GUI in Java (Basic Concepts)

Topics:

including

- What is GUI (Graphical User Interface)
- Making GUIs (**`JFrame`**, **`JButton`** in **`javax.swing.*`**)
- Event Handling: User Events, Listener Interfaces and Event Sources (**`java.awt.event.*`**)
- Layout Managers: **`FlowLayout`**, **`GridLayout`**, **`BorderLayout`**

Chapters 8, 17 – "Big Java" book
Chapters 12, 13 – "Head First Java" book
Chapters 12–14 – "Introduction to Java Programming" book

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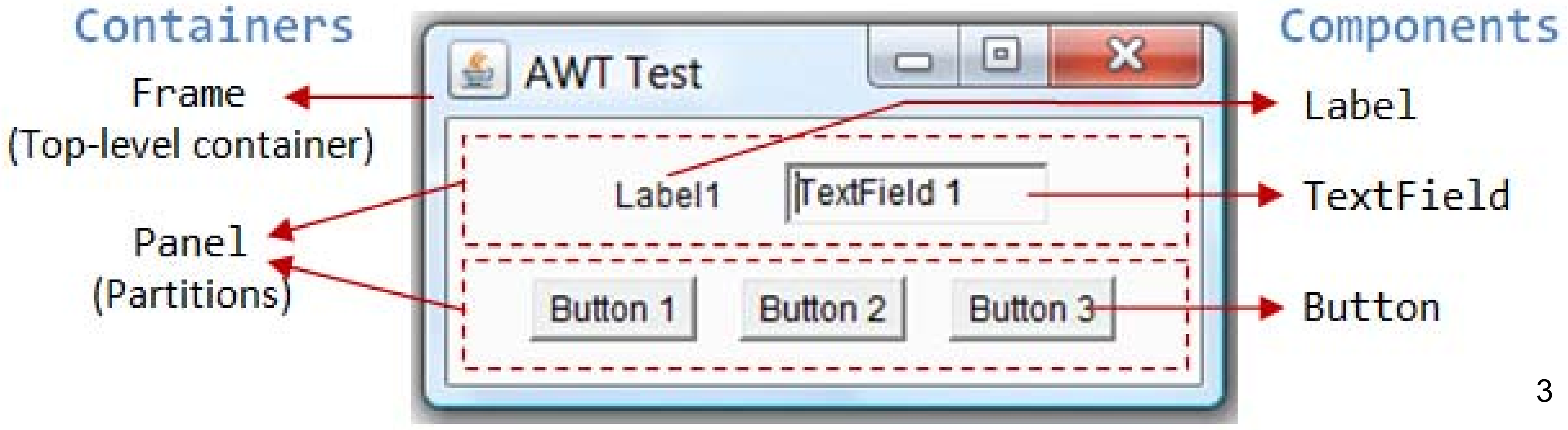
What is GUI?

- **GUI**: Method for interacting with a computer via the manipulation of text, images and "widgets".
  - GUIs display visual elements, e.g. buttons, icons, windows.
  - **Examples** of operating systems that support GUIs: MAC OS, Microsoft Windows.
- GUIs were introduced to address some of the issues with text based user interfaces (*aka* as CLIs – Command Line Interfaces), e.g. CLIs often require long command words to be typed in.
- **Widgets**: Things you can put in a window, such as a button.

What is (in a) GUI?

- There are *3 main concepts* when doing GUI programming in Java:
  - Component: An *object* that the user can see on the screen and can also interact with.
  - Container: A *component* that can hold other components.
  - Event: An *action* triggered by the user (e.g. pressing a key, click a mouse button).
- Designing a GUI involves creating *components*, putting them into *containers*, and arranging for the program to respond to *events* (e.g. responding to mouse clicks).



A First GUI

- Steps to **making a GUI**:
  1. Make a frame: create an instance of **`JFrame`**

     ```
     JFrame myFrame = new JFrame();
     ```

     object for window on the screen; **`javax.swing.*`**

  2. Make a widget (e.g. make a button or text field)

     ```
     JButton myButton = new JButton(“Click me”);
     ```

  3. Add the widget to the frame

     ```
     myFrame.getContentPane().add(myButton);
     ```

  4. Display the frame: must *give it a size* and *make it visible*

     ```
     myFrame.setSize(100, 100);
     myFrame.setVisible(true);
     ```

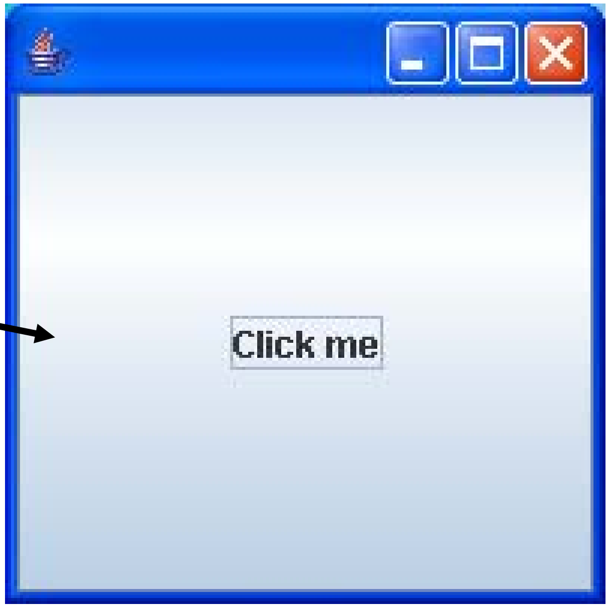
Example: Simple GUI

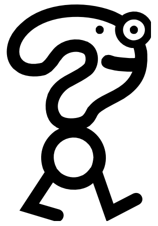
```
import javax.swing.*;

public class SimpleGui {
  public static void main(String[] args) {
    JFrame myFrame = new JFrame();
    JButton myButton = new JButton("Click me");
    myFrame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
    myFrame.getContentPane().add(myButton);
    myFrame.setSize(200, 200);
    myFrame.setVisible(true);
  }
}
```

To make the program quit when the window is closed.

Button is as big as the frame.





What happens when you click the button?

Running program …

```
> java SimpleGui
```

Some Background: `java.awt` Package (1/2)

- The **`java.awt`** package contains most of the classes needed to create GUI applications and Applets in Java.
- There are over 40 classes in the AWT package. They fall into the following general class types:
  - Container Classes: Graphical *widgets* capable of containing collections of other graphical widgets (i.e. **`Panel`**, **`Window`**, **`Dialog`** and **`Frame`**).
  - Component Classes: Atomic graphical widgets like **`Button`**, **`Menu`** and **`List`**.
  - Layout Manager Classes: Control the layout of component objects on/in container objects.

