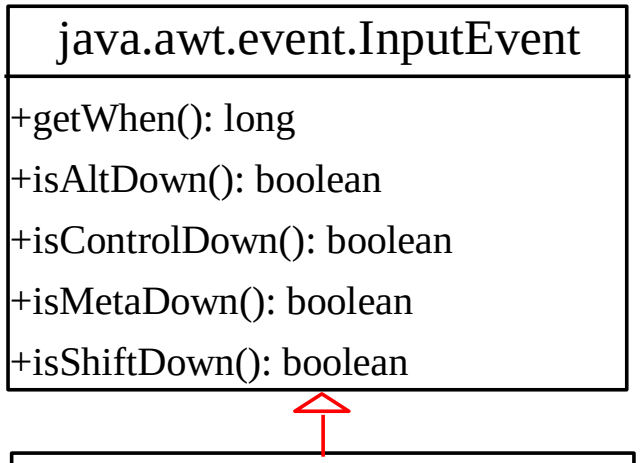
MoveMessageDemo

Mouse Listeners

java.awt.event.MouseListener	
+mousePressed(e: MouseEvent): void	Invoked when the mouse button has been pressed on the source component.
+mouseReleased(e: MouseEvent): void	Invoked when the mouse button has been released on the source component.
+mouseClicked(e: MouseEvent): void	Invoked when the mouse button has been clicked (pressed and released) on the source component.
+mouseEntered(e: MouseEvent): void	Invoked when the mouse enters the source component.
+mouseExited(e: MouseEvent): void	Invoked when the mouse exits the source component.

java.awt.event.MouseMotionListener	
+mouseDragged(e: MouseEvent): void	Invoked when a mouse button is moved with a button pressed.
+mouseMoved(e: MouseEvent): void	Invoked when a mouse button is moved without a button pressed.

MouseEvent



Returns the timestamp when this event occurred.

Returns whether or not the Alt modifier is down on this event.

Returns whether or not the Control modifier is down on this event.

Returns whether or not the Meta modifier is down on this event

Returns whether or not the Shift modifier is down on this event.

Indicates which mouse button has been clicked.

Returns the number of mouse clicks associated with this event.

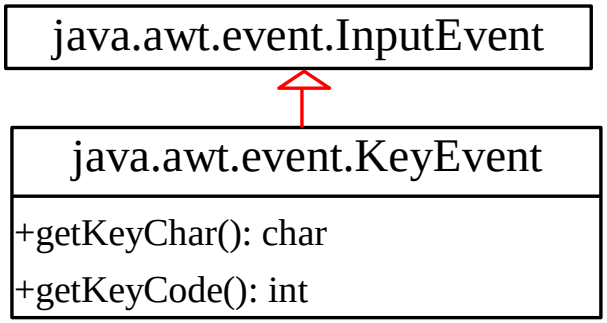
Returns a Point object containing the x and y coordinates.

Returns the x-coordinate of the mouse point.

Returns the y-coordinate of the mouse point.

Handling Keyboard Events

- To process a keyboard event, use the following handlers in the KeyListener interface:
  - keyPressed(KeyEvent e) - Called when a key is pressed.
  - keyReleased(KeyEvent e) - Called when a key is released.
  - keyTyped(KeyEvent e) - Called when a key is pressed and then released.
  - Corresponding Adapter – KeyAdapter



Keys:

Home	VK_HOME
End	VK_END
Page Up	VK_PGUP
Page Down	VK_PGDN
etc...	

Defined as some constant values in the class

Returns the character associated with the key in this event.

Returns the integer keyCode associated with the key in this event.

KeyEventDemo

The Timer Class

- Some non-GUI components can fire events. The javax.swing.Timer class is a source component that fires an ActionEvent at a predefined rate.
- The Timer class can be used to control animations. For example, you can use it to display a moving message.

