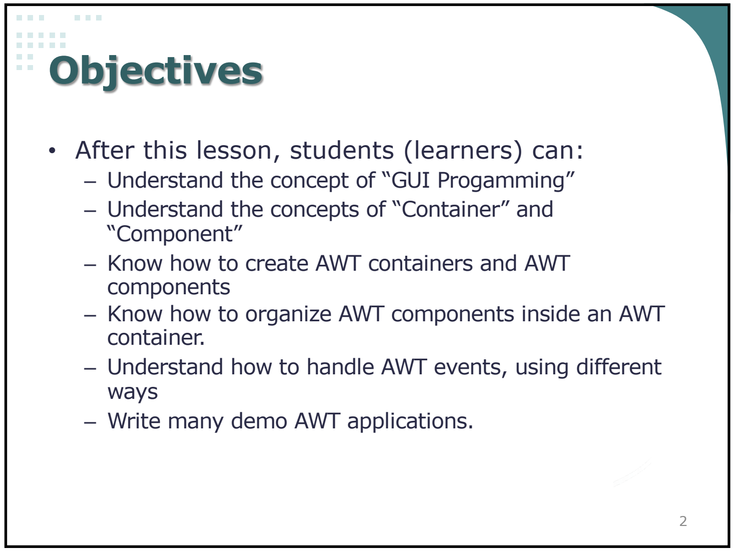
GUI and Event Programming (1/2)

Trịnh Tuấn Đạt

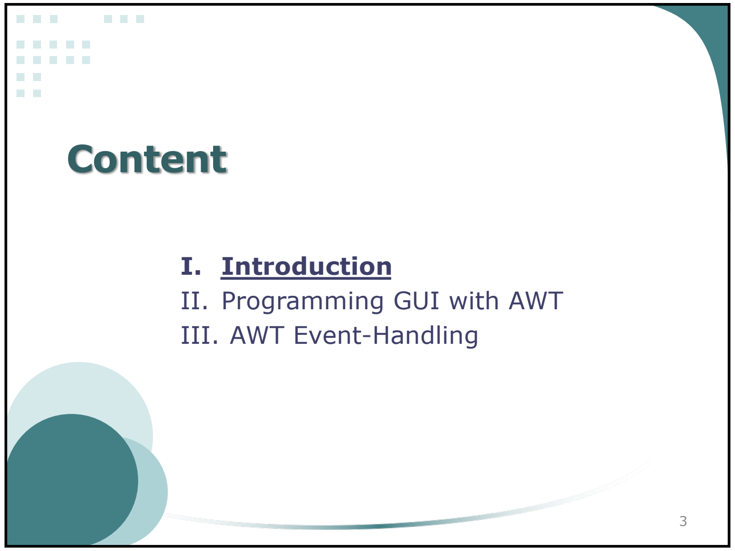
1



Objectives

- After this lesson, students (learners) can:
  - Understand the concept of "GUI Progamming"
  - Understand the concepts of "Container" and "Component"
  - Know how to create AWT containers and AWT components
  - Know how to organize AWT components inside an AWT container.
  - Understand how to handle AWT events, using different ways
  - Write many demo AWT applications.

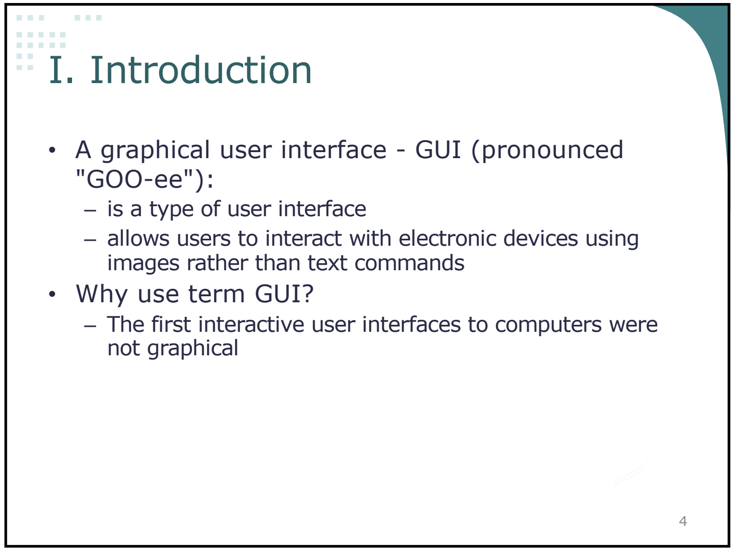
2



Content

I. <u>Introduction</u>
II. Programming GUI with AWT
III. AWT Event-Handling

3

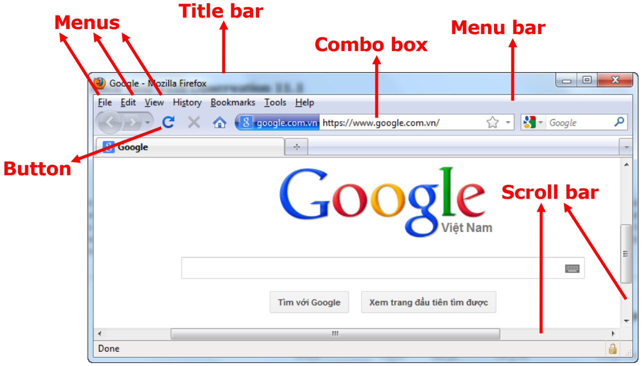


I. Introduction

- A graphical user interface - GUI (pronounced "GOO-ee"):
  - is a type of user interface
  - allows users to interact with electronic devices using images rather than text commands
- Why use term GUI?
  - The first interactive user interfaces to computers were not graphical

