GUI Programming II

Event-Driven Programming

Procedural and Event-Driven Programming

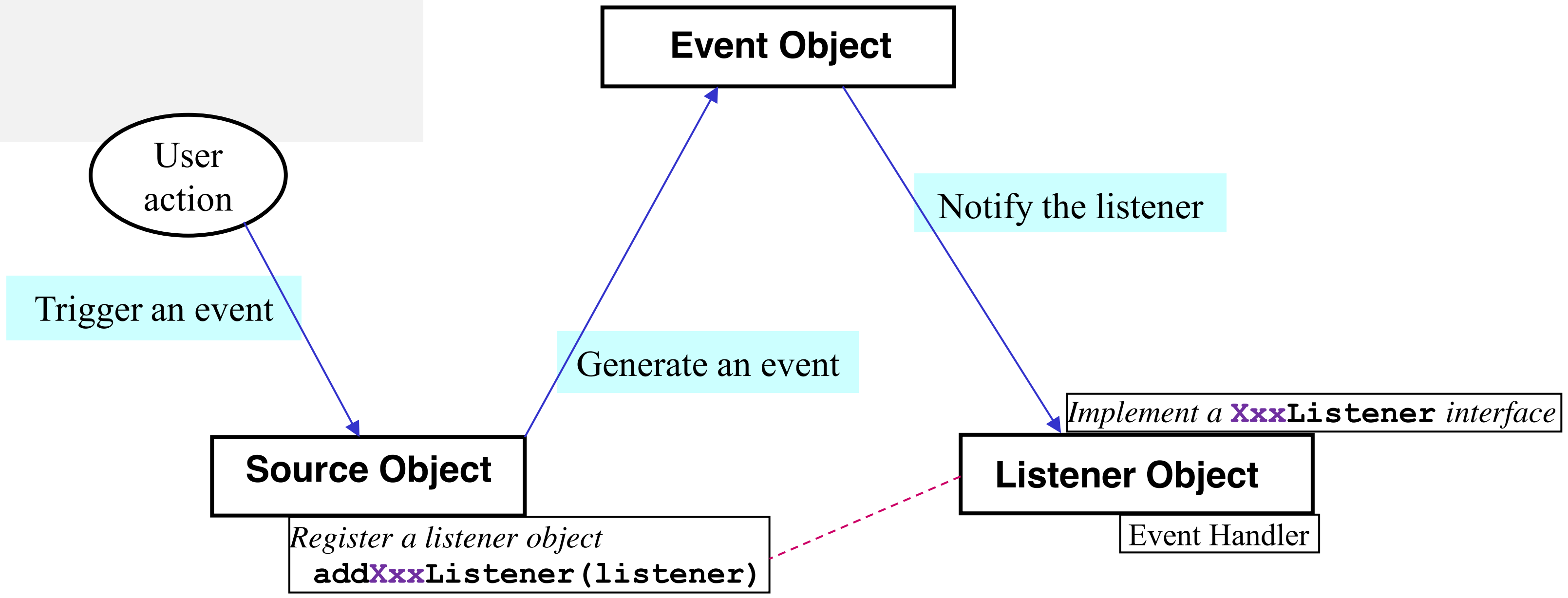
- ***Text-based applications***: object-oriented but executed in a procedural order
  - The program dictates the flow of execution and code is executed in procedural order
- ***GUI applications***: object-oriented and event-driven
  - code is executed upon activation of events: *a button click; a mouse movement* etc.

Events

- An ***event*** can be defined as a type of signal to the program that something has happened
- Any operating environment constantly monitors events and reports them to running programs. Each program decides what, if any, to do in response to these events.
- The event is generated by
  - External user actions
    - mouse movements, mouse button clicks, and keystrokes etc.
  - Internal program activities (or the operating system)
    - Timer
- Event Source
  - Source Object
    - the component on which an event is fired or generated
  - Event objects contain properties pertinent to the event

Java Event Delegation Model

An user action on a source object triggers an event, and an object interested (registered) in the event receives the event.



Event Handling

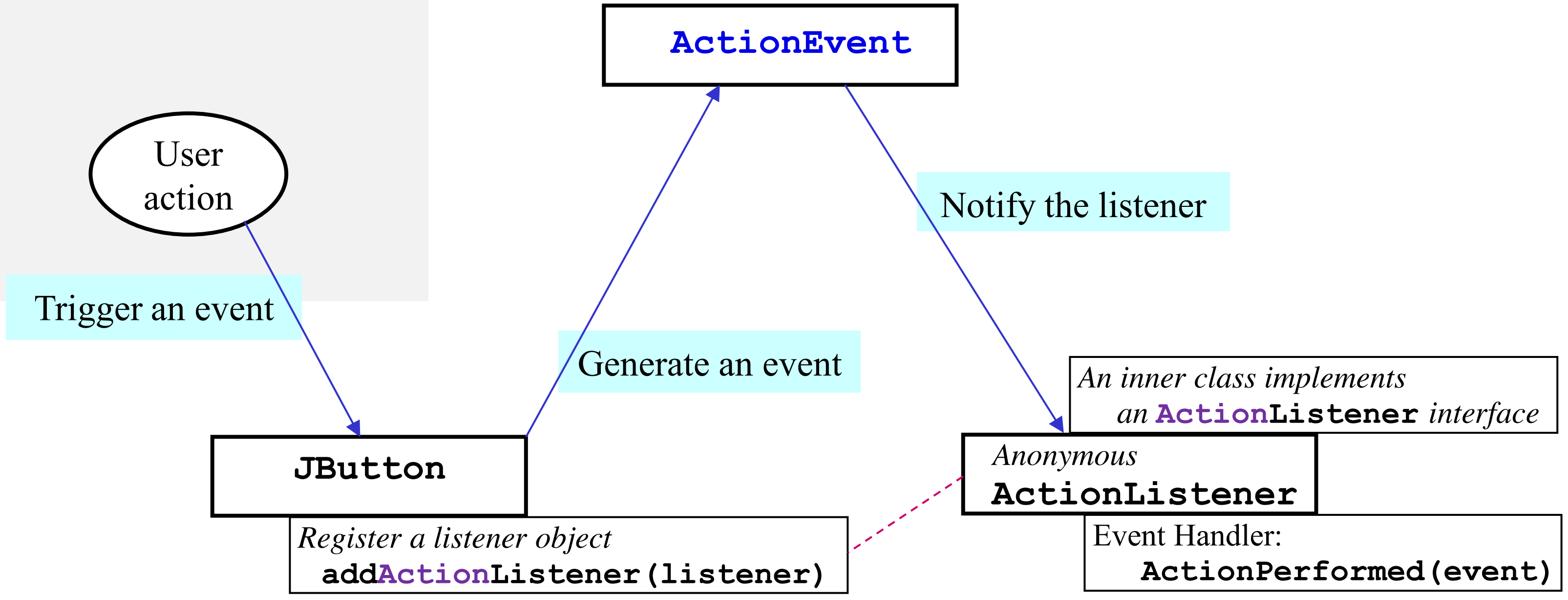
- 3 Parts - Model
  - Event Source
    - GUI components users interact with
  - Event Object
    - Encapsulates event information
  - Event Listener
    - Receives the event object when notified, then responds
- 2 Programming Tasks
  - Register ***event listener*** for event source
  - Implement event-handling methods (***handlers***)