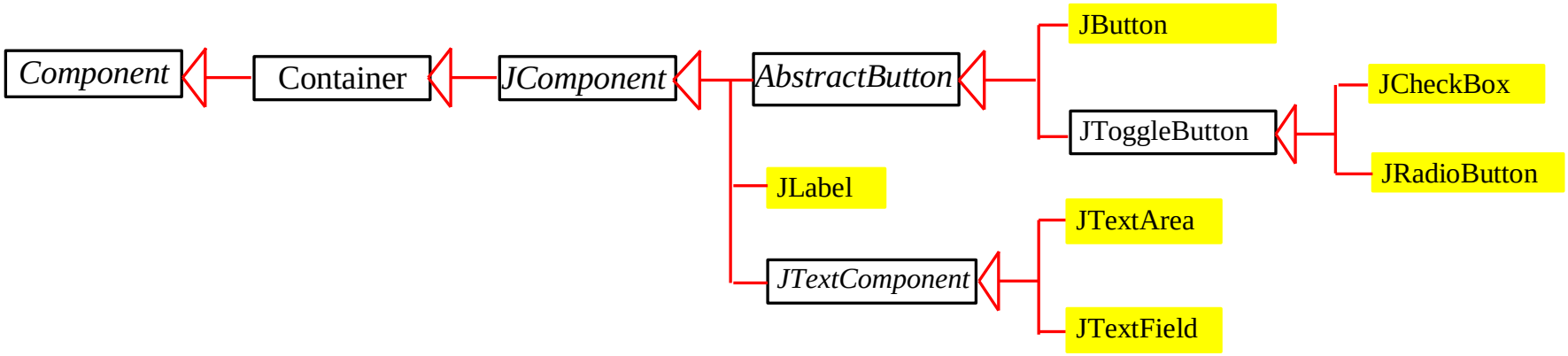
javax.swing.Timer	
+Timer(delay: int, listener: ActionListener)	Creates a Timer with a specified delay in milliseconds and an ActionListener.
+addActionListener(listener: ActionListener): void	Adds an ActionListener to the timer.
+start(): void	Starts this timer.
+stop(): void	Stops this timer.
+setDelay(delay: int): void	Sets a new delay value for this timer.

AnimationDemo

Introduction to Other Useful Components

Frequently Used Components

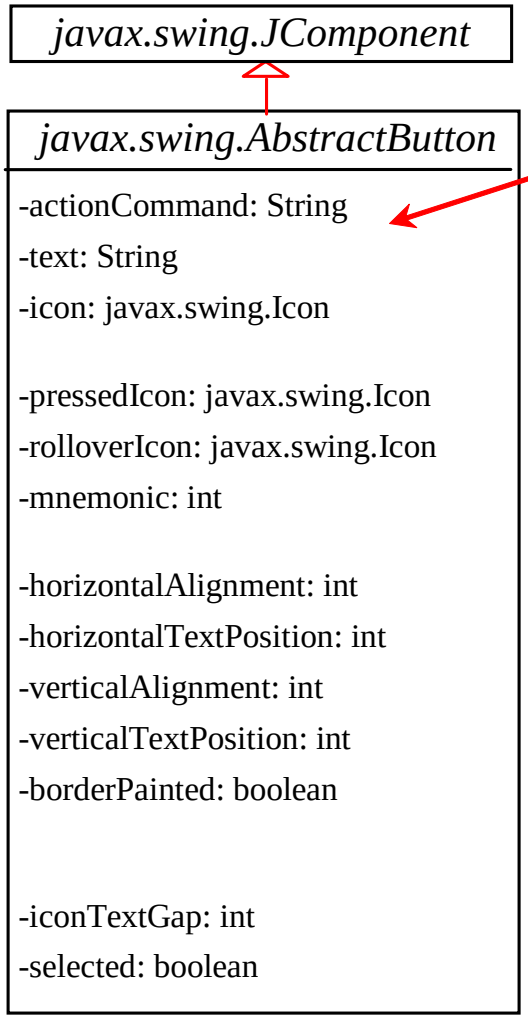
- Introduces the frequently used GUI components



Types of Button

- A button is a component that triggers an action event when clicked.
- Swing provides regular buttons, toggle buttons (two-state button), check box buttons, and radio buttons.
- The common features of these buttons are generalized in javax.swing.AbstractButton.

AbstractButton



The get and set methods for these data fields are provided in the class, but omitted in the UML diagram for brevity.

The action command of this button.

The button's text (i.e., the text label on the button).

The button's default icon. This icon is also used as the "pressed" and "disabled" icon if there is no explicitly set pressed icon.

The pressed icon (displayed when the button is pressed).

The rollover icon (displayed when the mouse is over the button).

The mnemonic key value of this button. You can select the button by pressing the ALT key and the mnemonic key at the same time.

The horizontal alignment of the icon and text (default: CENTER).

The horizontal text position relative to the icon (default: RIGHT).

The vertical alignment of the icon and text (default: CENTER).

The vertical text position relative to the icon (default: CENTER).