4

1. Introduction


Menus
Title bar
Combo box
Menu bar
Button
Scroll bar
Google - Mozilla Firefox
File Edit View History Bookmarks Tools Help
google.com.vn https://www.google.com.vn/
Google
Google
Việt Nam
Tìm với Google
Xem trang đầu tiên tìm được
Done

Java APIs for graphics programming

- Two core sets of Java APIs for graphics programming:
  - AWT (Abstract Windowing Toolkit)
  - Swing
- AWT:
  - introduced in JDK 1.0
  - should be replaced by newer Swing components
- Swing:
  - enhances AWT
  - integrated into core Java since JDK 1.2
- Others:
  - Eclipse's Standard Widget Toolkit (SWT)
  - Google Web Toolkit (GWT)
  - 3D Graphics API such as Java bindings for OpenGL (JOGL) and Java3D.

Content

I. Introduction

II. Programming GUI with AWT

III. AWT Event-Handling

II. Programming GUI with AWT

2.1 AWT Packages

2.2 Containers and Components

2.3 AWT Container Classes

2.4 AWT Component Classes

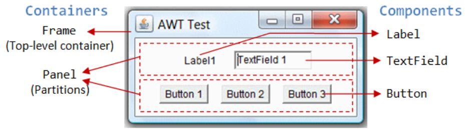
2.5. Layout Managers

2.1. AWT Packages

- Huge: there are 12 packages.
  - Only 2 packages: java.awt & java.awt.event are commonly-used
  - Platform-independent & device-independent
- Core graphics classes of java.awt:
  - GUI Component classes (such as Button, TextField, and Label),
  - GUI Container classes (such as Frame, Panel, Dialog and ScrollPane),
  - Layout managers (such as FlowLayout, BorderLayout and GridLayout),
  - Custom graphics classes (such as Graphics, Color and Font).
- java.awt.event package supports event handling
  - Event classes (such as ActionEvent, MouseEvent, KeyEvent and WindowEvent),
  - Event Listener Interfaces (such as ActionListener, MouseListener, KeyListener and WindowListener),
  - Event Listener Adapter classes (such as MouseAdapter, KeyAdapter, and WindowAdapter).

2.2. Containers and Components

- Two types of GUI elements:
  - *Component*: elementary GUI entities (Button, Label, TextField.)
  - *Container* (Frame, Panel and Applet): *hold components in a specific layout*. A container can also hold sub-containers

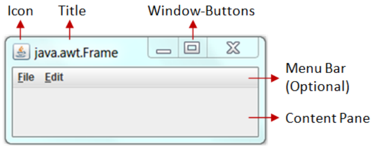


2.3. AWT Container Classes

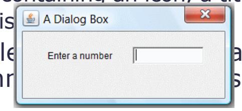
- **Top-level AWT containers: Frame, Dialog and Applet.**
- Frame:
  - provides "main window" for GUI application, including:
    - a title bar (containing an icon, a title, the minimize, maximize/restore-down and close buttons)
    - an optional menu bar
    - the content display area.
- Dialog: a *"pop-up window*", including:
  - a title-bar (containing an icon, a title and a close button)
  - a content display area
- Applet: top-level container for an applet - a Java program running inside a browser

2.3. AWT Container Classes

- **Top-level AWT containers: Frame, Dialog and Applet.**
- Frame:



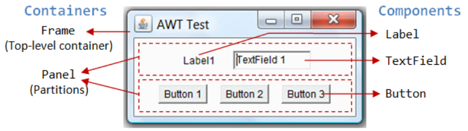
  - provides cluding:
    - a title ize, maxim
    - an opt
    - the co
- Dialog: a *"pop-up window*", including:
  - a title-bar (containing an icon, a title and a close button)
  - a content dis



- Applet: top-le an applet - a Java program runr ser

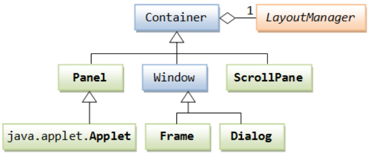
2.3. AWT Container Classes

- **Secondary Containers: Panel, ScrollPane**
  - are placed inside a top-level container or another secondary container
- Panel:
  - a rectangular box (partition) under a higher-level container,
  - used to *layout* a set of related GUI components
- ScrollPane: provides automatic horizontal and/or vertical scrolling for a single child component



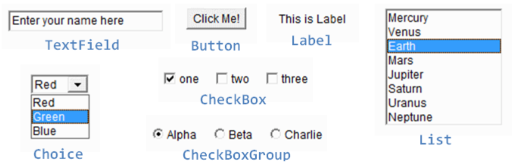
2.3. AWT Container Classes

- **Hierarchy of the AWT Container Classes**



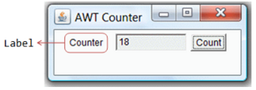
2.4. AWT Component Classes

- AWT provides many GUI components:
  - Button, TextField, Label, Checkbox, CheckboxGroup (radio buttons), List, and Choice



2.4. AWT Component Classes

- **java.awt.Label:** provides a text description message.
- Constructors:
  - // Construct a Label with the given text String, of the text alignment
  - public Label(String *strLabel*, int *alignment*);
  - public Label(String *strLabel*); // Construct a Label with the given text
  - public Label(); // Construct an initially empty Label
- Constants:
  - public static final LEFT; // Label.LEFT
  - public static final RIGHT; // Label.RIGHT
  - public static final CENTER; // Label.CENTER
- Public methods:
  - public String getText();
  - public void setText(String strLabel);
  - public int getAlignment();
  - public void setAlignment(int alignment);