Fundamentally important to GUI programming

Example 1: Button Frame

```
public class ButtonFrame {
    public static void main(String[] args) {
        JFrame frame = new JFrame("My Button Frame");
        ButtonPanel panel = new ButtonPanel();
        frame.add(panel);
        frame.setSize(400, 300);
        frame.setVisible(true);
        frame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
    }
}
class ButtonPanel extends JPanel {
    ButtonPanel() {
        JButton redButton = new JButton("Red");                       //add red button
        add(redButton);                                                //add button to panel
        redButton.addActionListener(new ActionListener() {            //register event listener
                public void actionPerformed(ActionEvent event){
                    setBackground(Color.RED);
                }
            });
        JButton blueButton = new JButton("Blue");                     //add blue button
        add(blueButton);                                               //add button to panel
        blueButton.addActionListener(new ActionListener() {           //register event listener
                public void actionPerformed(ActionEvent event){
                    setBackground(Color.BLUE);
                }
            });
    }
}
```

Example 1: Button Frame


ActionEvent
User action
Trigger an event
Generate an event
Notify the listener
JButton
Register a listener object
addActionListener(listener)
An inner class implements an ActionListener interface
Anonymous ActionListener
Event Handler: ActionPerformed(event)

Learn a Java Idiom – Add Listener and Handler

```
SourceObject.addEventListener(new EventListener() {
    public void EventHandler(Event event) {
        /* Code here will be executed
         * when the event is triggered.
         */
    }
});
```

Anonymous Inner Class

Example

```
blueButton.addActionListener(new ActionListener() {

    public void actionPerformed(ActionEvent event) {
        setBackground(Color.BLUE);
    }
});
```

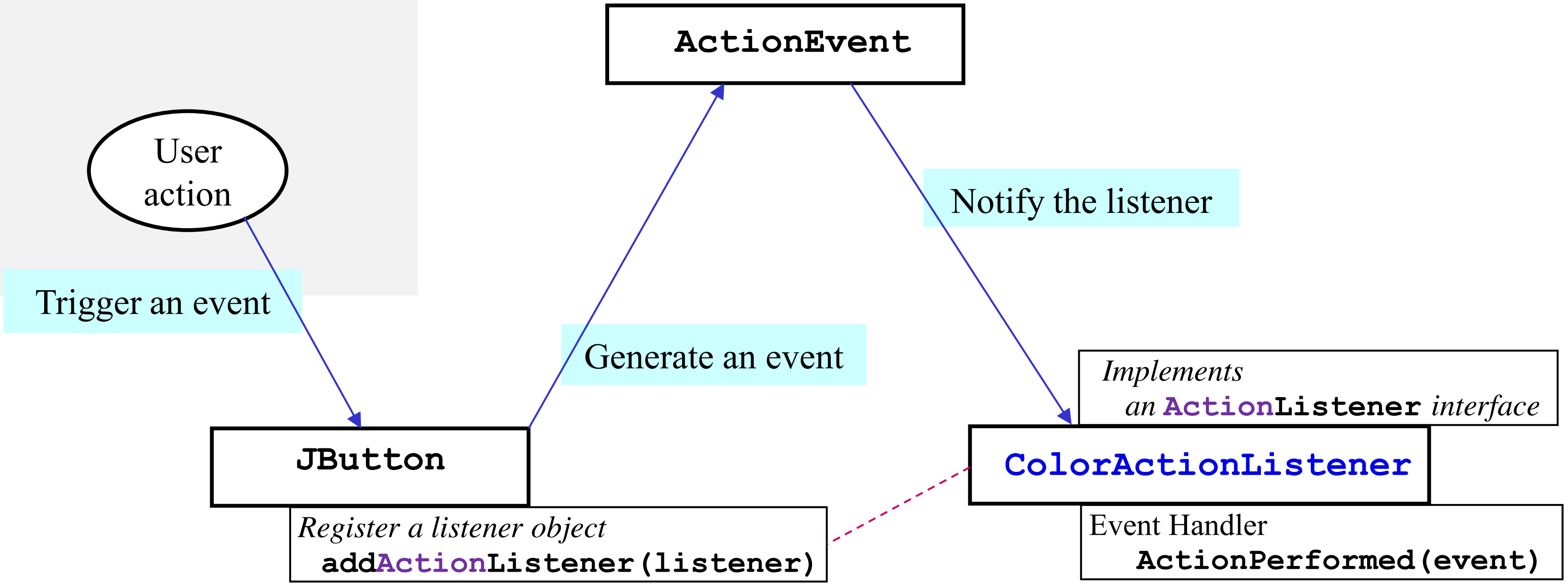
Example 2: Create Listener Class

```
public class ListeningClass {
    public static void main(String[] args) {
        JFrame frame = new JFrame("My Listening Class");
        MyButtonPanel panel = new MyButtonPanel();
        …
}
class MyButtonPanel extends JPanel {
    JButton yellowButton = new JButton("Yellow");
    JButton greenButton = new JButton("Green");

     MyButtonPanel()  {
         ColorActionListener acitonListeningObject = new ColorActionListener();
         add(yellowButton);                                                       //add Yellow button to panel
         yellowButton.addActionListener(acitonListeningObject);                  //register event listener
         add(greenButton);                                                        //add Green button to panel
         greenButton.addActionListener(acitonListeningObject);                   //register event listener
     }

   class ColorActionListener implements ActionListener{
       public void actionPerformed(ActionEvent event)  {  //implementing the ActionEvent handler
           if (event.getSource() == yellowButton)  {
               setBackground(Color.YELLOW);
           } else if  (event.getSource()  == greenButton){
               setBackground(Color.GREEN);
           }
       }
   }
}
```