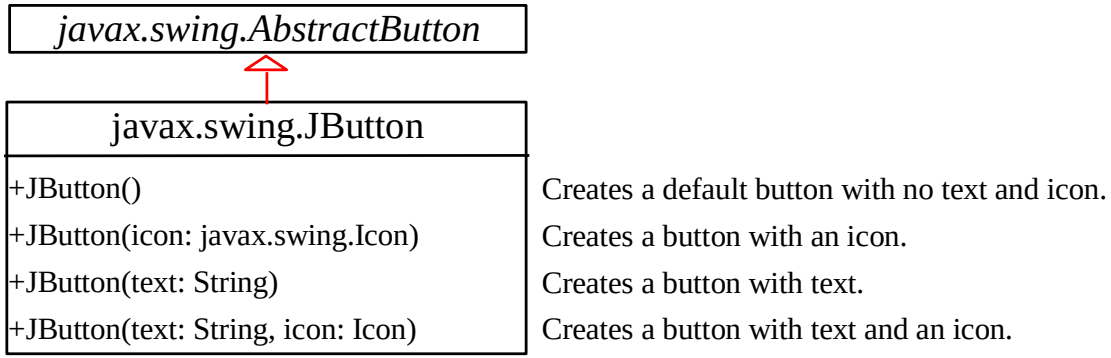
Indicates whether the border of the button is painted. By default, a regular button's border is painted, but the borders for a check box and a radio button is not painted.

The gap between the text and the icon on the button (JDK 1.4).

The state of the button. True if the check box or radio button is selected, false if it's not.

JButton Constructors and Properties

- JButton inherits AbstractButton and provides several constructors to create buttons.
- Constructor
  - JButton()
  - JButton(String text)
  - JButton(String text, Icon icon)
  - JButton(Icon icon)
- Properties
  - text
  - icon
  - Mnemonic (shortcut key)
  - horizontalAlignment
  - verticalAlignment
  - horizontalTextPosition
  - verticalTextPosition
  - iconTextGap



Default Icons, Pressed Icon, and Rollover Icon

- A regular button has a default icon, pressed icon, and rollover icon. Normally, you use the default icon. All other icons are for special effects. A pressed icon is displayed when a button is pressed and a rollover icon is displayed when the mouse is over the button but not pressed.

(A) Default icon

(B) Pressed icon

(C) Rollover icon


```
jbt.setPressedIcon(imageIcon);
```

TestButtonIcons

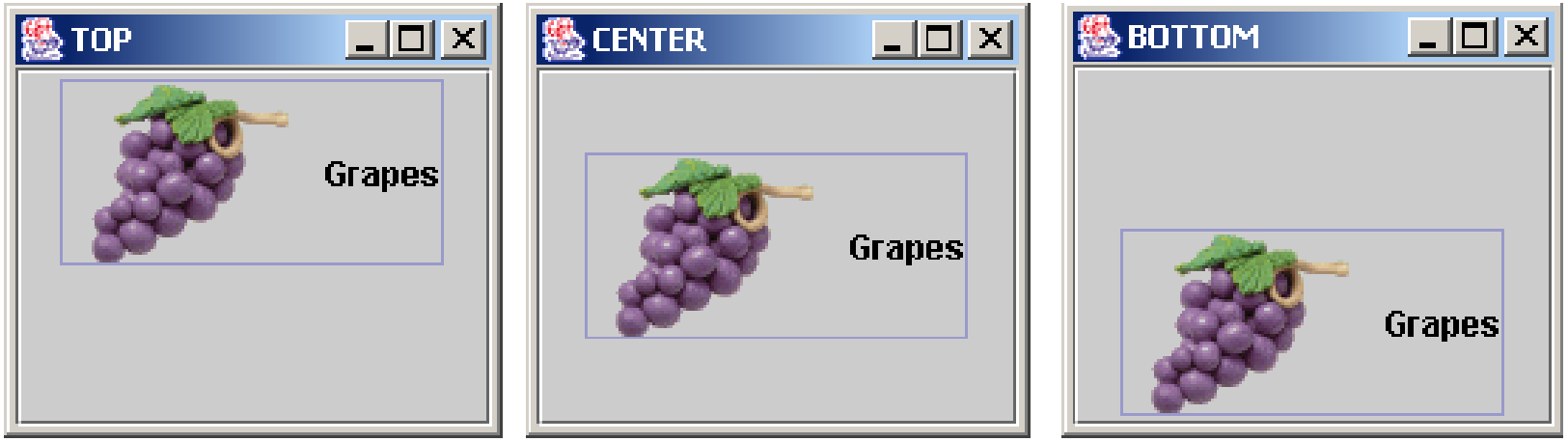
Horizontal Alignments

- Horizontal alignment specifies how the icon and text are placed horizontally on a button.
- You can set the horizontal alignment using one of the three constants: LEFT, CENTER, RIGHT.
- These constants are inherited from the *SwingConstants* interface.
- The default horizontal alignment is SwingConstants.CENTER.


```
jbt.setHorizontalAlignment(SwingConstants.CENTER);
```