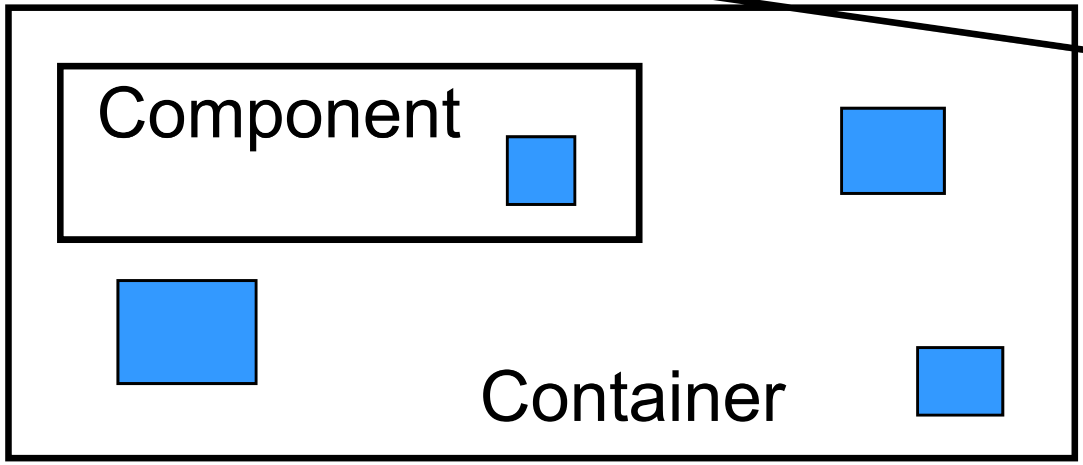
Some Background: `java.awt` Package (2/2)

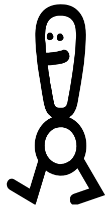
- More general class types in `java.awt` package:
  - Primitive Graphics Classes: Control and access primitive graphics like **`Point`**, **`Rectangle`** and **`Polygon`**.
  - Event Handling Classes: Deal with events received from the GUI and other system items.
  - Listener Classes: Receive events from graphical components and act on them.

Containers *versus* Components: What

- *Containers*: objects capable of containing other Component objects.
- *Components:* single entities with no *containment* abilities.

abstract classes



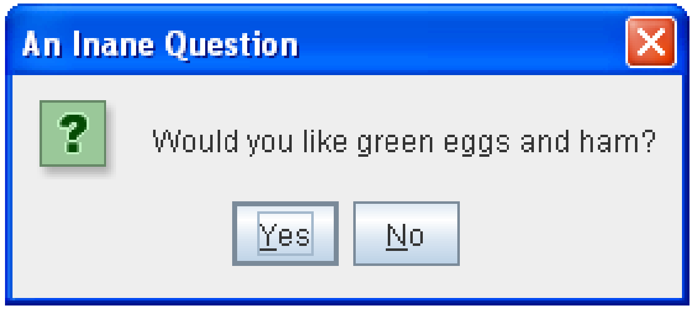


The filled boxes are components. They can be buttons on screen. There is no nesting for components.

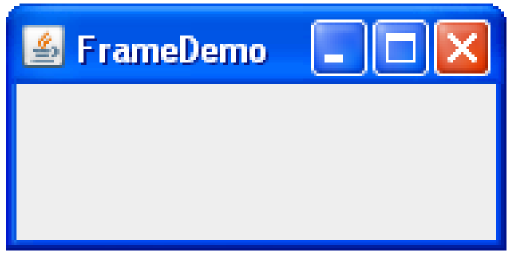
Containers: Examples

- *Top-level Containers*: At least one of these containers *must* be present in any Swing application.

JApplet

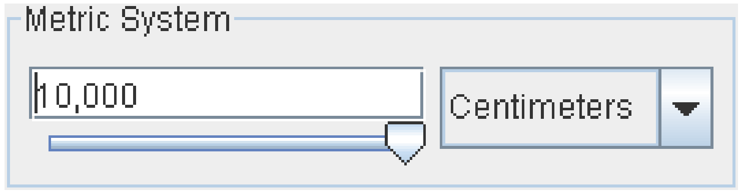


JDialog



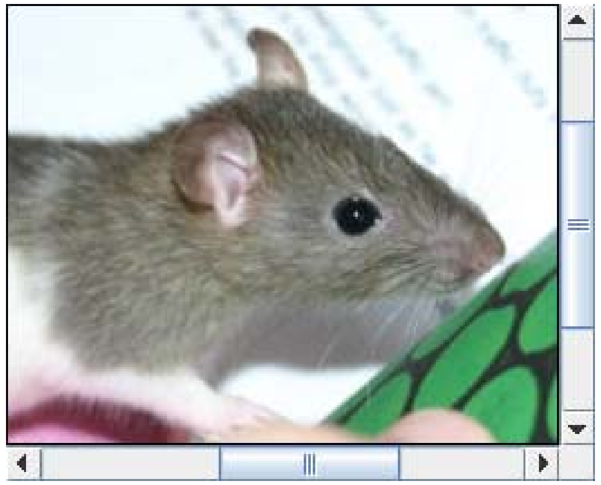
JFrame

- *General-purpose Containers:*
  Found in most Swing applications.