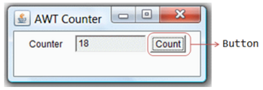
2.4. AWT Component Classes

- To construct a Component and add into a Container:
  - Declare the component with an *identifier*
  - Construct the component
  - Identify the container designed to hold this component. Use `add` method:
    - *Ex: aContainer*.add(*aComponent*)
- Example:

```
Label lblInput;
lblInput = new Label("Enter ID");
this.add(lblInput);
lblInput.setText("Enter password");
lblInput.getText();
```

2.4. AWT Component Classes

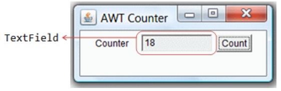
- **java.awt.Button**: triggers a certain programmed *action* upon clicking.
- Constructors:
  - public Button(String *buttonLabel*);
  - public Button();



- Public Methods
  - public String getLabel();
  - public void setLabel(String *buttonLabel*);
  - public void setEnable(boolean *enable*);
- Example:
  - Button btnColor = new Button("Red");
  - this.add(btnColor);
  - ...
  - btnColor.setLabel("green");
  - btnColor.getLabel();

2.4. AWT Component Classes

- **java.awt.TextField**: single-line text box to enter texts. (**TextArea**: multiple-line text box)
- Constructor:
  - public TextField(String *strInitialText*, int *columns*);
  - public TextField(String *strInitialText*);
  - public TextField(int *columns*);



- Public methods:
  - public String getText();
  - public void setText(String *strText*);
  - public void setEditable(boolean *editable*);

2.5. Layout Managers

- Layout manager: arranges a container's components
- Layout managers from AWT: (in package java.awt)
  - FlowLayout
  - GridLayout
  - BorderLayout
  - GridBagLayout
  - BoxLayout
  - CardLayout

Set a layout manager

- A container has a setLayout() method to set its layout manager:
  - public void setLayout(LayoutManager mgr)
- To set up the layout of a Container:
  - Construct an instance of the chosen layout object, e.g., new FlowLayout()
  - Invoke the setLayout() method, with the layout object created as the argument;
  - Place the GUI components into the Container using the add() method in the correct order; or into the correct zones.
- Example:

```
Panel p = new Panel();
p.setLayout(new FlowLayout());
p.add(new JLabel("One"));
p.add(new JLabel("Two"));
p.add(new JLabel("Three"));
```

21

Layout managers

- Construct a Panel with a layout

```
// Construct a Panel in the given layout
// By default, Panel (and JPanel) has FlowLayout
public void Panel (LayoutManager layout)
```

  - Example: create a Panel in BorderLayout

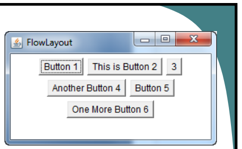
```
Panel mainPanel = new Panel(new BorderLayout());
```

- To get layout of a Container: use getLayout()

```
Panel awtPanel = new Panel();
System.out.println(awtPanel.getLayout());
//java.awt.FlowLayout[hgap=5,vgap=5,align=center]
```

22

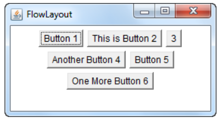
a. FlowLayout

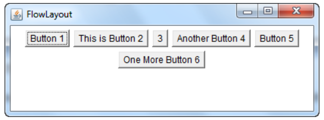


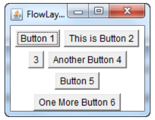
- Inside a Container with FlowLayout:
  - components are arranged from left-to-right (in the added order)
  - when one row is filled, new row will be started
- Constructors:
  - public FlowLayout();
  - public FlowLayout(int *align*);
  - public FlowLayout(int *align*, int *hgap*, int *vgap*);
- *Align*:
  - FlowLayout.LEFT (or LEADING)
  - FlowLayout.RIGHT (or TRAILING)
  - FlowLayout.CENTER
- *hgap*, *vgap*: horizontal/vertical gap between the components.
- By default: hgap=5, vgap=5, align=CENTER

23

FlowLayout example





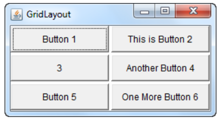


```
import java.awt.*;
import java.awt.event.*;
public class AWTFlowLayout extends Frame {
  public AWTFlowLayout () {
    setLayout(new FlowLayout());
    add(new Button("Button 1"));
    add(new Button("This is Button 2"));
    add(new Button("3"));
    add(new Button("Another Button 4"));
    add(new Button("Button 5"));
    add(new Button("One More Button 6"));

    setTitle("FlowLayout"); // "this" Frame sets title
    setSize(280, 150);     // "this" Frame sets initial size
    setVisible(true);      // "this" Frame shows
  }
  public static void main(String[] args) {
    new AWTFlowLayout();  // Let the constructor do the job
  }
}
```