Vertical Alignments

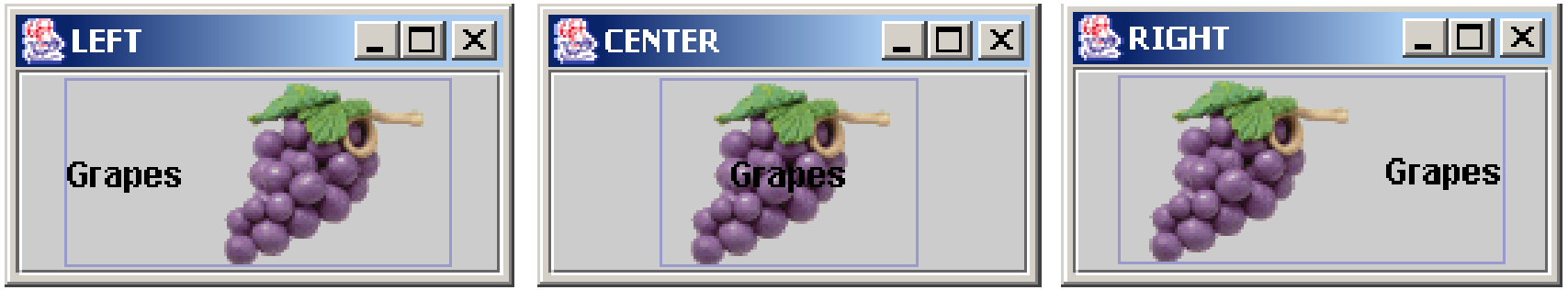
- Vertical alignment specifies how the icon and text are placed vertically on a button. You can set the vertical alignment using one of the three constants: TOP, CENTER, BOTTOM.
- The default vertical alignment is SwingConstants.CENTER.




```
jbt.setVerticalAlignment(SwingConstants.CENTER);
```

Horizontal Text Positions

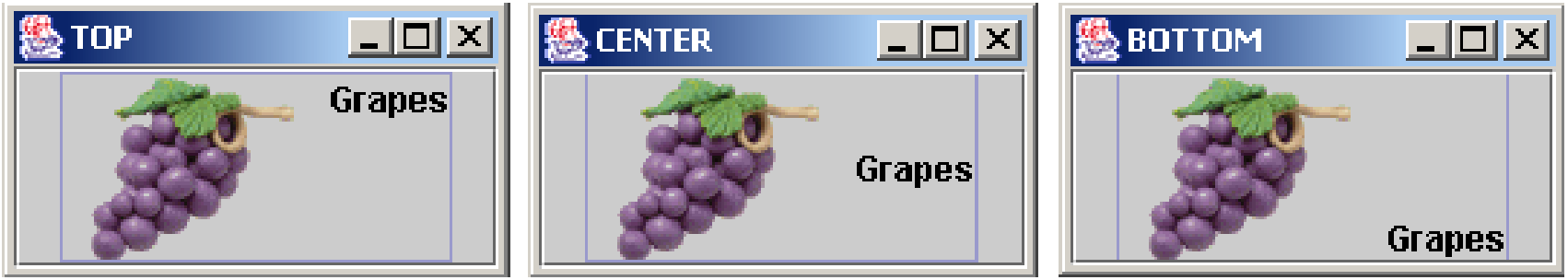
- Horizontal text position specifies the horizontal position of the text relative to the icon.
- You can set the horizontal text position using one of the three constants: LEFT, CENTER, RIGHT.
- The default horizontal text position is SwingConstants.RIGHT.




```
jbt.setHorizontalTextPosition(SwingConstants.CENTER);
```

Vertical Text Positions

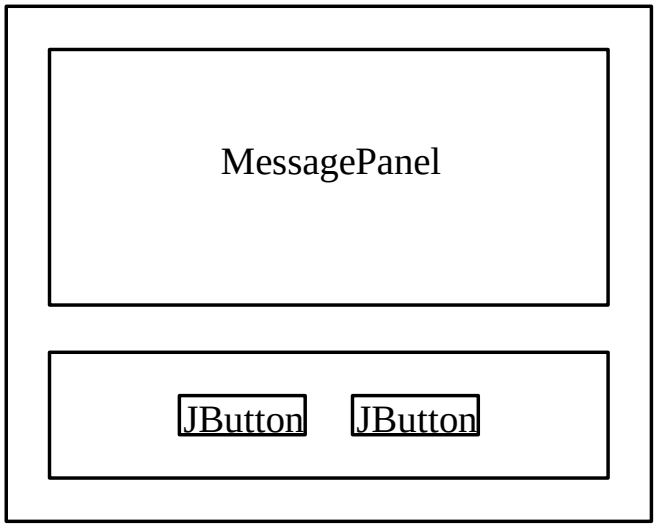
- Vertical text position specifies the vertical position of the text relative to the icon.
- You can set the vertical text position using one of the three constants: TOP, CENTER, BOTTOM.
- The default vertical text position is SwingConstants.CENTER.