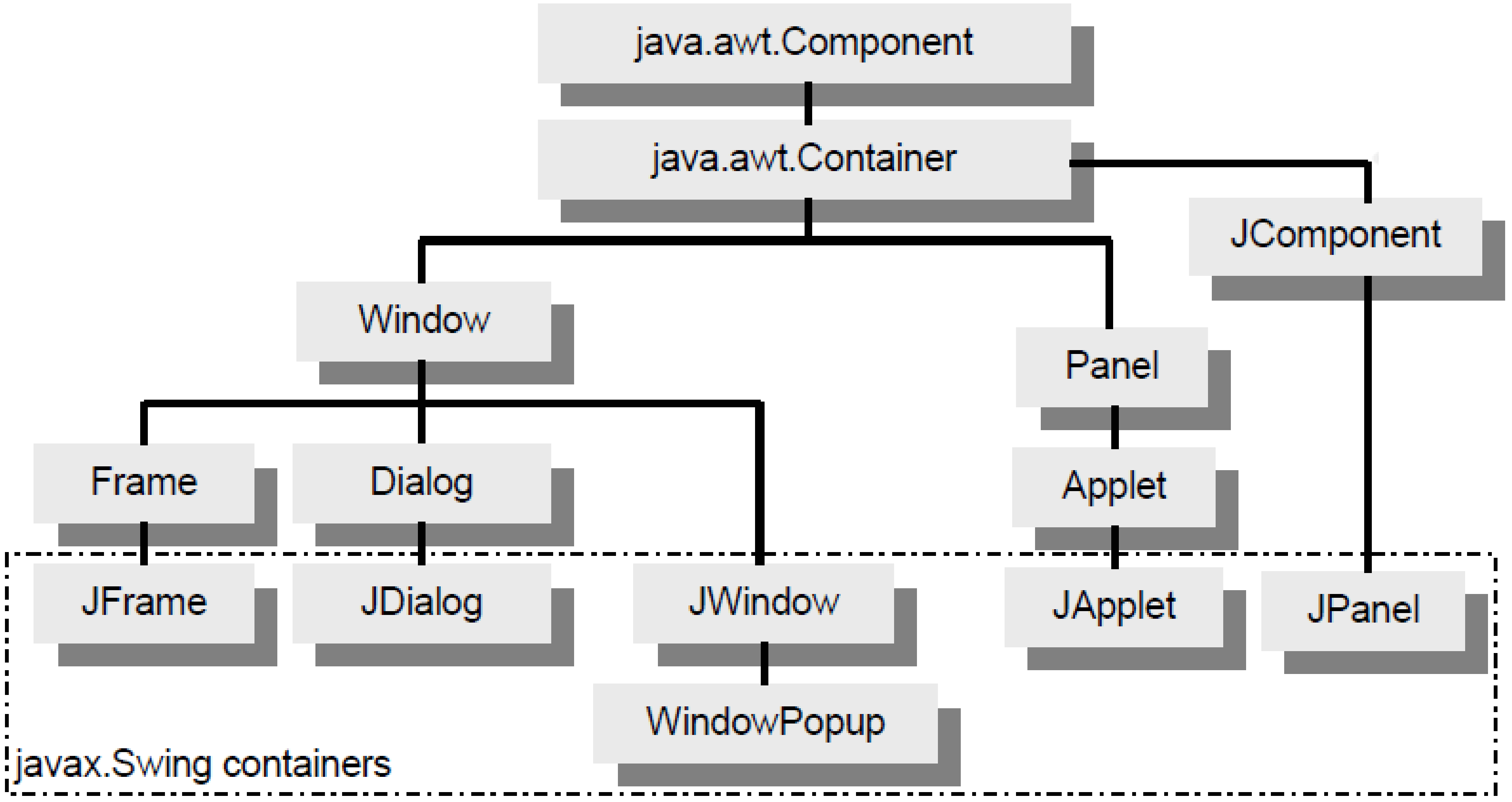
JPanel

JScrollPane



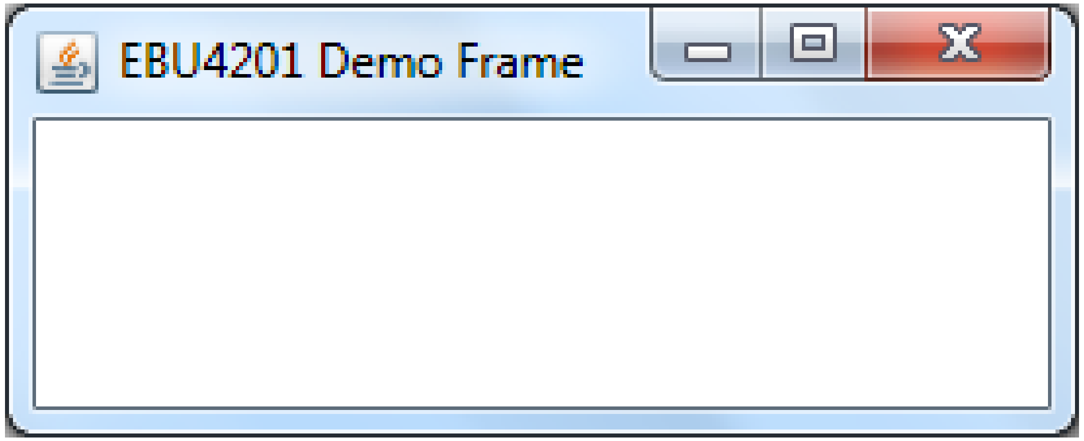
Other relevant examples at http://docs.oracle.com/javase/tutorial/uiswing/components/componentlist.html

Containers: Where in the Java API



java.awt.Frame

- A Frame is a simple, resizeable window with a border, title bar and possibly a menu bar.



- You can extend Frame in your program (more common), or instantiate the Frame class in your own class (less common) to build a basic GUI.
- Frame defaults:
  - Initially created with *0* size → `setSize(int,int);`
  - Initially created invisible → `setVisible(boolean);`
- To change the text in a Frame object's title bar, use the method **`setTitle(String);`**.

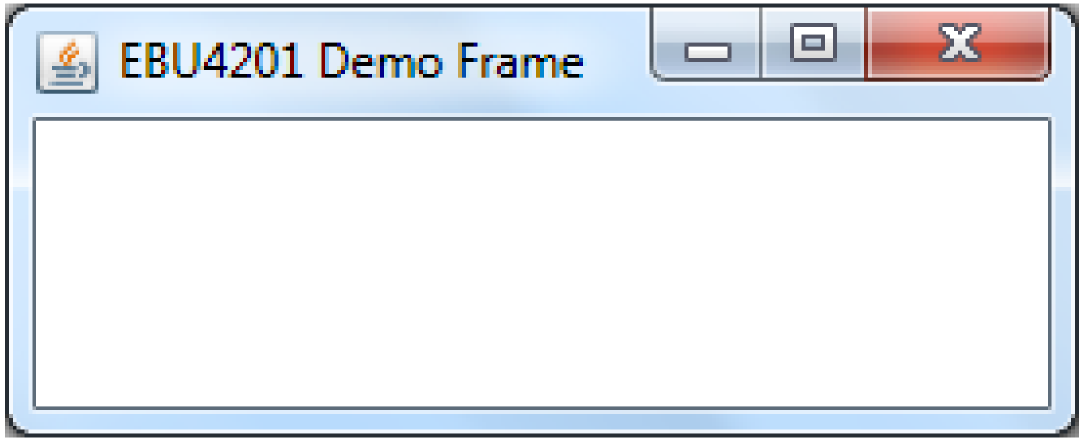
Another Example: Creating a Frame

```
import java.awt.Frame;

public class FrameDemo extends Frame {
  public FrameDemo() {
    this.setTitle("EBU4201 Demo Frame");
    this.setSize(250,100);
    this.setVisible(true);
  }
  public static void main(String[] args) {
    FrameDemo myFrame = new FrameDemo();
  }
}
```

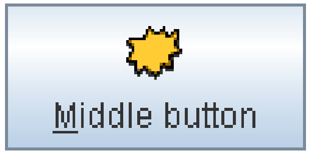
Output is …

```
> java FrameDemo
```

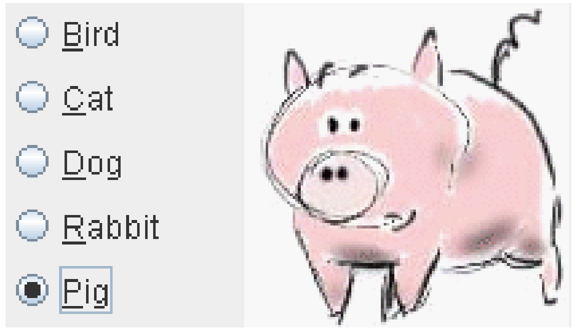


Components: Examples

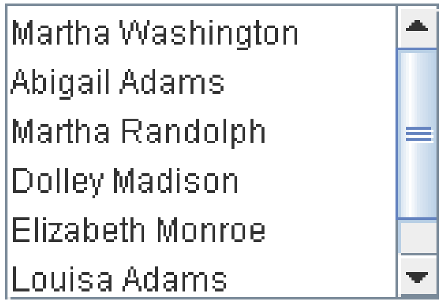
- *Basic Swing Components*: Used mainly for getting input from the user.