24

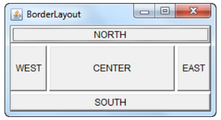
b. GridLayout

- Inside a Container with FlowLayout:
  - components are arranged in a grid of rows and columns
  - components are added in a left-to-right, top-to-bottom manner in the added order
- Constructor:
  - public GridLayout(int *rows*, int *columns*);
  - public GridLayout(int *rows*, int *columns*, int *hgap*, int *vgap*);
- By default: rows=1, cols=0, hgap=0, vgap=0



c. BorderLayout

- With BorderLayout, container is divided into 5 zones: EAST, WEST, SOUTH, NORTH, and CENTER
- To add a components:
  - *aContainer*.add(*acomponent*, *aZone*)
    - aZone: can be
      - BorderLayout.NORTH (or PAGE_START)
      - BorderLayout.SOUTH (or PAGE_END)
      - BorderLayout.WEST (or LINE_START)
      - BorderLayout.EAST (or LINE_END)
      - BorderLayout.CENTER
  - *aContainer*.add(*aComponent*): adds the component to the CENTER
- No need to add components to all the 5 zones
- Constructors:
  - `public BorderLayout();`
  - `public BorderLayout(int hgap, int vgap);`
  - By default hgap=0, vgap=0



Content

I. Introduction

II. Programming GUI with AWT

III. AWT Event-Handling

III. AWT Event-Handling

3.1. Introduction

3.2. Event-Handling Steps

3.3. Available pairs of Event and Listener

3.4. Adapters

3.1. Introduction

- Event-handling model: “Event-driven”
  - When event has been fired (by user input): a piece of event-handling codes is executed
- Package java.awt.event: contains AWT's event-handling classes
- 3 objects involved in the event-handling: ***source***, ***listener***, ***event***
  - **source** object interacts with the user to create an **event** object
  - **event** object will be messaged to all the *registered* ***listener*** objects
  - appropriate event-handler method of the **listener(s)** is called-back to provide the response

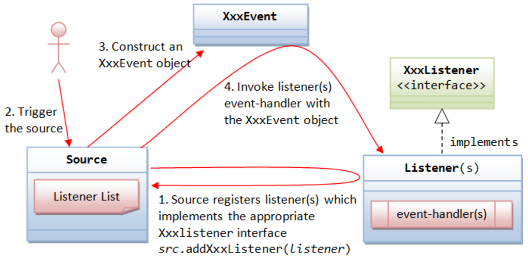
3.1. Introduction

- Use ***subscribe-publish*** or ***observable-observer*** design pattern:
  - The **listener(s)** must be registered with the **source** to express interest for a certain **event** triggered on a **source**

  → The **listener(s)** "subscribes" to an **event** of a **source**, and the **source** "publishes" the **event** to all its subscribers upon activation

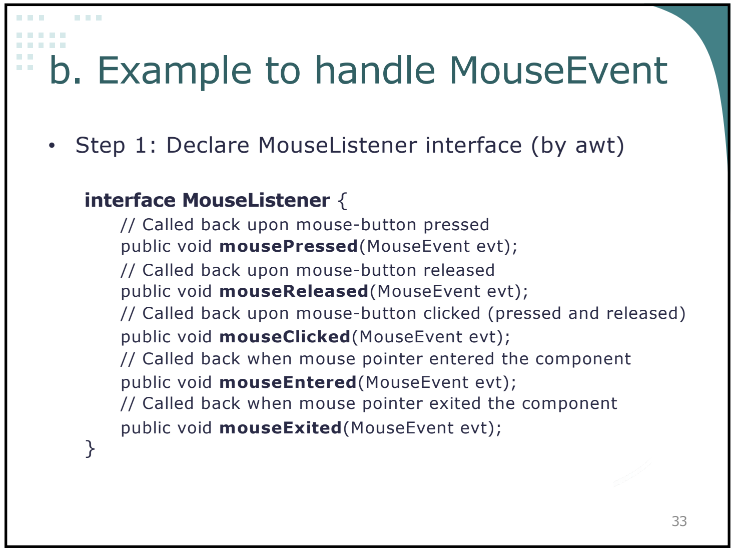
3.2. Event-Handling Steps

- Use ***subscribe-publish*** or ***observable-observer*** design pattern:


XxxEvent
3. Construct an XxxEvent object
2. Trigger the source
4. Invoke listener(s) event-handler with the XxxEvent object
XxxListener
<<interface>>
implements
Source
Listener List
Listener(s)
event-handler(s)
1. Source registers listener(s) which implements the appropriate Xxxlistener interface
src.addXxxListener(listener)

a. *Source object registers* for a certain type of *event*

- The **source** & **listener** understand each other via an agreed-upon interface
- 3 steps: (to support XxxEvent event type for a Source)
  - Declare an interface called XxxListener, container the names of the handler methods
  - Listeners interested in the XxxEvent must implement the XxxListener interface
  - Source has to maintain the list of listener object(s).
    - public void addXxxListener(XxxListener l);
    - public void removeXxxListener(XxxListener l);