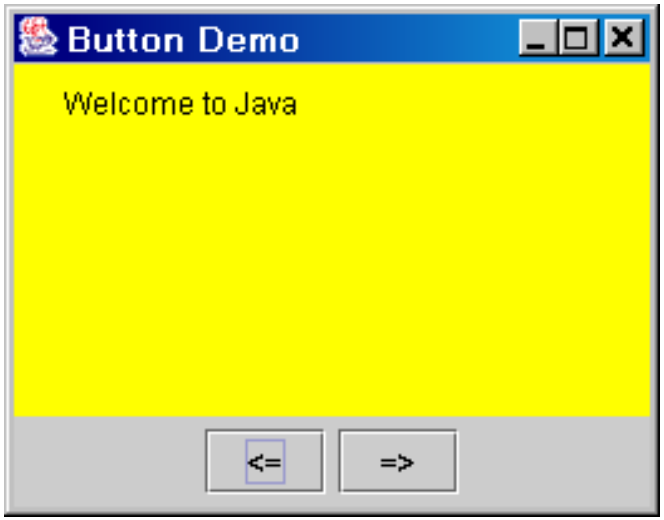



```
jbt.setVerticalTextPosition(SwingConstants.CENTER);
```

Example: Using Buttons

- Write a program that displays a message on a panel and uses two buttons, <= and =>, to move the message on the panel to the left or right.

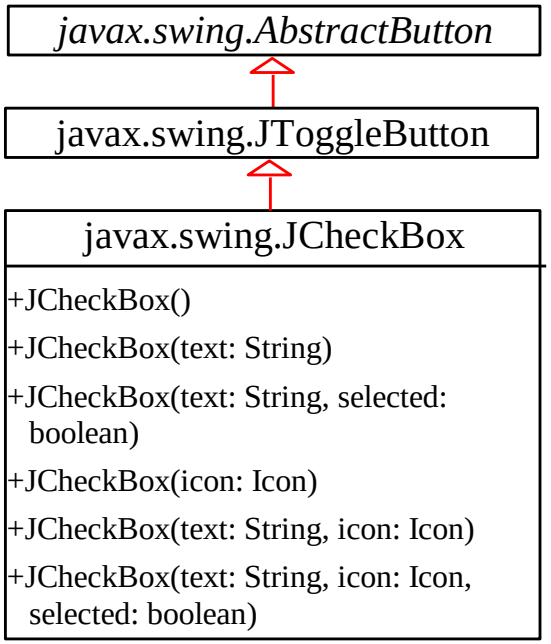




ButtonDemo

JCheckBox

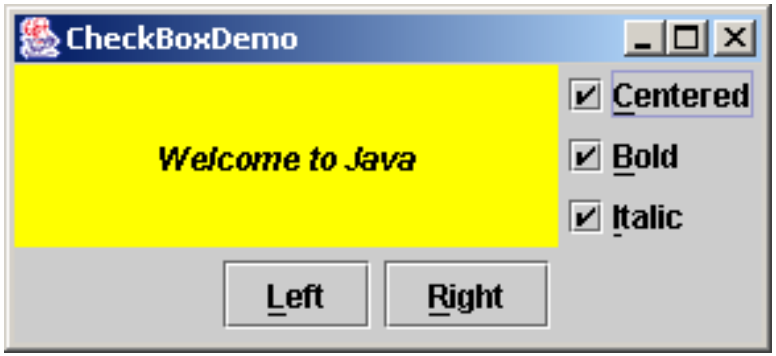
- JCheckBox inherits all the properties such as text, icon, mnemonic, verticalAlignment, horizontalAlignment, horizontalTextPosition, verticalTextPosition, and selected from AbstractButton, and provides several constructors to create check boxes.
- To detect if a box is checked, use *isSelected()*



+JCheckBox()	Creates a default check box button with no text and icon.
+JCheckBox(text: String)	Creates a check box with text.
+JCheckBox(text: String, selected: boolean)	Creates a check box with text and specifies whether the check box is initially selected.
+JCheckBox(icon: Icon)	Creates a checkbox with an icon.
+JCheckBox(text: String, icon: Icon)	Creates a checkbox with text and an icon.
+JCheckBox(text: String, icon: Icon, selected: boolean)	Creates a check box with text and an icon, and specifies whether the check box is initially selected.