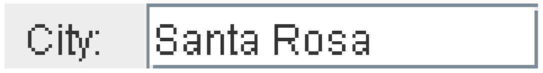
JButton



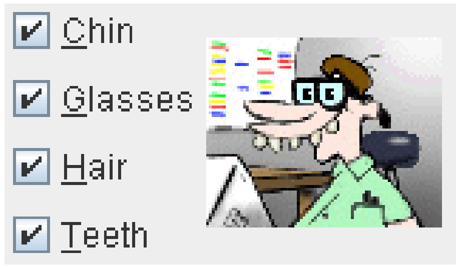
JRadioButton



JList



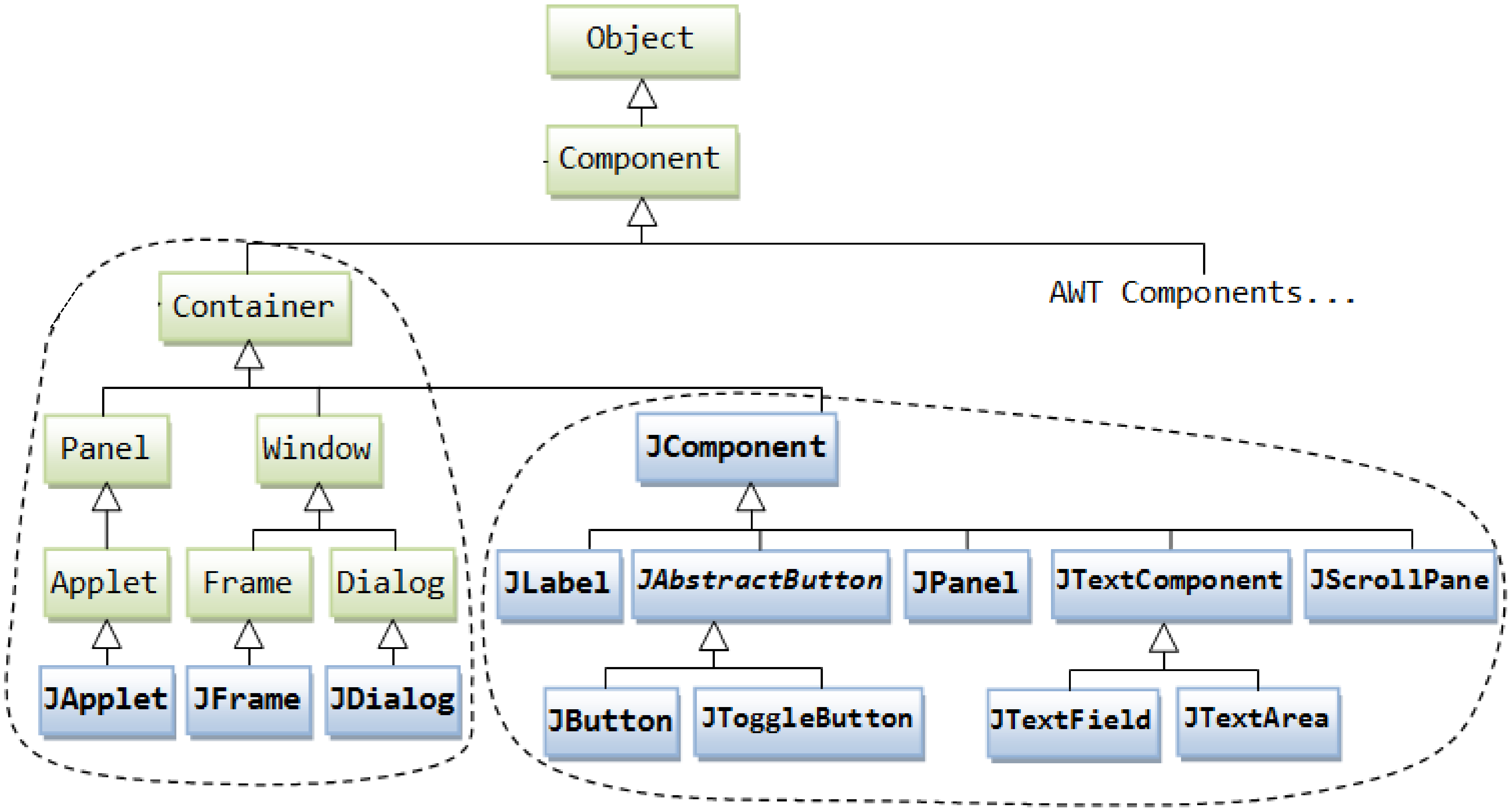
JTextField



JCheckBox

Other relevant examples at
http://docs.oracle.com/javase/tutorial/uiswing/components/componentlist.html

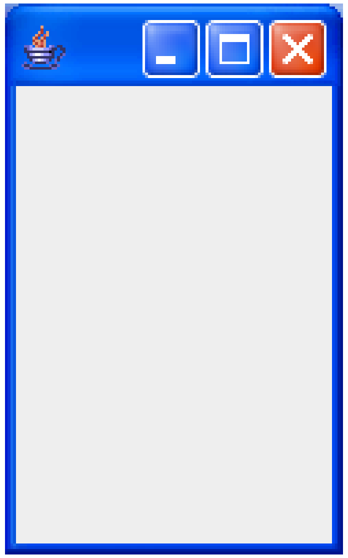
Components : Where in the Java API



Exercise 1

- The program below is supposed to display a message on the panel, but nothing is displayed. There are 2 problems; identify them.

```
import javax.swing.JFrame;
public class TestDrawMessage extends JFrame {
  public void TestDrawMessage() {
    getContentPane().add(new DrawMessage());
  }
  public static void main(String[] args) {
    JFrame frame = new TestDrawMessage();
    frame.setSize(100,200);
    frame.setVisible(true);
  }
}
```

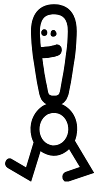


```
import javax.swing.JPanel;
import java.awt.Graphics;
class DrawMessage extends JPanel {
  protected void PaintComponent(Graphics g) {
    super.paintComponent(g);
    g.drawString("Welcome to Java",20,20);
  }
}
```

… and things for you to try out!

`java.awt` *versus* `javax.swing`

- Historical **`java.awt`** problems: runtime peer resources were required.
  - slow on some platforms (e.g. Windows);
  - portability problems (slightly different look and behaviour).
- Why **`javax.swing`** is better …
  - *More efficient use of resources*: Lightweight components are really "lighter" than heavyweight components.
  - *More consistency across platforms* because **`Swing`** is written entirely in Java.
  - *Cleaner look-and-feel integration*: Can give a set of *components* a matching look-and-feel by implementing them using **`Swing`**.



`javax.swing` components: e.g. **`JLabel`**, **`JList`**, **`JMenuBar`**.

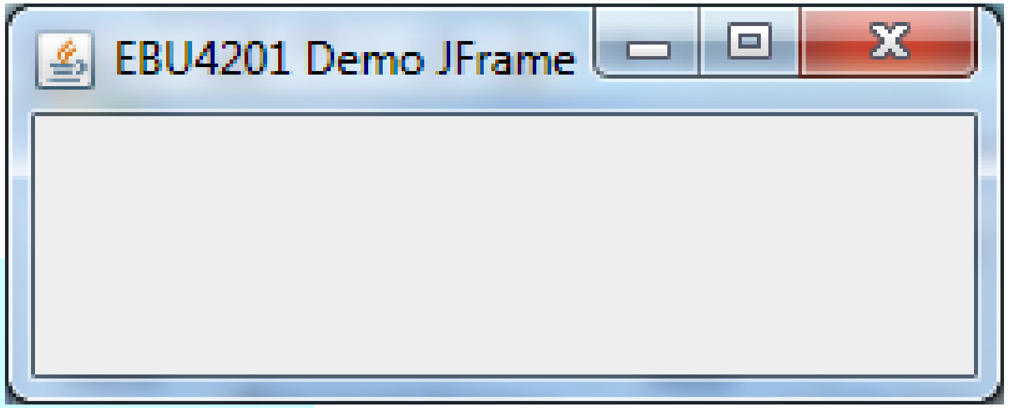
Example: Using `javax.swing` Package

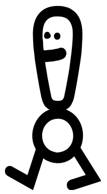
```
import javax.swing.JFrame;

public class FrameDemo extends JFrame {
  public FrameDemo() {
    this.setTitle("EBU4201 Demo JFrame");
    this.setSize(250, 100);
    this.setVisible(true);
  }
  public static void main(String[] args) {
    FrameDemo myFrame = new FrameDemo();
  }
}
```

Output is …

```
> java FrameDemo
```





How to use the **`javax.swing`** package (tutorial):
http://docs.oracle.com/javase/tutorial/uiswing/

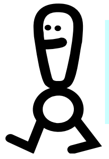
Java & Event Driven Programming

- A (user) *event* is triggered any time when some sort of defined signal is received by the program.
  - An event is generated by external user actions, e.g.
    - typing a character;
    - mouse button clicks or movement;

    or by the operating system, e.g. a timer going off.
- **Event handling**: the process of getting and handling user events.