Example 2: Create Listener Class



Example 3: Turning Components into Event Listeners

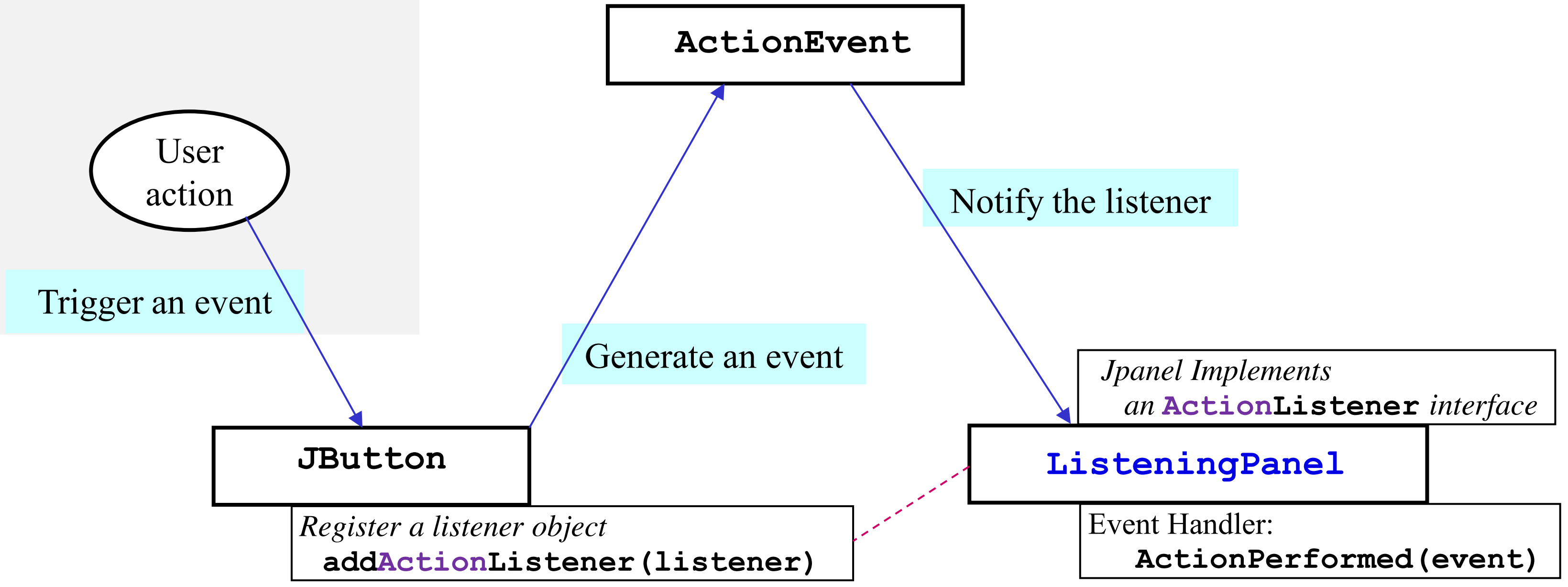
```
public class TestListeningPanel {
    public static void main(String[] args) {
        JFrame frame = new JFrame("My Listening Panel");
        ListeningPanel panel = new ListeningPanel();
                …
}

class ListeningPanel extends JPanel implements ActionListener {
    JButton orangeButton = new JButton("Orange");
    JButton pinkButton = new JButton("Pink");

    ListeningPanel() {
        add(orangeButton);                                        //add Orange button to panel
        orangeButton.addActionListener(this);                     //register event listener
        add(pinkButton);                                          //add Pink button to panel
        pinkButton.addActionListener(this);                       //register event listener
    }

    public void actionPerformed(ActionEvent event) {    //implementing the ActionEvent handler
        if (event.getSource() == orangeButton) {
            setBackground(Color.ORANGE);
        } else if (event.getSource() == pinkButton) {
            setBackground(Color.PINK);
        }
    }
}
```

Example 3: Turning Components into Event Listeners


ActionEvent
User action
Trigger an event
Generate an event
Notify the listener
JButton
Register a listener object
addActionListener(listener)
Jpanel Implements an ActionListener interface
ListeningPanel
Event Handler: ActionPerformed(event)

Completely free to designate ***any object*** of a class that implements the `Listener` interface as an ***event listener***

How Event Handling Works

- How do event handlers get ***registered***
  - Through component's method **`addEventListener()`**

- How does a component know to call **`EventHandler()`**
  - Event is dispatched only to listeners of the appropriate type
  - Each event type has corresponding event-listener interface

Event Handling Programming

1. Implement a listener interface
2. Register the listener with an event source
3. Wait for the event source to call your event-handler method

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User Action, Source Object and Event Type

User Action	Source Object	Event Type Generated
Click a button	`JButton`	`ActionEvent`
Press return on a text field	`JTextField`	`ActionEvent`
Select a new item	`JComoBox`	`ItemEvent, ActionEvent`
Select item(s)	`JList`	`ListSelectionEvent`
Click a check box	`JCheckBox`	`ItemEvent, ActionEvent`
Click a radio button	`JRadioButton`	`ItemEvent, ActionEvent`
Select a menu item	`JMenuItem`	`ActionEvent`
Move the scroll bar	`JScrollBar`	`AdjustmentEvent`
Window opened, closed, iconified, deiconified or closing	`Window`	`WindowEvent`
Component added or removed from the container	`Container`	`ContainerEvent`
Component moved, resized, hidden or shown	`Component`	`ComponentEvent`
Component gained or lost focus	`Component`	`FocusEvent`
Key released or pressed	`Component`	`KeyEvent`
Mouse pressed, released, clicked, entered or exited	`Component`	`MouseEvent`
Mouse moved or dragged	`Component`	`MouseEvent`