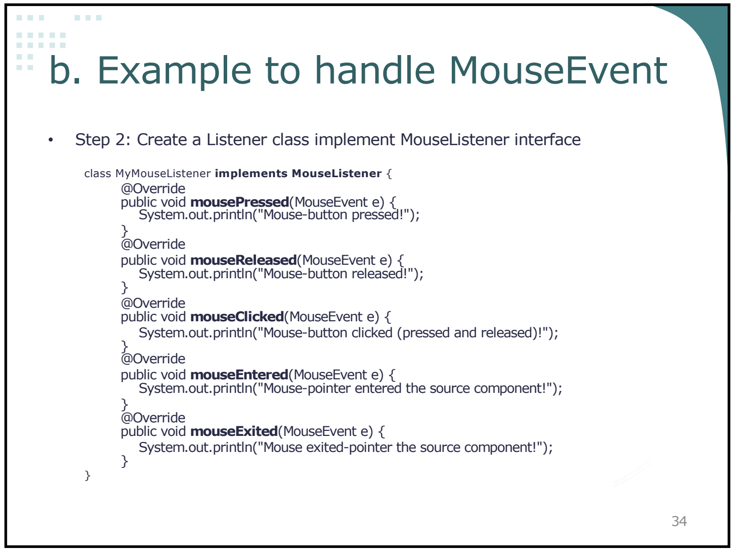


b. Example to handle MouseEvent

- Step 1: Declare MouseListener interface (by awt)

```
interface MouseListener {
    // Called back upon mouse-button pressed
    public void mousePressed(MouseEvent evt);
    // Called back upon mouse-button released
    public void mouseReleased(MouseEvent evt);
    // Called back upon mouse-button clicked (pressed and released)
    public void mouseClicked(MouseEvent evt);
    // Called back when mouse pointer entered the component
    public void mouseEntered(MouseEvent evt);
    // Called back when mouse pointer exited the component
    public void mouseExited(MouseEvent evt);
}
```

33

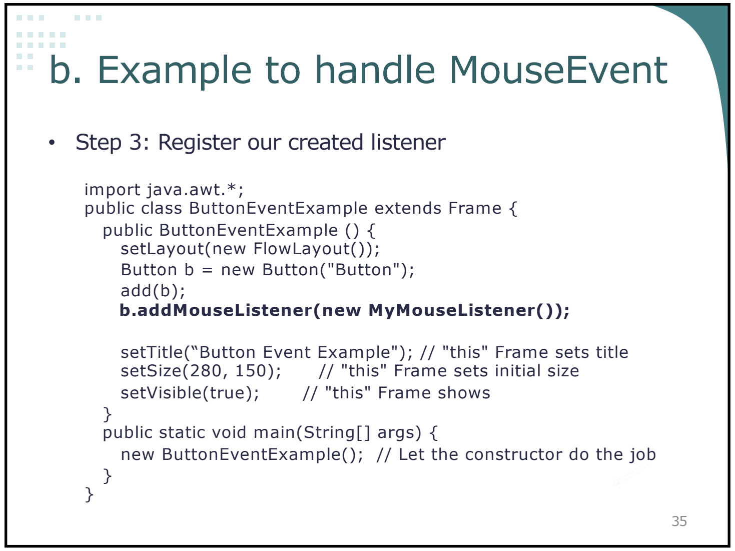


b. Example to handle MouseEvent

- Step 2: Create a Listener class implement MouseListener interface

```
class MyMouseListener implements MouseListener {
        @Override
        public void mousePressed(MouseEvent e) {
           System.out.println("Mouse-button pressed!");
        }
        @Override
        public void mouseReleased(MouseEvent e) {
           System.out.println("Mouse-button released!");
        }
        @Override
        public void mouseClicked(MouseEvent e) {
           System.out.println("Mouse-button clicked (pressed and released)!");
        }
        @Override
        public void mouseEntered(MouseEvent e) {
           System.out.println("Mouse-pointer entered the source component!");
        }
        @Override
        public void mouseExited(MouseEvent e) {
           System.out.println("Mouse exited-pointer the source component!");
        }
}
```

34

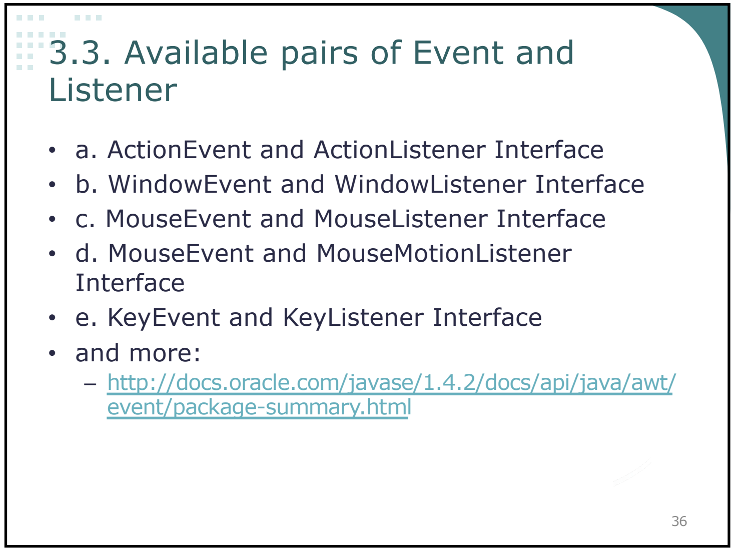


b. Example to handle MouseEvent

- Step 3: Register our created listener

```
import java.awt.*;
public class ButtonEventExample extends Frame {
   public ButtonEventExample () {
      setLayout(new FlowLayout());
      Button b = new Button("Button");
      add(b);
      b.addMouseListener(new MyMouseListener());

      setTitle(“Button Event Example"); // "this" Frame sets title
      setSize(280, 150);      // "this" Frame sets initial size
      setVisible(true);       // "this" Frame shows
   }
   public static void main(String[] args) {
      new ButtonEventExample();  // Let the constructor do the job
   }
}
```

35



3.3. Available pairs of Event and Listener

- a. ActionEvent and ActionListener Interface
- b. WindowEvent and WindowListener Interface
- c. MouseEvent and MouseListener Interface
- d. MouseEvent and MouseMotionListener Interface
- e. KeyEvent and KeyListener Interface
- and more:
  - http://docs.oracle.com/javase/1.4.2/docs/api/java/awt/event/package-summary.html