Example *Events*

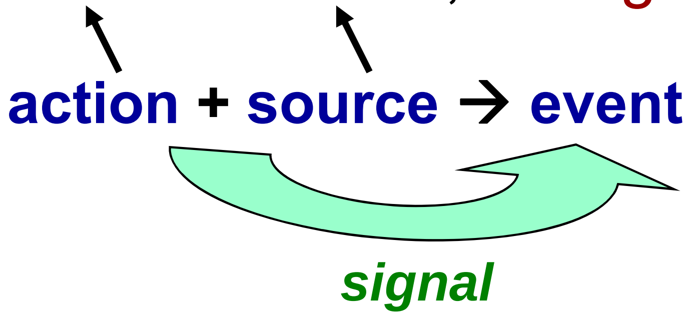
Event Generating Action	Listener Type	Event Type
User clicks a button, presses Return while typing in a text field, or chooses a menu item	ActionListener	ActionEvent
User closes a frame (main window)	WindowListener	WindowEvent
User presses a mouse button while the cursor is over a component	MouseListener MouseMotionListener	MouseEvent MouseEvent
User moves the mouse over a component	ComponentListener	ComponentEvent
Component becomes visible	FocusListener	FocusEvent



Other event listeners and types available in **`java.awt.event.*`**.

Doings Things in GUI

- Example: When I click on button, change the button text.



- Need to know:
  - Which user action leads to a change: e.g. clicking, moving mouse, pressing return key …
  - The corresponding widget (component).
  - What needs to happen (or change) as a result of the action on the source (i.e. the event).
    - But still need to be able to get (and handle) the event.

Events, Sources & Listeners

- **Listener Interface**: the *bridge* between the listener (the user) and the event source (e.g. the button).
  - Implementing a listener interface gives the button a way to call the user back.
- **Event source**: object that can turn user actions (e.g. click a mouse, close a window) into events.
- Every event type has a matching listener interface.
  - **Example**: For MouseEvents, you need to implement the MouseListener interface.
  - You must provide implementations for its methods.

Steps: Writing an Event Handler

- Every event handler (e.g. how to get a button's `ActionEvent`) requires three bits of code:
  1. Implement the `ActionListener` interface: In the declaration for the event handler class, code specifies that class either implements a listener interface ***or*** extends a class that implements a listener interface.

     ```
     public class MyClass implements ActionListener {...}
     ```

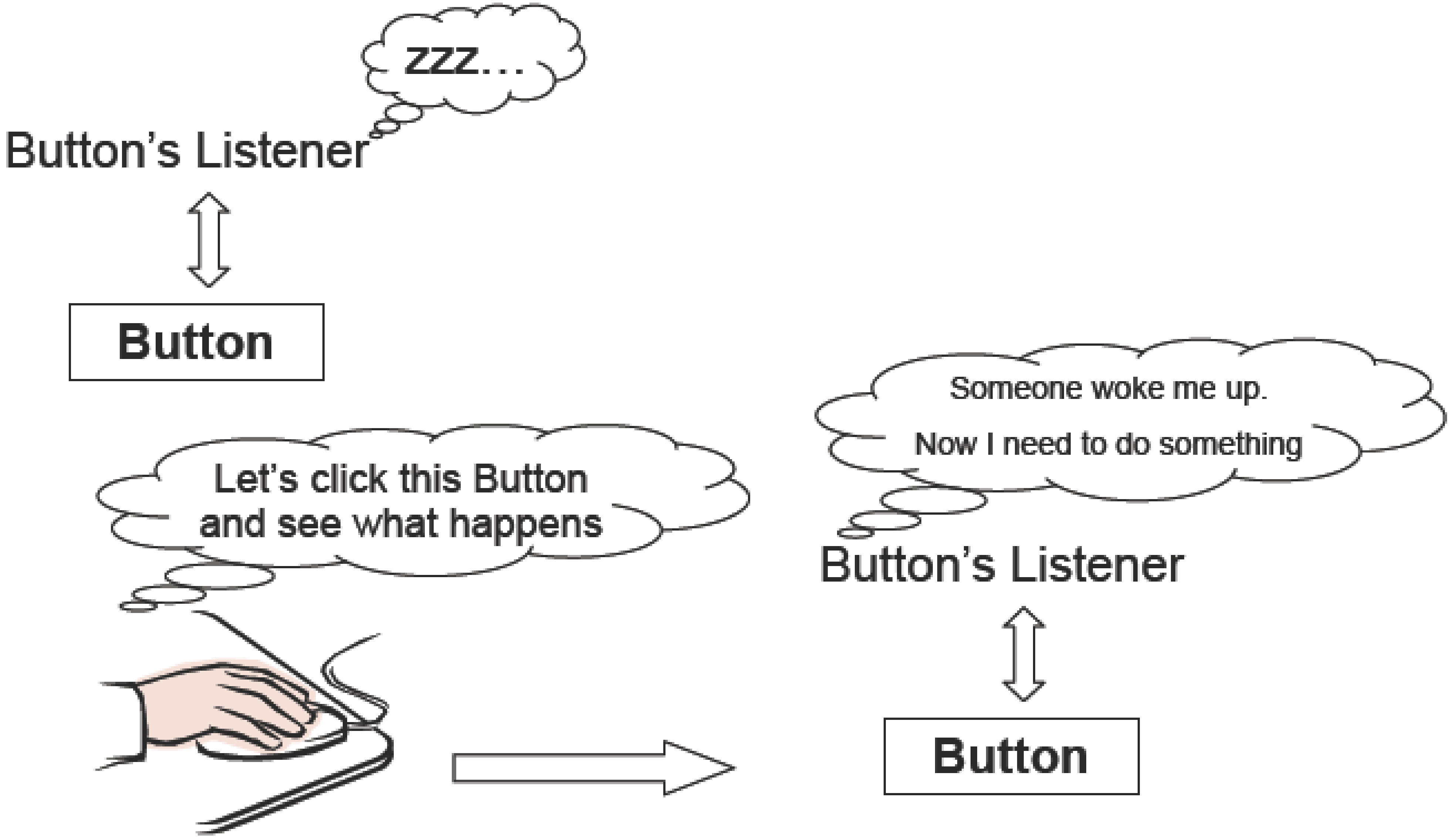
  2. Register with the widget: Code indicates that your program wants to listen for events, by registering an instance of the event handler class as a listener upon one or more components.