Example: Using Check Boxes

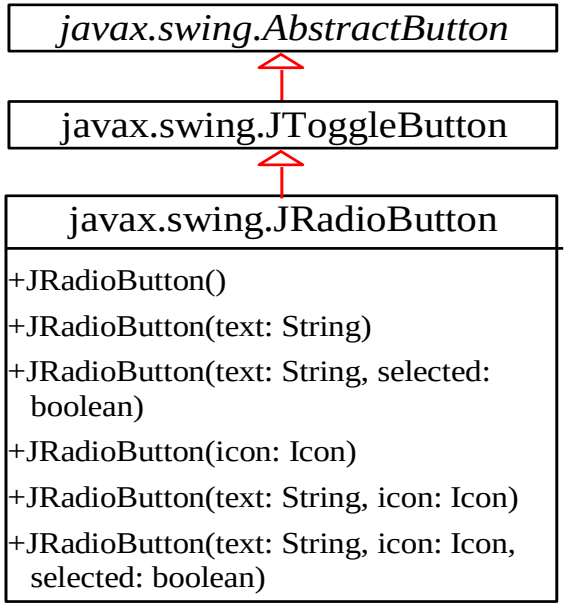
- Add three check boxes named Centered, Bold, and Italic into the previous example to let the user specify whether the message is centered, bold, or italic.



CheckBoxDemo

JRadioButton

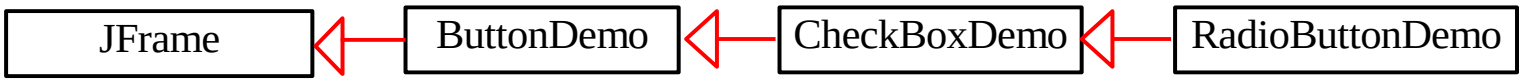
- Radio buttons are variations of check boxes. They are often used in the group, where only one button is checked at a time. They can be grouped with the following code:
  - ButtonGroup btg = new ButtonGroup();
  - btg.add(jrb1);
  - btg.add(jrb2);



+JRadioButton()	Creates a default radio button with no text and icon.
+JRadioButton(text: String)	Creates a radio button with text.
+JRadioButton(text: String, selected: boolean)	Creates a radio button with text and specifies whether the radio button is initially selected.
+JRadioButton(icon: Icon)	Creates a radio button with an icon.
+JRadioButton(text: String, icon: Icon)	Creates a radio button with text and an icon.
+JRadioButton(text: String, icon: Icon, selected: boolean)	Creates a radio button with text and an icon, and specifies whether the radio button is initially selected.

Example: Using Radio Buttons

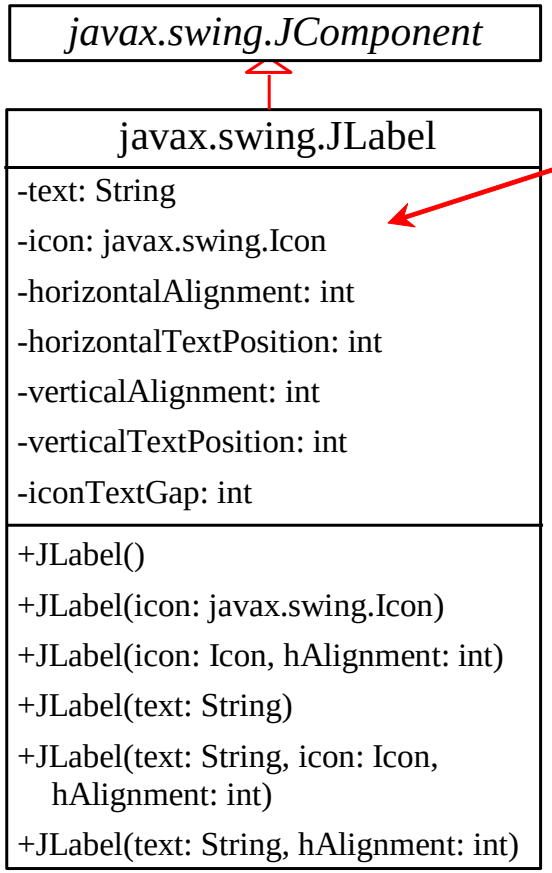
- Add three radio buttons named Red, Green, and Blue into the preceding example to let the user choose the color of the message.



RadioButtonDemo

JLabel

- A label is a display area for a short text, an image, or both.



The get and set methods for these data fields are provided in the class, but omitted in the UML diagram for brevity.