36

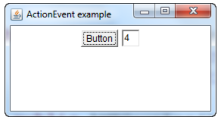
a. ActionEvent and ActionListener Interface

- To fire an ActionEvent
  - Click a Button
  - Pushing the "enter" key on a TextField
- The ActionEvent will be sent to all listeners
  - Listener for ActionEvent must implement ActionListener interface.

```
interface ActionListener {
   // Called back upon button clicked, enter key pressed
   public void actionPerformed(ActionEvent e);
}
```

a. ActionEvent and ActionListener Interface-Example

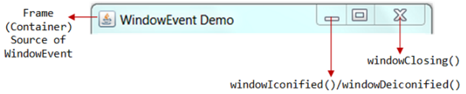
```
import java.awt.*;
import java.awt.event.*;

public class AWTCounter extends Frame implements ActionListener {
  public int count = 0;
  private TextField txt;

  public AWTCounter(){
    setLayout(new FlowLayout());
    Button b = new Button("Button");
    add(b);
    b.addActionListener(this);
    txt = new TextField();
    add(txt);

    setTitle("ActionEvent example");
    setSize(280, 150);
    setVisible(true);
  }
  @Override
  public void actionPerformed(ActionEvent evt) {
    count++;
    txt.setText(count + "");
  }
  public static void main(String args[]){
     new AWTCounter();
  }
}
```



b. WindowEvent and WindowListener Interface

- A WindowEvent is fired when a window (e.g., Frame) has been:
  - opened/closed
  - activated/deactivated
  - iconified/deiconified

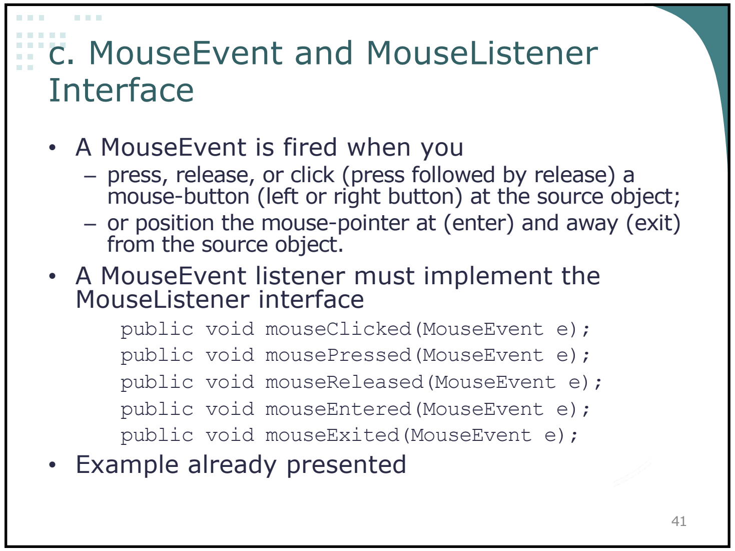
  via the 3 buttons at the top-right corner or other means.
- The source of a WindowEvent shall be a **top-level** window-container such as Frame.



b. WindowEvent and WindowListener Interface

- A WindowEvent listener must implement WindowListener interface.

```
/* Called-back when the user attempts to close the window by clicking the window
   close button. This is the most-frequently used handler*/
public void windowClosing(WindowEvent e).
/* Called-back the first time a window is made visible. */
public void windowOpened(WindowEvent e)
/* Called-back when a window has been closed as the result of calling dispose on
   the window.*/
public void windowClosed(WindowEvent e)
/* Called-back when the Window is set to be the active Window.*/
public void windowActivated(WindowEvent e)
/* Called-back when a Window is no longer the active Window*/
public void windowDeactivated(WindowEvent e)
/* Called-back when a window is changed from a normal to a minimized state.*/
public void windowIconified(WindowEvent e)
/* Called-back when a window is changed from a minimized to a normal state*/
public void windowDeiconified(WindowEvent e).
```

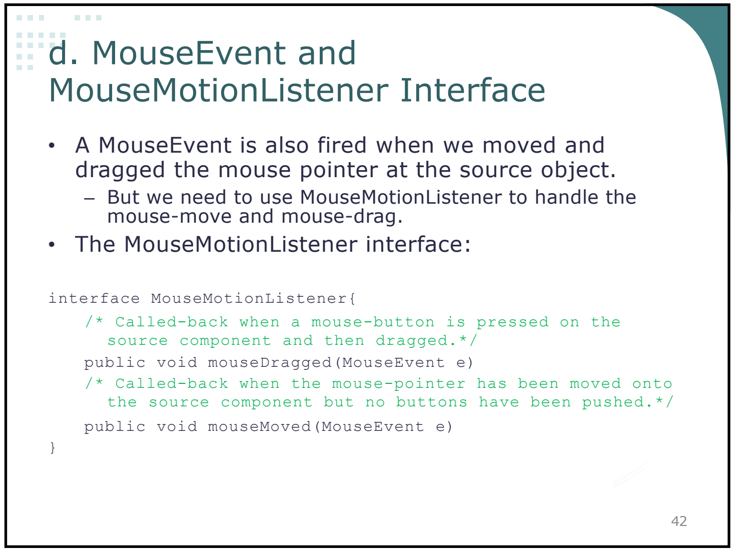


c. MouseEvent and MouseListener Interface

- A MouseEvent is fired when you
  - press, release, or click (press followed by release) a mouse-button (left or right button) at the source object;
  - or position the mouse-pointer at (enter) and away (exit) from the source object.
- A MouseEvent listener must implement the MouseListener interface

```
public void mouseClicked(MouseEvent e);
public void mousePressed(MouseEvent e);
public void mouseReleased(MouseEvent e);
public void mouseEntered(MouseEvent e);
public void mouseExited(MouseEvent e);
```