     ```
     someComponent.addActionListener(instanceOfMyClass);
     ```

  3. Define the event-handling method: Code implements the methods in the listener interface.

     ```
     public void actionPerformed(ActionEvent e) {
       // code that reacts to the action ...
     }
     ```

Writing an Event Handler (*visual interpretation*)


zzz…
Button's Listener
Button
Let's click this Button and see what happens
Someone woke me up. Now I need to do something
Button's Listener
Button

Example: Event Handler (1/2)

```
import javax.swing.*;
import java.awt.event.*;
public class AnotherSimpleGui implements ActionListener {
  JButton myButton;
  public static void main(String[] args) {
    AnotherSimpleGui myGui = new AnotherSimpleGui();
    myGui.go();
  }
  public void go() {
    JFrame myFrame = new JFrame();
    myButton = new JButton("Click me");
    myButton.addActionListener(this);
    myFrame.add(myButton);
    myFrame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
    myFrame.setSize(200, 200);
    myFrame.setVisible(true);
  }
  public void actionPerformed(ActionEvent event) {
    myButton.setText("I've been clicked");
  }
}
```

Step 1 – implement interface **`ActionListener`**

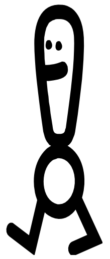
Step 2 – register interest with button (tell button "I want to listen to actions on you").

Step 3 – implement **`ActionListener`**'s interface method (it handles the event).

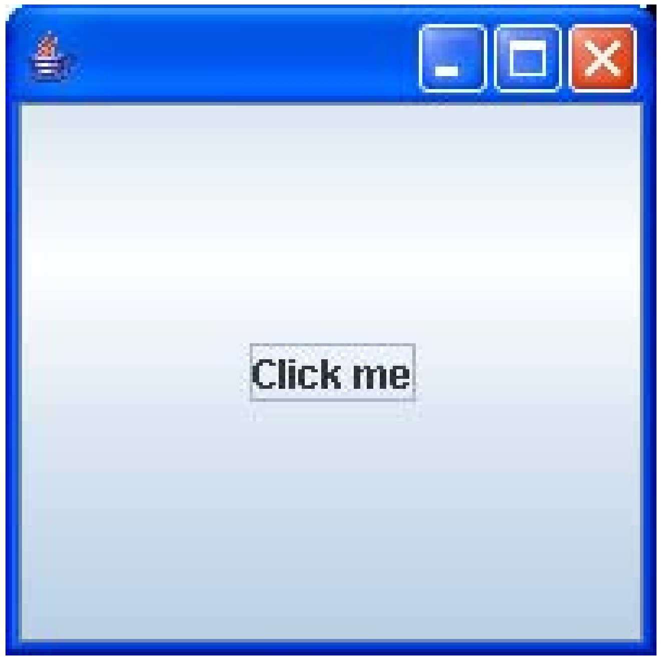
Example: Event Handler (2/2)

Running program …

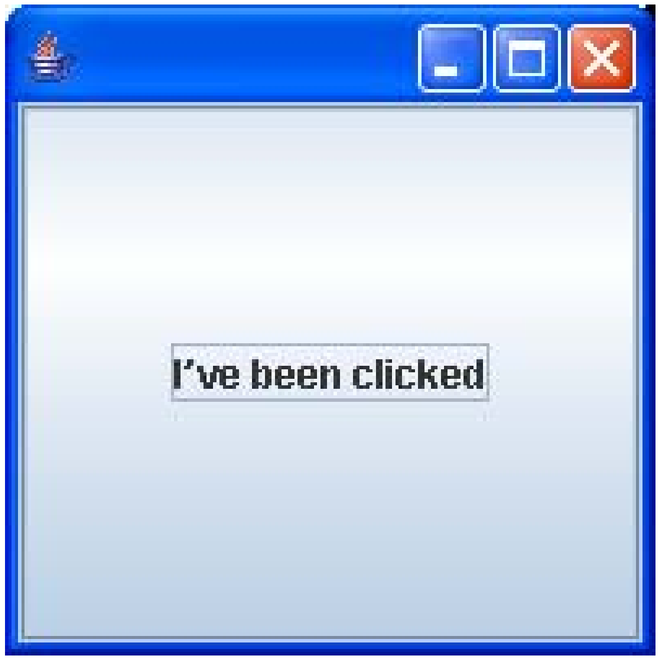
```
> java AnotherSimpleGui
```



Homework: Add code so that you can change the colour of the button.



upon clicking button …



Other Event Types: MouseEvents

Action	Source	Event
• Click		`mouseClicked(MouseEvent e)`
• Press		`mouse_______(MouseEvent e)`
• Release		`mouse_______(MouseEvent e)`
• Enter		`mouse_______(MouseEvent e)`
• Exit		`mouse_______(MouseEvent e)`
• Move		`mouse_______(MouseEvent e)`
• Drag		`mouse_______(MouseEvent e)`

Fill in the gaps to complete the method names.

Exercise 2

- What is wrong in the following code?

```
import java.awt.*;
import java.swing.*;
public class Test extends JFrame implements ActionListener {
  public Test() {
    JButton jbtOK = new JButton(“OK”);
    getContentPane().add(jbtOK);
  }
  public void actionPerform(ActionEvent e) {
    if (e.getSource() == jbtOK)
      System.out.println(“OK button is clicked”);
  }
}
```

Homework

Write a simple GUI program with a button that responds to events from a mouse being pressed and released. The *button should display*:

- the message “No action” when no action is taken on the mouse.
- the message “Pressing down” when the mouse is pressed.
- the message “Releasing” when the mouse is released.

JLabel and JButton Classes

- **`JLabel`**: component that you can put text into.
  - When creating a label, you can specify the initial value and the alignment you wish to use within the label.

    ```
    JLabel myLabel = new JLabel(“text”, JLabel.RIGHT);
    ```

  - You can use methods **`getText()`** and **`setText()`** to get and change the value of the label, respectively.
- **`JButton`**: extends **`Component`**, displays a string and delivers an **`ActionEvent`** for each mouse click.
  - Normally buttons are displayed with a *border*.
  - In addition to text, **`JButtons`** can also display icons.

    ```
    JButton myButton = new JButton(“text”);
    ```

Components, Containers & Layout Managers

- **Layout Manager**: An interface that defines methods for positioning and sizing objects within a container.
  - Java defines several default implementations of **`LayoutManager`**.
  - **Geometrical placement in a Container** is controlled by a **`LayoutManager`** object.

- **Containers** may contain components → so containers can contain containers!
  - All containers come equipped with a *layout manager* which positions and shapes (lays out) the container's components.
  - Much of the action in the AWT occurs between *components*, *containers*, and their *layout managers*.