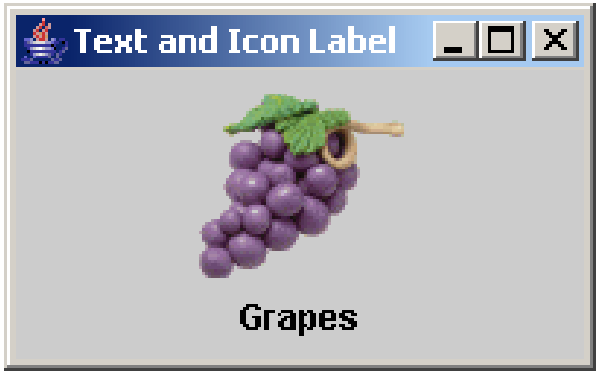
-text: String	The label's text.
-icon: javax.swing.Icon	The label's image icon.
-horizontalAlignment: int	The horizontal alignment of the text and icon on the label.
-horizontalTextPosition: int	The horizontal text position relative to the icon on the label.
-verticalAlignment: int	The vertical alignment of the text and icon on the label.
-verticalTextPosition: int	The vertical text position relative to the icon on the label.
-iconTextGap: int	The gap between the text and the icon on the label (JDK 1.4).
+JLabel()	Creates a default label with no text and icon.
+JLabel(icon: javax.swing.Icon)	Creates a label with an icon.
+JLabel(icon: Icon, hAlignment: int)	Creates a label with an icon and the specified horizontal alignment.
+JLabel(text: String)	Creates a label with text.
+JLabel(text: String, icon: Icon, hAlignment: int)	Creates a label with text, an icon, and the specified horizontal alignment.
+JLabel(text: String, hAlignment: int)	Creates a label with text and the specified horizontal alignment.

JLabel Constructors & Properties

- The constructors for labels are as follows:
  - JLabel()
  - JLabel(String text, int horizontalAlignment)
  - JLabel(String text)
  - JLabel(Icon icon)
  - JLabel(Icon icon, int horizontalAlignment)
  - JLabel(String text, Icon icon, int horizontalAlignment)

- JLabel inherits all the properties from JComponent and has many properties similar to the ones in JButton, such as text, icon, horizontalAlignment, verticalAlignment, horizontalTextPosition, verticalTextPosition, and iconTextGap.

Using Labels



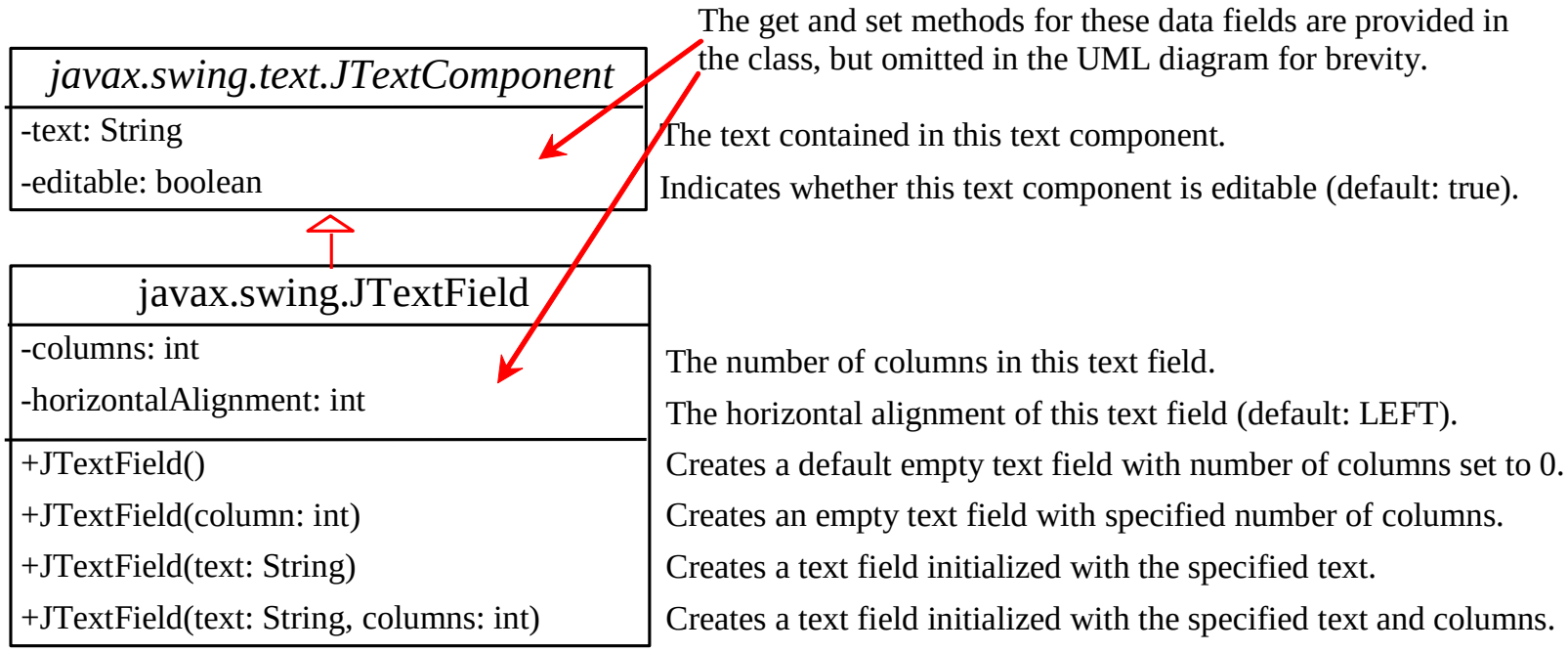

```
// Create an image icon from image file
ImageIcon icon = new ImageIcon("image/grapes.gif");

// Create a label with text,
// an icon, with centered horizontal alignment
JLabel jlbl = new JLabel("Grapes", icon, SwingConstants.CENTER);

// Set label's text alignment and gap between text and icon
jlbl.setHorizontalTextPosition(SwingConstants.CENTER);
jlbl.setVerticalTextPosition(SwingConstants.BOTTOM);
jlbl.setIconTextGap(5);
```