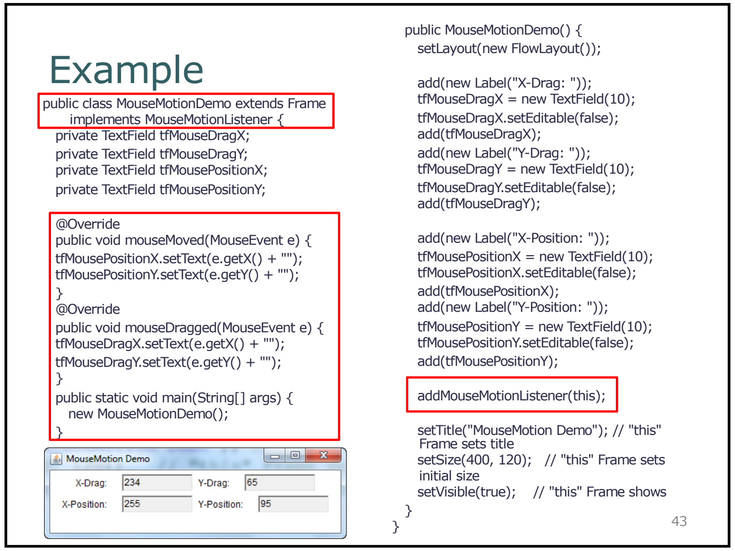
- Example already presented



d. MouseEvent and MouseMotionListener Interface

- A MouseEvent is also fired when we moved and dragged the mouse pointer at the source object.
  - But we need to use MouseMotionListener to handle the mouse-move and mouse-drag.
- The MouseMotionListener interface:

```
interface MouseMotionListener{
   /* Called-back when a mouse-button is pressed on the
     source component and then dragged.*/
   public void mouseDragged(MouseEvent e)
   /* Called-back when the mouse-pointer has been moved onto
     the source component but no buttons have been pushed.*/
   public void mouseMoved(MouseEvent e)
}
```



Example

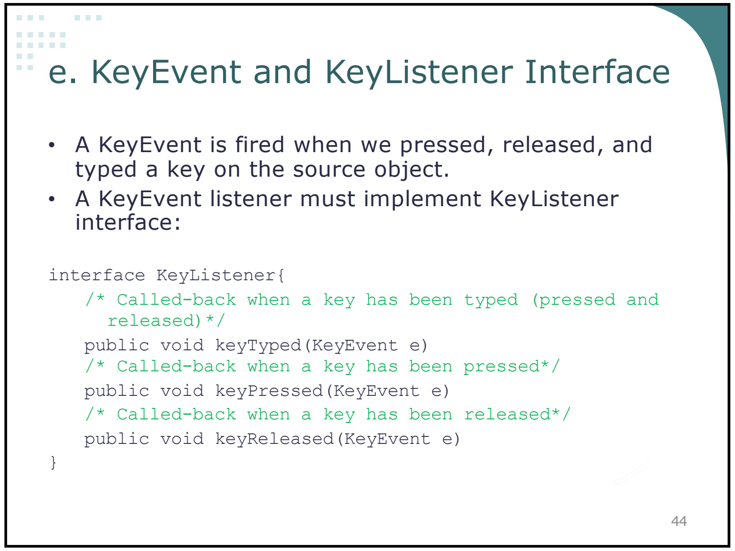
```
public class MouseMotionDemo extends Frame
     implements MouseMotionListener {
  private TextField tfMouseDragX;
  private TextField tfMouseDragY;
  private TextField tfMousePositionX;
  private TextField tfMousePositionY;

  @Override
  public void mouseMoved(MouseEvent e) {
  tfMousePositionX.setText(e.getX() + "");
  tfMousePositionY.setText(e.getY() + "");
  }
  @Override
  public void mouseDragged(MouseEvent e) {
  tfMouseDragX.setText(e.getX() + "");
  tfMouseDragY.setText(e.getY() + "");
  }
  public static void main(String[] args) {
     new MouseMotionDemo();
  }
```

MouseMotion Demo

X-Drag: 234 Y-Drag: 65

X-Position: 255 Y-Position: 95

```
public MouseMotionDemo() {
   setLayout(new FlowLayout());

   add(new Label("X-Drag: "));
   tfMouseDragX = new TextField(10);
   tfMouseDragX.setEditable(false);
   add(tfMouseDragX);
   add(new Label("Y-Drag: "));
   tfMouseDragY = new TextField(10);
   tfMouseDragY.setEditable(false);
   add(tfMouseDragY);

   add(new Label("X-Position: "));
   tfMousePositionX = new TextField(10);
   tfMousePositionX.setEditable(false);
   add(tfMousePositionX);
   add(new Label("Y-Position: "));
   tfMousePositionY = new TextField(10);
   tfMousePositionY.setEditable(false);
   add(tfMousePositionY);

   addMouseMotionListener(this);

   setTitle("MouseMotion Demo"); // "this"
    Frame sets title
   setSize(400, 120);   // "this" Frame sets
    initial size
   setVisible(true);    // "this" Frame shows
 }
}
```



e. KeyEvent and KeyListener Interface

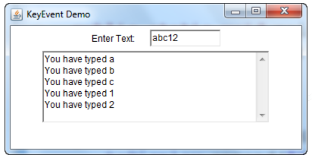
- A KeyEvent is fired when we pressed, released, and typed a key on the source object.
- A KeyEvent listener must implement KeyListener interface:

```
interface KeyListener{
   /* Called-back when a key has been typed (pressed and
     released)*/
   public void keyTyped(KeyEvent e)
   /* Called-back when a key has been pressed*/
   public void keyPressed(KeyEvent e)
   /* Called-back when a key has been released*/
   public void keyReleased(KeyEvent e)
}
```