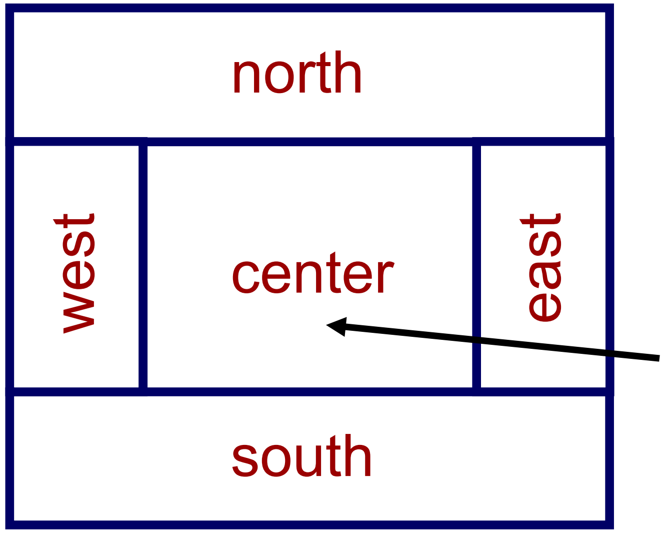
Layout Managers

- **Layouts** allow you to format components on the screen in a platform independent way.
- The standard JDK provides five classes that implement the **`LayoutManager`** interface:
  - **`FlowLayout`**
  - **`GridLayout`**
  - **`BorderLayout`**
  - **`CardLayout`**
  - **`GridBagLayout`**

  } *Not discussed here!*
- **Layout managers** are defined in the **`java.awt`** package.

Buttons, Frames and Layout

- How to **put several things on a frame**: need to use a GUI *layout*.
  - **Frames** have 5 regions you can add things to!



default region
to add things to

recommended way
of adding a button

  - How to add a button to a frame:

```
myFrame.getContentPane().add(myButton);
```

OR

```
myFrame.getContentPane().add(BorderLayout.CENTER, myButton);
```

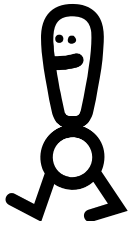
Changing the Layout

- **Steps to change the layout** in a container:
  - Step 1: Create the layout.
  - Step 2: Invoke the **`setLayout()`** method on the container to use the new layout.

```
JPanel p = new JPanel();
p.setLayout(new FlowLayout());
```

  - Or both Steps at once:

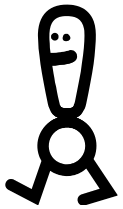
```
JPanel p = new JPanel(new FlowLayout());
```



The layout manager should be established before any components are added to the container.

FlowLayout

- **`FlowLayout`** is the default layout for the **`JPanel`** class.
  - When you add components to the screen, they flow left to right (centered), based on the order added and the width of the screen.
  - Very similar to *word wrap* and *full justification* on a word processor.
  - If the screen is resized, the components' flow will change based on the new width and height.
  - Constructors:
    - `FlowLayout()`
    - `FlowLayout(int align)`
    - `FlowLayout(int align, int hgap, int vgap)`

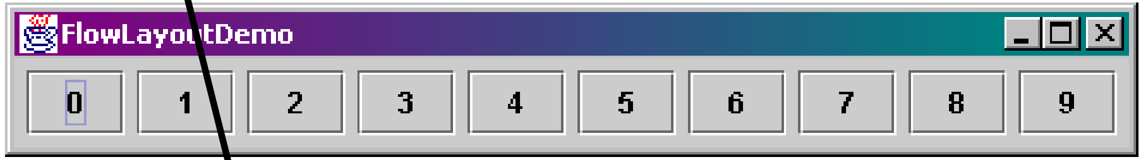


This is the default layout manager for a *panel*!

Example using `FlowLayout`

```
import javax.swing.*;
import java.awt.FlowLayout;
public class FlowLayoutDemo extends JFrame {
  public FlowLayoutDemo(String title, int num) {
    this.setTitle(title);
    this.getContentPane().setLayout(new FlowLayout());
    for (int i = 0; i < num; i++)
      this.getContentPane().add(new JButton(“” + i));
  }
  public static void main(String args[]) {
    FlowLayoutDemo frame = new FlowLayoutDemo("FlowLayoutDemo",10);
    frame.pack();
    frame.setVisible(true);
  }
}
```

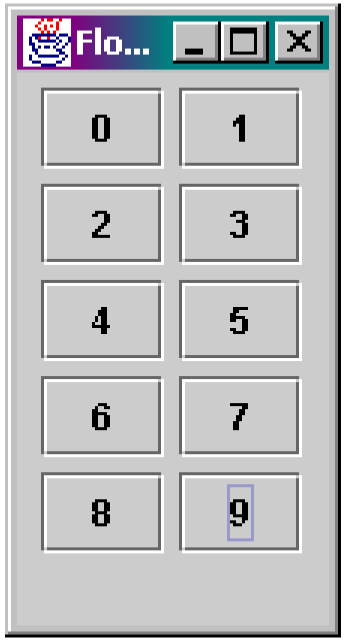
Output is …



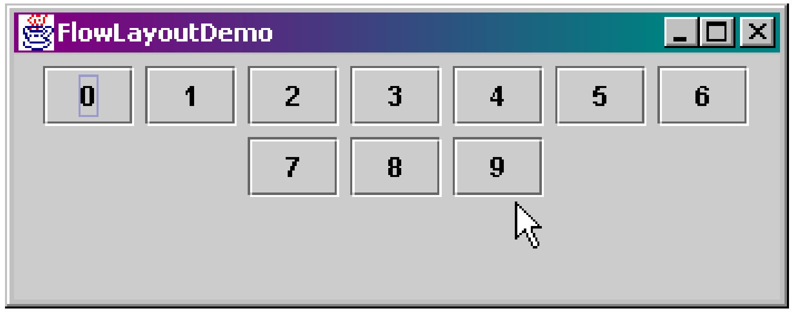
Methods from **`java.awt.Window`** and **`java.awt.Component`**

Resizing the window:

(1)



(2)

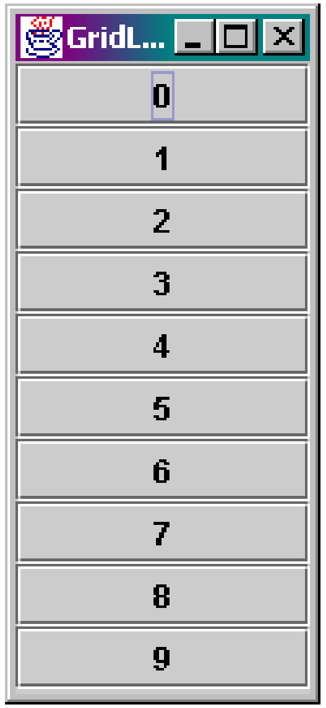


… and things for you to try out!

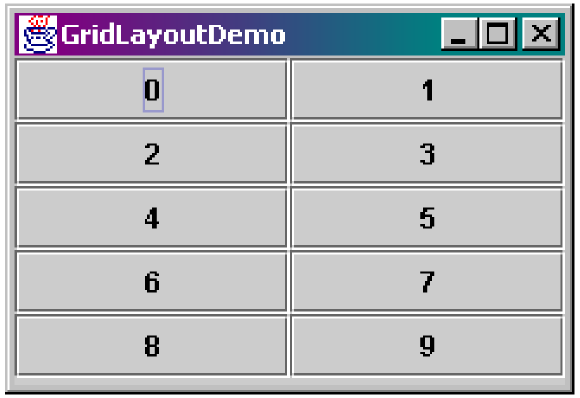
GridLayout

- **`GridLayout`** arranges components in rows or columns:
  - If number of rows is specified, the number of columns will be the number of components divided by the rows.
  - If number of columns is specified, the number of rows will be the number of components divided by the columns.
  - Specifying the number of columns affects the layout only when the number of rows is set to zero.
  - The order in which you add components is relevant.
  - Constructors:
    - `GridLayout()`:default of 1 column per component, in a single row.
    - `GridLayout(int rows, int cols)`
    - `GridLayout(int rows, int cols, int hgap, int vgap)`