Events, Event Listeners and Listener Methods

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

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

`ContainerEvent`	`ContainerListener` (*`ContainerAdapter`*)	`componentAdded(ContainerEvent e)`
		`componentRemoved(ContainerEvent e)`

`ComponentEvent`	`ComponentListener` (*`ComponentAdapter`*)	`componentMoved(ComponentEvent e)`
		`componentHidden(ComponentEvent e)`
		`componentResized(ComponentEvent e)`
		`componentShown(ComponentEvent e)`

`FocusEvent`	`FocusListener` (*`FocusAdapter`*)	`foucsGained(FocusEvent e)`
		`foucsLost(FocusEvent e)`

`TextEvent`	`TextListener`	`textValueChanged(TextEvent e)`

`KeyEvent`	`KeyListener` (*`KeyAdapter`*)	`keyPressed(KeyEvent e)`
		`keyReleased(KeyEvent e)`
		`keyTyped(KeyEvent e)`

`MouseEvent`	`MouseListener` (*`MouseAdapter`*)
	
	`MouseMotionListener` (*`MouseMotionAdapter`*)
		`mousePressed(MouseEvent e)`
		`mouseReleased(MouseEvent e)`
		`mouseEntered(MouseEvent e)`
		`mouseExited(MouseEvent e)`
		`mouseClicked(MouseEvent e)`
		`mouseDragged(MouseEvent e)`
		`mouseMoved(MouseEvent e)`

`AdjustmentEvent`	`AdjustmentListener`	`adjustmentValueChanged(AdjustmentEvent e)`

Semantic and Low-level Events

- Semantic Events:
  what the user is doing – combination of low-level events

  - AcitonEvent
  - AdjustmentEvent
  - ItemEvent
  - TextEvent

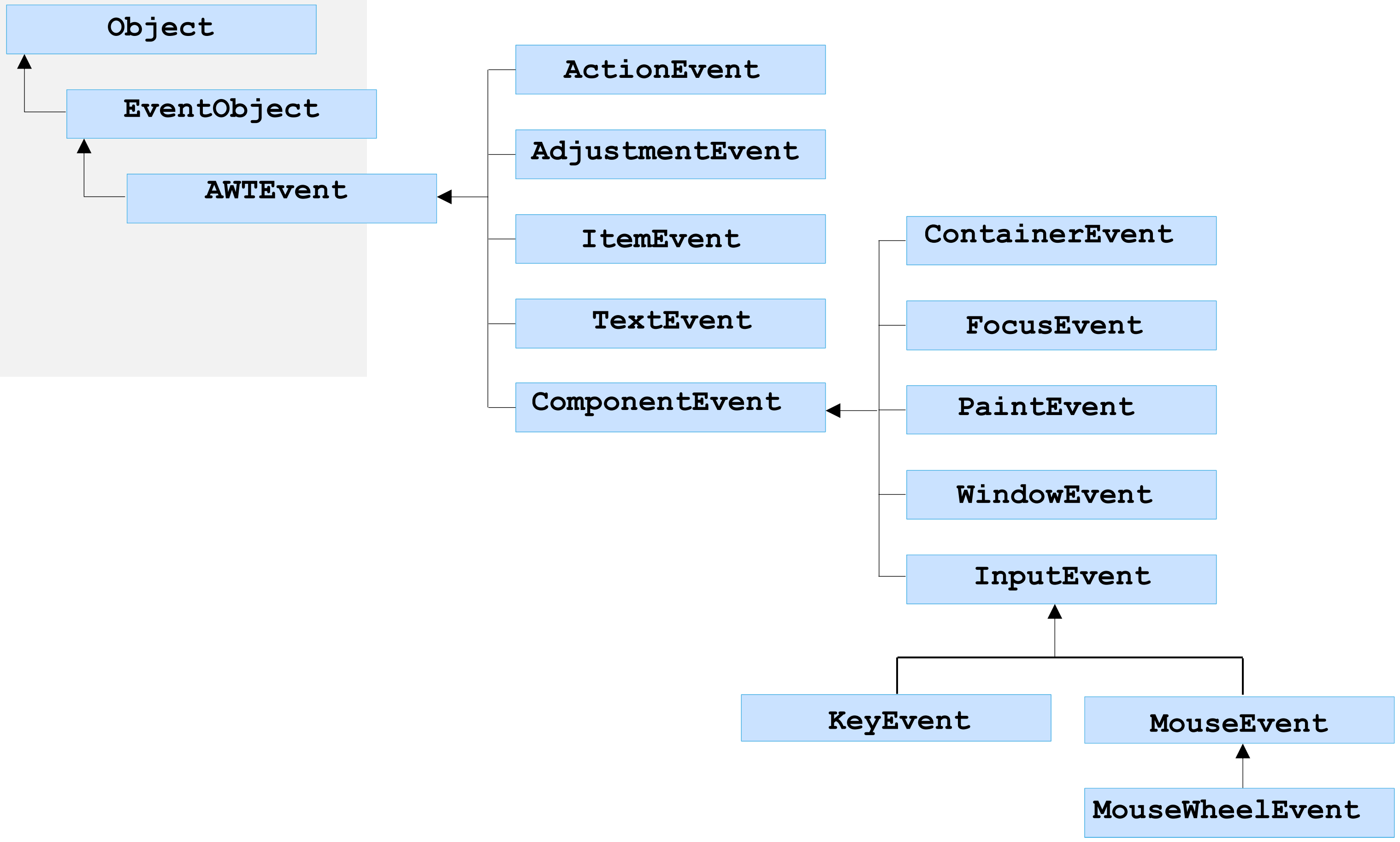
- Low-level Events
  window-system occurrences or low-level input