JTextField

- A text field is an input area where the user can type in characters. Text fields are useful in that they enable the user to type in variable data (such as a name or a description).



JTextField Constructors & Properties

- Constructors
  - JTextField(int columns)
  - Creates an empty text field with the specified number of columns.
  - JTextField(String text)
  - Creates a text field initialized with the specified text.
  - JTextField(String text, int columns)
  - Creates a text field initialized with the specified text and the column size.

- Properties
  - text
  - horizontalAlignment
  - editable
  - columns

JTextField Methods

- getText()
  - Returns the string from the text field.
- setText(String text)
  - Puts the given string in the text field.
- setEditable(boolean editable)
  - Enables or disables the text field to be edited. By default, editable is true.
- setColumns(int)
  - Sets the number of columns in this text field. The length of the text field is changeable.

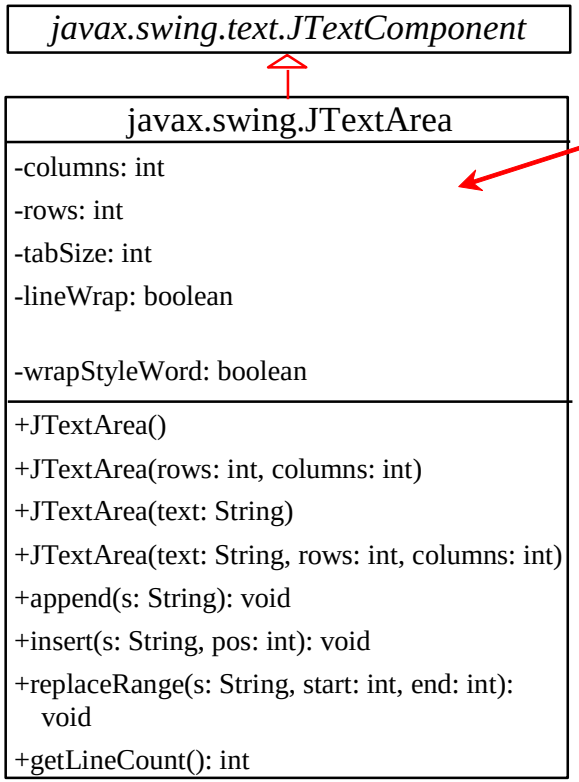
Example: Using Text Fields

- Add a text field to the preceding example to let the user set a new message.

TextFieldDemo

JTextArea

- If you want to let the user enter multiple lines of text, you cannot use text fields unless you create several of them. The solution is to use JTextArea, which enables the user to enter multiple lines of text.



The get and set methods for these data fields are provided in the class, but omitted in the UML diagram for brevity.

The number of columns in this text area.

The number of rows in this text area.

The number of characters used to expand tabs (default: 8).

Indicates whether the line in the text area is automatically wrapped (default: false).

Indicates whether the line is wrapped on words or characters (default: false).

Creates a default empty text area.

Creates an empty text area with the specified number of rows and columns.

Creates a new text area with the specified text displayed.

Creates a new text area with the specified text and number of rows and columns.

Appends the string to text in the text area.

Inserts string s in the specified position in the text area.

Replaces partial text in the range from position start to end with string s.

Returns the actual number of lines contained in the text area.

JTextArea Constructors & Properties

- Constructors
  - JTextArea(int rows, int columns)
  - Creates a text area with the specified number of rows and columns.
  - JTextArea(String s, int rows, int columns)
  - Creates a text area with the initial text and the number of rows and columns specified.

- Properties
  - text
  - editable
  - columns
  - lineWrap
  - wrapStyleWord
  - rows
  - lineCount
  - tabSize

TestTextArea