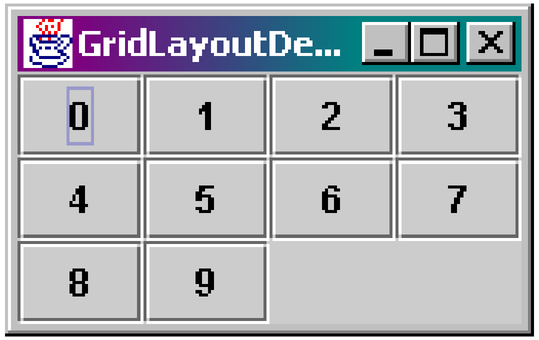
Examples using `GridLayout`



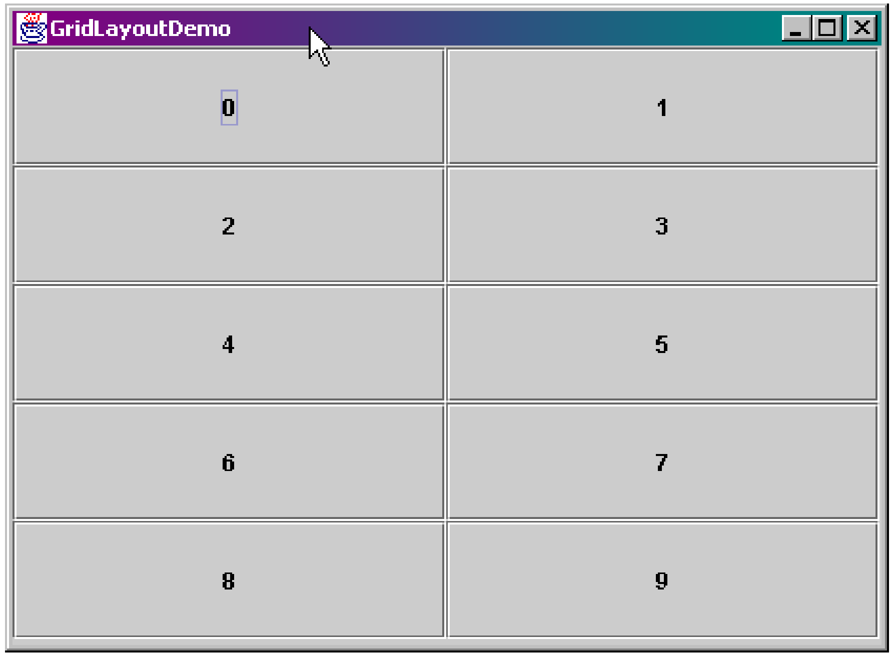
`GridLayout(10,0)`



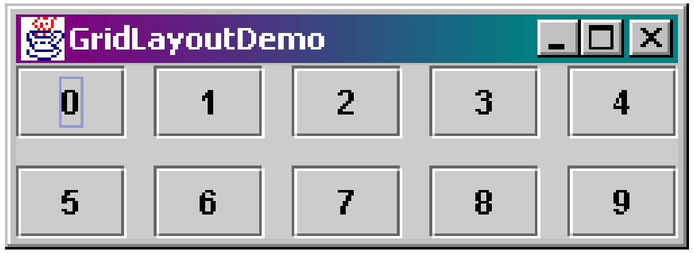
`GridLayout(0,2)`



`GridLayout(0,4)`



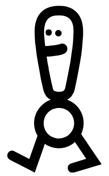
`GridLayout(0,2)` **(Resized)**



`GridLayout(0,5,10,10)`

BorderLayout

- **`BorderLayout`** provides 5 areas to hold components.
  - These are named after the four different borders of the screen, North, South, East, West, and Center.
  - To add a *Component*, you must specify which area to place it in.
  - The order in which components are created is not important.
  - The NORTH and SOUTH components may be stretched horizontally.
  - The EAST and WEST components may be stretched vertically.
  - The CENTER component may stretch both horizontally and vertically to fill any space left over.
  - **Constructors**:
    - `BorderLayout()`: default; provides no gaps between components.
    - `BorderLayout(int hgap, int vgap)`



This is the default layout manager for a *frame*!

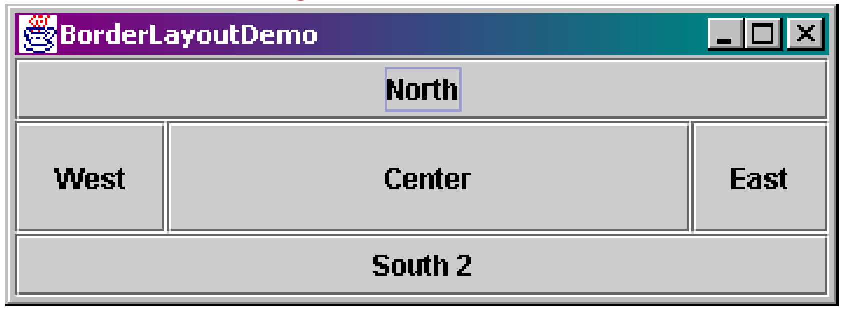
Example using BorderLayout

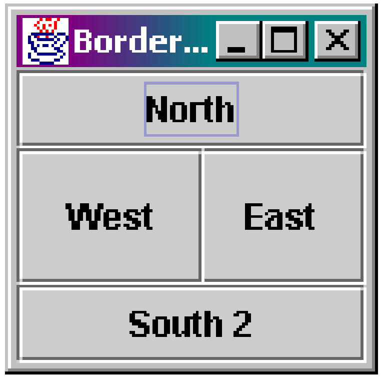
```
import javax.swing.*;
import java.awt.*;

public class BorderLayoutDemo extends JFrame {
  public BorderLayoutDemo() {
    setTitle("BorderLayoutDemo");
    Container content = getContentPane();
    content.setLayout(new BorderLayout());
    content.add(BorderLayout.NORTH, new JButton("North"));
    content.add(BorderLayout.SOUTH, new JButton("South"));
    content.add(BorderLayout.EAST, new JButton("East"));
    content.add(BorderLayout.WEST, new JButton("West"));
    content.add(BorderLayout.SOUTH, new JButton("South 2"));
    content.add(BorderLayout.CENTER, new JButton("Center"));
  }
  public static void main(String args[]) {
    BorderLayoutDemo frame = new BorderLayoutDemo();
    frame.pack();
    frame.setVisible(true);
  }
}
```

Resizing the window:

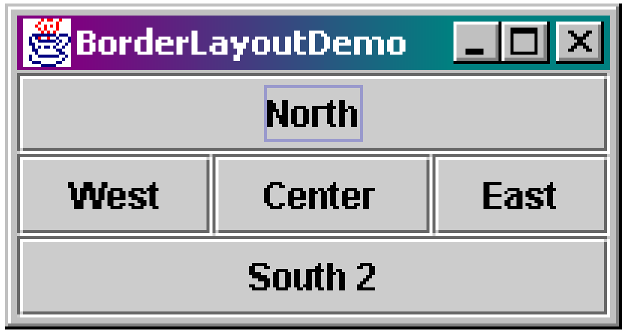
(1)





(2)

Output is …



… and things for you to try out!