  - ComponentEvent
  - KeyEvent
  - MouseEvent
  - MouseWheelEvent (from SDK 1.4)
  - FocusEvent
  - WindowEvent
  - ContainerEvent

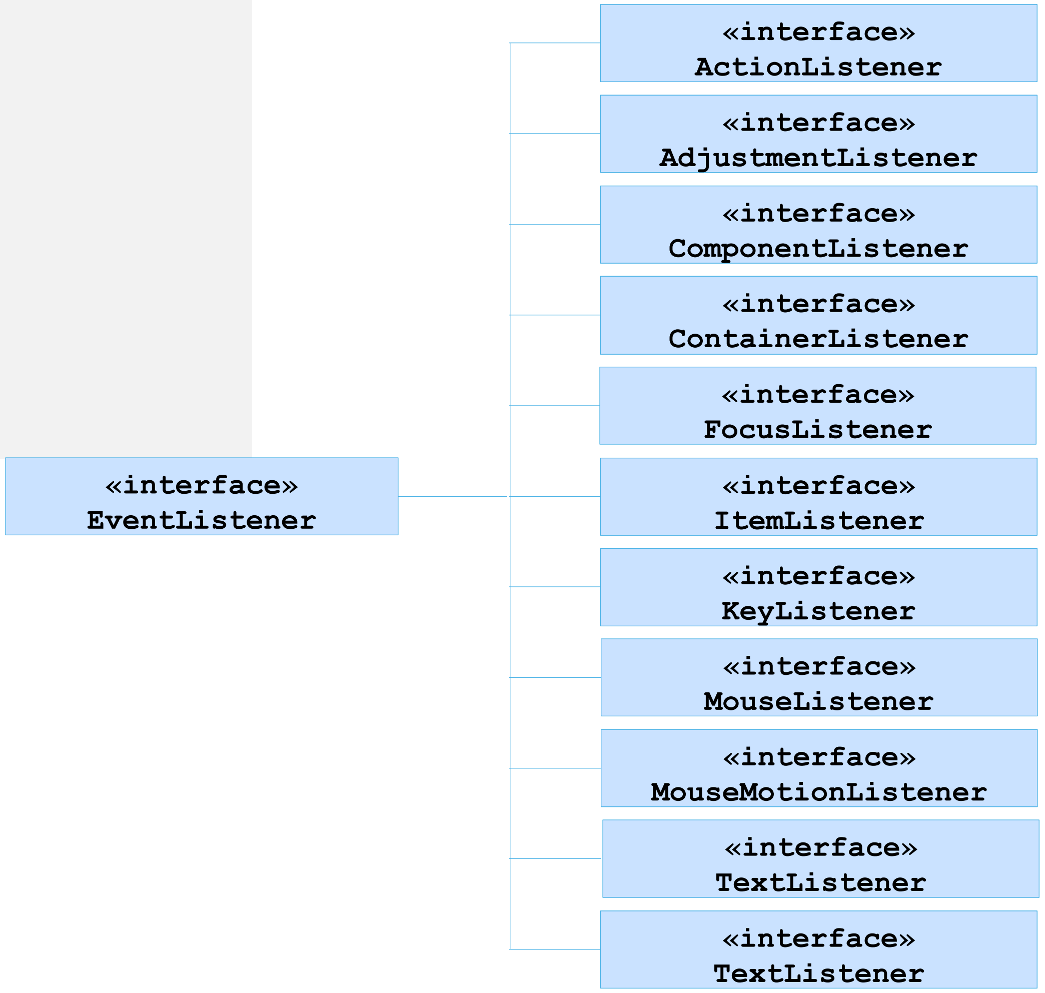
Event Objects

`id`	A number that identifies the event.
`target`	The source component upon which the event occurred.
`arg`	Additional information about the source components.
`x, y coordinates`	The mouse pointer location when a mouse movement event occurred
`clickCount`	The number of consecutive clicks for the mouse events. For other events, it is zero.
`when`	The time stamp of the event
`key`	The key that was pressed or released.

Some Event Classes



Event-listener Interfaces



Example: Do-nothing Methods

Monitor when the user tries to close the main frame because you don't want your users to lose unsaved work

```
public interface WindowListener
{
   void windowOpened(WindowEvent e);
   void windowClosing(WindowEvent e);
   void windowClosed(WindowEvent e);
   void windowIconified(WindowEvent e);
   void windowDeiconified(WindowEvent e);
   void windowActivated(WindowEvent e);
   void windowDeactivated(WindowEvent e);
}
```

```
WindowListener listener = . . .;
frame.addWindowListener(listener);

class Terminator implements WindowListener
{
   public void windowClosing(WindowEvent e)
   {
      if (user agrees)
         System.exit(0);
   }
   public void windowOpened(WindowEvent e)  {}
   public void windowClosed(WindowEvent e)  {}
   public void windowIconified(WindowEvent e)  {}
   public void windowDeiconified(WindowEvent e)  {}
   public void windowActivated(WindowEvent e)  {}
   public void windowDeactivated(WindowEvent e)  {}
}
```

What a tedious busywork for nothing!

Event Adapter Classes

- Listener interfaces having more than one method come with a companion adapter class
- Implement the **`Event`** interface
- Provide default implementation (*do-nothing*) of each interface method
- Used when all methods in interface is not needed
- The listener classes that you define can extend adapter classes and override only the methods that you need