Example of handling KeyEvent

```
public class KeyEventDemo extends Frame
      implements KeyListener {
   private TextField tfInput;
   private TextArea taDisplay;

   public KeyEventDemo() {
      setLayout(new FlowLayout());

      add(new Label("Enter Text: "));
      tfInput = new TextField(10);
      add(tfInput);
      taDisplay = new TextArea(5, 40);
      add(taDisplay);

      tfInput.addKeyListener(this);

      setTitle("KeyEvent Demo");
      setSize(400, 200);
      setVisible(true);
   }
```

```
public static void main(String[] args) {
   new KeyEventDemo();
}

@Override
public void keyTyped(KeyEvent e) {
   taDisplay.append("You have typed " +
   e.getKeyChar() + "\n");
}
@Override
public void keyPressed(KeyEvent e) { }
@Override
public void keyReleased(KeyEvent e) { }
}
```



```
abc12
You have typed a
You have typed b
You have typed c
You have typed 1
You have typed 2
```

3.4. Adapter

- Disadvantages of using XxxListener interfaces:
  - Each contains more than 1 method. If we care about only 1, we have to implements all (see previous KeyEvent example)
  - → many have empty body → harder to read & maintain
- To avoid: AWT provides an ***adapter*** class for each listener interface with more than one method
  - An adapter class **implements** empty versions of all its interface's methods (e.g., **MouseAdapter** implements **MouseListener**)
- To use an adapter, we create a subclass of it, instead of directly implementing a listener interface

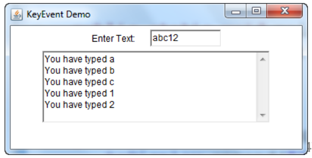
Example of using Adapter

Exit the application if we press close button

```
public KeyEventDemo() {
   setLayout(new FlowLayout());
   add(new Label("Enter Text: "));
   tfInput = new TextField(10);
   add(tfInput);
   taDisplay = new TextArea(5, 40);
   add(taDisplay);

   tfInput.addKeyListener(new KeyAdapter() {
      @Override
      public void keyPressed(KeyEvent e) {
         taDisplay.append("You have typed " +
                          e.getKeyChar() + "\n");
      }
   });
```

Anonymous inner Class

```
addWindowListener(new WindowAdapter() {
    public void windowClosing(WindowEvent e) {
        setVisible(false);
        dispose();
        System.exit(0);
    }
});

setTitle("KeyEvent Demo"); // "this" Frame sets title
setSize(400, 200); // "this" Frame sets initial size
setVisible(true); // "this" Frame shows
} //End of Constructor
```



```
abc12
You have typed a
You have typed b
You have typed c
You have typed 1
You have typed 2
```

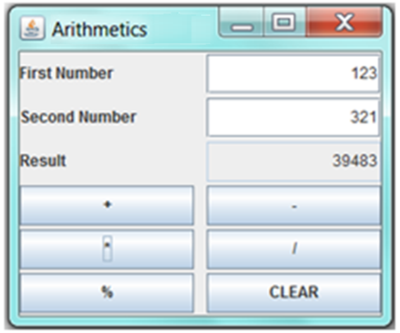
Quick quiz (1/2)

- 1. How many are there top-level containers in AWT? What are they?
- 2. How many are there secondary containers in AWT? What are they?
- 3. Which utilities should be used to organize components inside a container? Which one can arrange components from left-to-right in the added order?
- 4. Which model AWT uses to handle event? How many objects involved in the event-handling? What are they?

Quick quiz (2/2)

- 5. When we click onto a Button, which event will be fired?
  a. ButtonClickedEvent
  b. ButtonPressedEvent
  c. MouseEvent
  d. ButtonEvent
  e. ActionEvent
  f. WindowEvent
- 6. Which ways should be used, implementing a XxxListener or extending a XxxAdapter to handle AWT events?

Exercises



First Number 123

Second Number 321

Result 39483

Review

- GUI is a type of user interface that allows users to interact with electronic devices using images rather than text commands.
- Two core sets of Java APIs for graphics programming are AWT (Abstract Windowing Toolkit) and Swing
- AWT is huge with 12 packages
- There are two types of GUI elements: Component and Container
- Top-level AWT containers are Frame, Dialog and Applet.
- Secondary AWT Containers are Panel, ScrollPane

Review

- Layout manager can be used to arranges a container's components: FlowLayout, GridLayout, BorderLayout, …
- A container has a setLayout() method to set its layout manager
- Java adopts the so-called "Event-Driven" (or "Event-Delegation") programming model for event-handling
- 3 objects involved in the event-handling: ***source***, ***listenser***, ***event***
- AWT supports many kind of XxxEvent & XxxListener
- Use XxxAdapter to overcome disadvantages of XxxListener