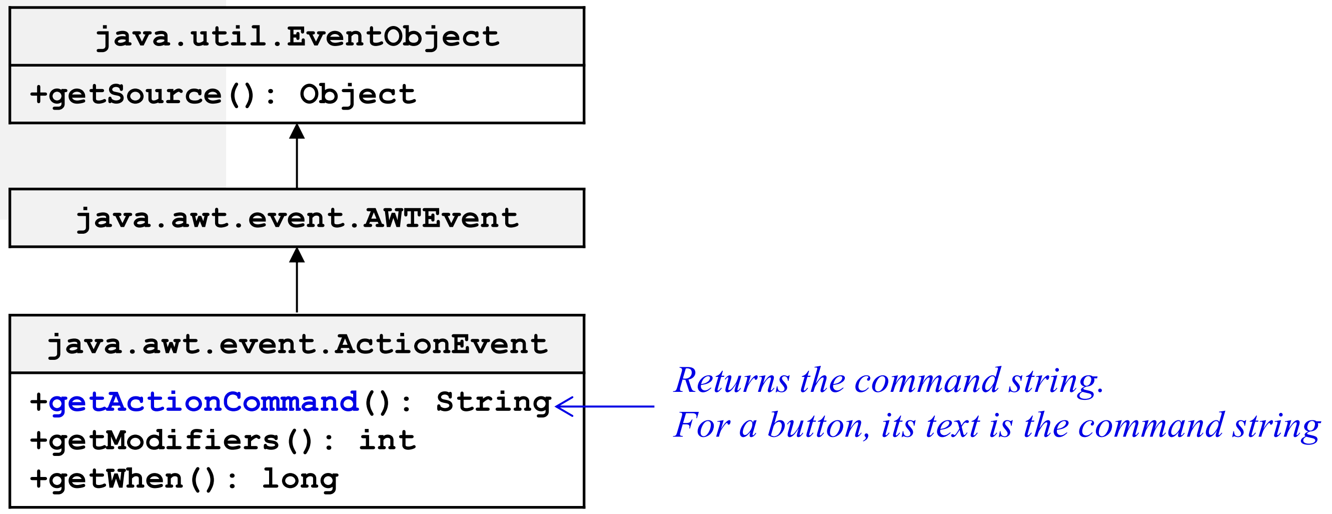
Convenient Adapters

Adapter	Interface
`WindowAdapter`	`WindowListener`
`MouseAdapter`	`MouseListener`
`MouseMotionAdapter`	`MouseMotionListener`
`KeyAdapter`	`KeyListener`
`ContainerAdapter`	`ContainerListener`
`CopomentAdapter`	`ComponentListener`
`FocusAdapter`	`Focuslistener`

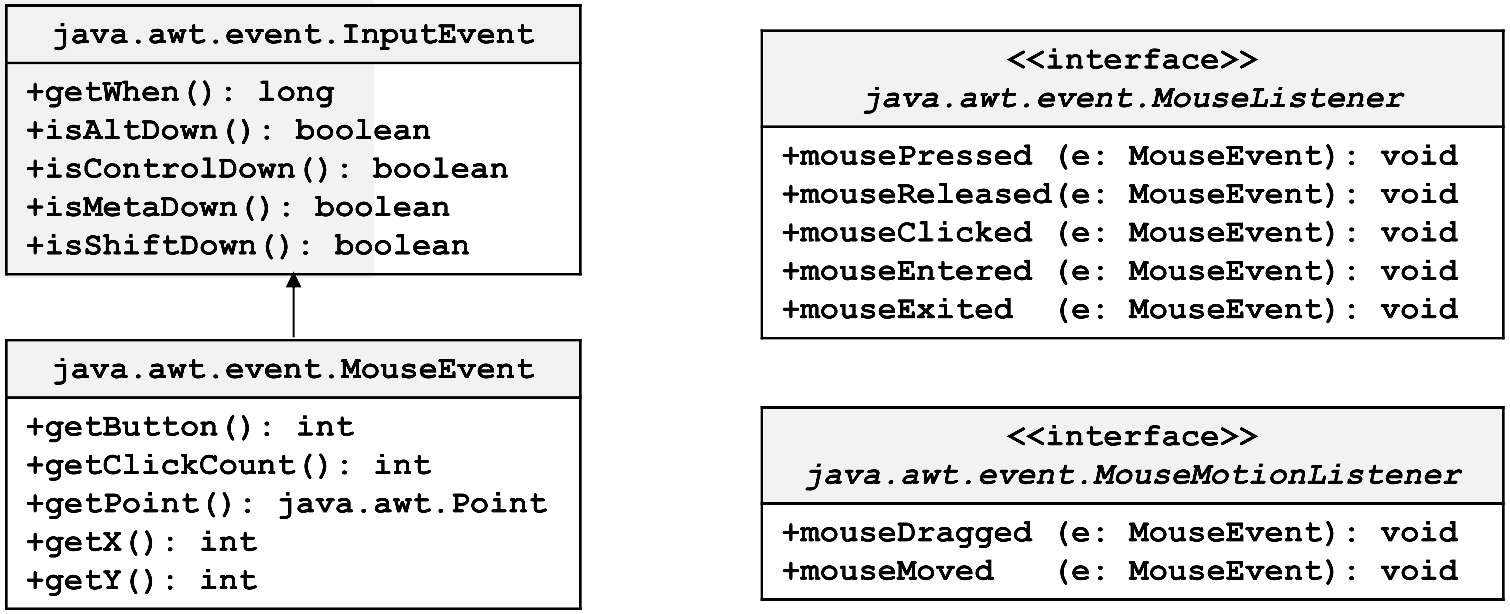
Previous example continues

```
class Terminator extends WindowAdapter
{
   public void windowClosing(WindowEvent e)
   {                      //override only what you need
      if (user agrees)
         System.exit(0);
   }
}
```

The Action Event


java.util.EventObject
+getSource(): Object
java.awt.event.AWTEvent
java.awt.event.ActionEvent
+getActionCommand(): String
+getModifiers(): int
+getWhen(): long
Returns the command string.
For a button, its text is the command string

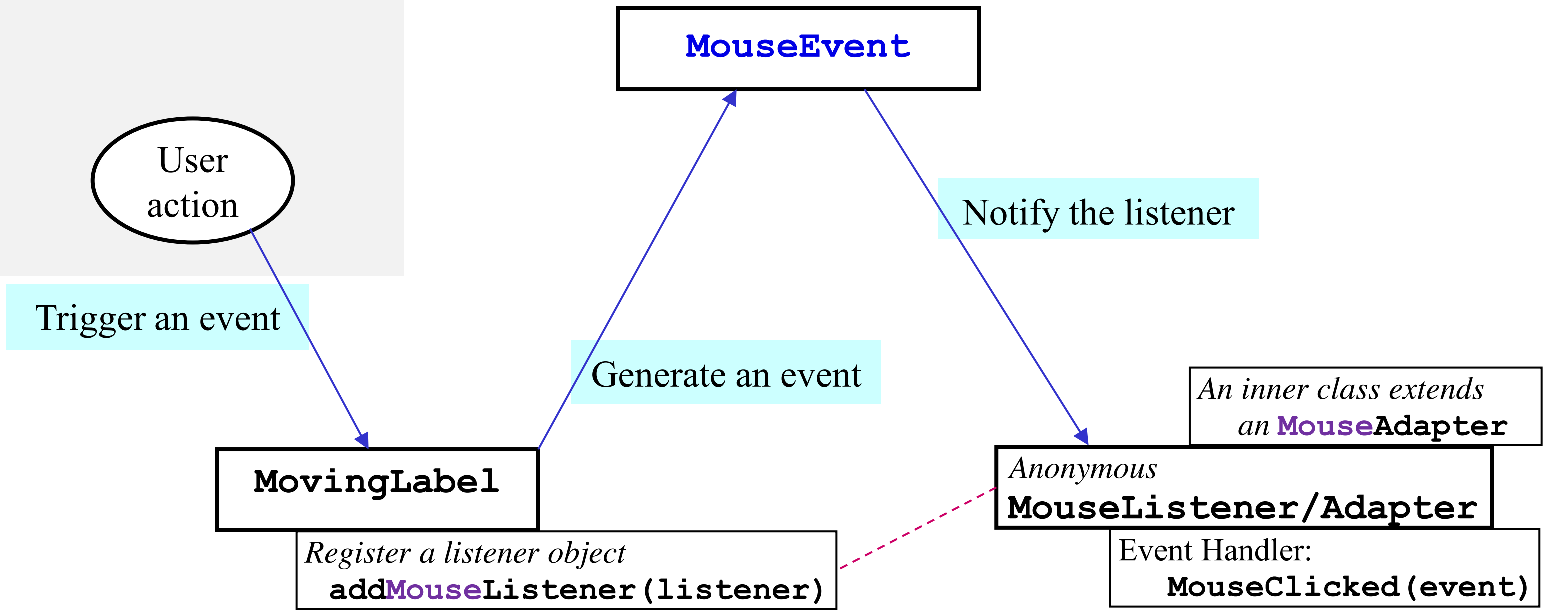
Mouse Events


java.awt.event.InputEvent
+getWhen(): long
+isAltDown(): boolean
+isControlDown(): boolean
+isMetaDown(): boolean
+isShiftDown(): boolean
java.awt.event.MouseEvent
+getButton(): int
+getClickCount(): int
+getPoint(): java.awt.Point
+getX(): int
+getY(): int
<<interface>>
java.awt.event.MouseListener
+mousePressed (e: MouseEvent): void
+mouseReleased(e: MouseEvent): void
+mouseClicked (e: MouseEvent): void
+mouseEntered (e: MouseEvent): void
+mouseExited (e: MouseEvent): void
<<interface>>
java.awt.event.MouseMotionListener
+mouseDragged (e: MouseEvent): void
+mouseMoved (e: MouseEvent): void

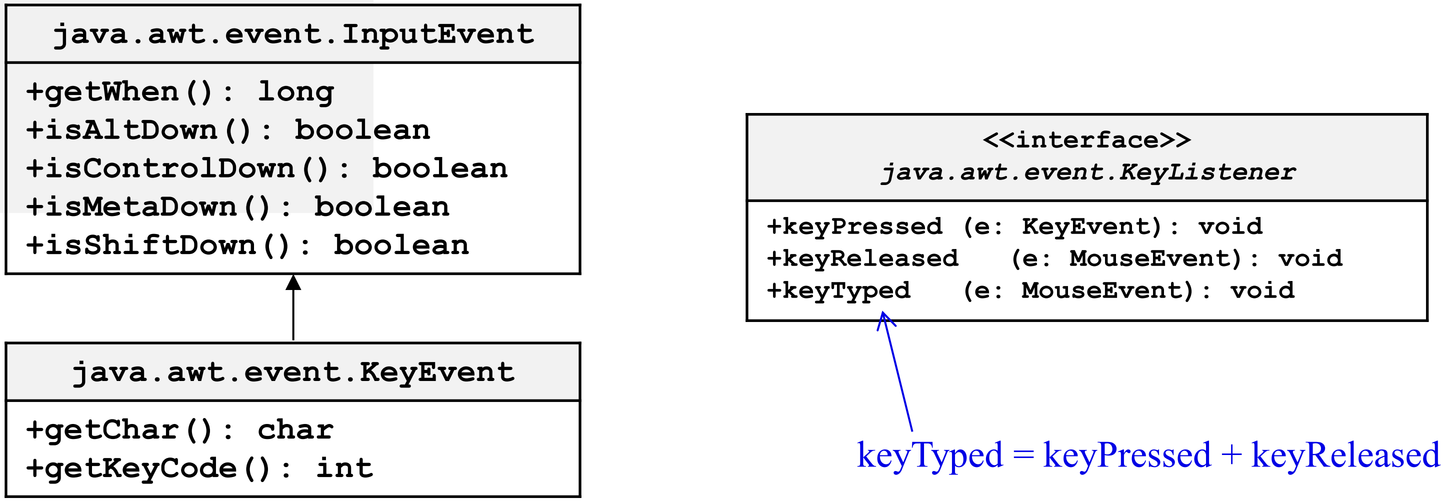
Example: Mouse Event

```
public class MouseFrame{
        public static void main(String[] args) {
                new Movinglabel("My Mouse Frame");
        }
}
class Movinglabel extends JFrame{

        JLabel label = new JLabel("You clicked @ here :-)");

        Movinglabel(String message) {
                super(message);
                setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
                setSize(500, 400);
                setLocationRelativeTo(null);
                add(label);
                setVisible(true);

                addMouseListener(new MouseAdapter() {          // add MouseListener
                        public void mouseClicked(MouseEvent event) {  // handle mouse clicked
                                int x = event.getX();
                                int y = event.getY();
                                label.setBounds(x-8,y-30,150,10);  // relocating label
                        }
                });
        }
}
```

Example: Mouse Event


MouseEvent
User action
Trigger an event
Generate an event
Notify the listener
MovingLabel
Register a listener object addMouseListener(listener)
An inner class extends an MouseAdapter
Anonymous MouseListener/Adapter
Event Handler: MouseClicked(event)

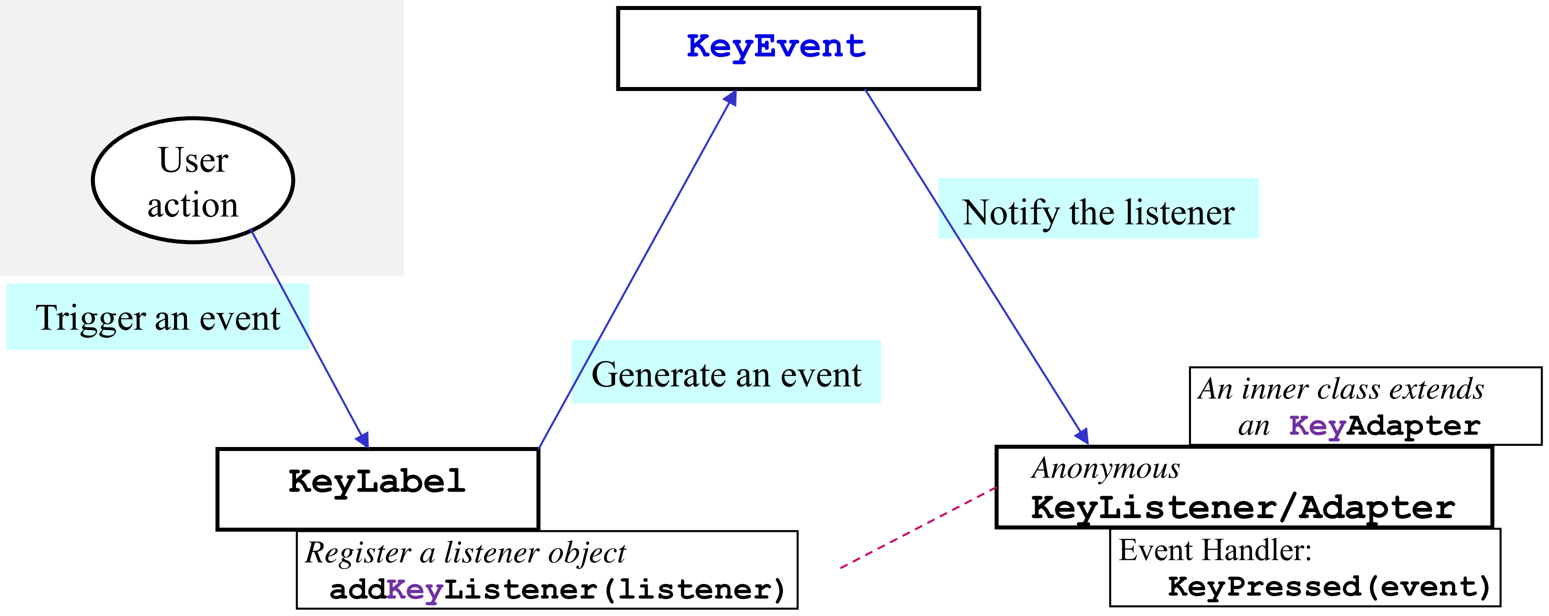
Key Events


java.awt.event.InputEvent
+getWhen(): long
+isAltDown(): boolean
+isControlDown(): boolean
+isMetaDown(): boolean
+isShiftDown(): boolean
java.awt.event.KeyEvent
+getChar(): char
+getKeyCode(): int
<<interface>>
java.awt.event.KeyListener
+keyPressed (e: KeyEvent): void
+keyReleased (e: MouseEvent): void
+keyTyped (e: MouseEvent): void
keyTyped = keyPressed + keyReleased

Example: Key Event

```java
public class KeyFrame{
      public static void main(String[] args) {
             new KeyLabel();
      }
}

class KeyLabel extends JFrame{

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

      KeyLabel() {
            setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
            setSize(500, 400);
            setLocationRelativeTo(null);
            label.setForeground(Color.BLUE);
            label.setFont(new Font("Serif", Font.BOLD, 40));
            add(label);
            setVisible(true);
            addKeyListener(new KeyAdapter() {
                  public void keyPressed(KeyEvent event) {              // add KeyListener
                        label.setText(String.valueOf(label.getText() + event.getKeyChar()));
                                                                         // update label
                  }
            });
      }
}
```

Example: Key Event


KeyEvent
User action
Trigger an event
Generate an event
Notify the listener
KeyLabel
Register a listener object addKeyListener(listener)
An inner class extends an KeyAdapter
Anonymous KeyListener/Adapter
Event Handler: KeyPressed(event)

Example: Timer Class A Non-GUI Event Source

```
public class MovingFrame{
      public static void main(String[] args) {
            MovingLabel movingLabel = new MovingLabel("A Moving Label");
            . . .
      }
}
class MovingLabel extends JFrame{
      private int x = 0;
      JLabel label = new JLabel("Hello again, again!");
      MovingLabel(String message) {
            label.setForeground(Color.BLUE);
            label.setFont(new Font("Serif", Font.BOLD, 20));
            add(label);
            Timer timer = new Timer(10, new TimerListener());
            timer.start();
      }
      class TimerListener implements ActionListener {        // create a ActionLister
            public void actionPerformed(ActionEvent event) {  // handling ActionEvent
                  if(x > getWidth()){
                        x = -150;
                  }
                  x += 1;
                  label.setBounds(x,166,160,30);              // relocating label
            }
      }
}
```

A **Timer** object serves as the source of an **ActionEvent**

Notes on Event Handling

- The listener object's class must implement the corresponding event-listener interface and must be registered by the source object
- One source object may fire several types of events
- One event handler can respond to multiple event sources
  - the same listener is added to multiple event sources
  - `Action` interface that extends `ActionListener` interface; abstract class `AbstractAction` that implements `Action` interface; Your class extends the `AbstractAction` then add the `actionPerformed` method
- Multiple listeners can react to the same event
  - all register to the same event and their handlers are called when the event occurs