Chapter 12 Part 1: GUI Programming

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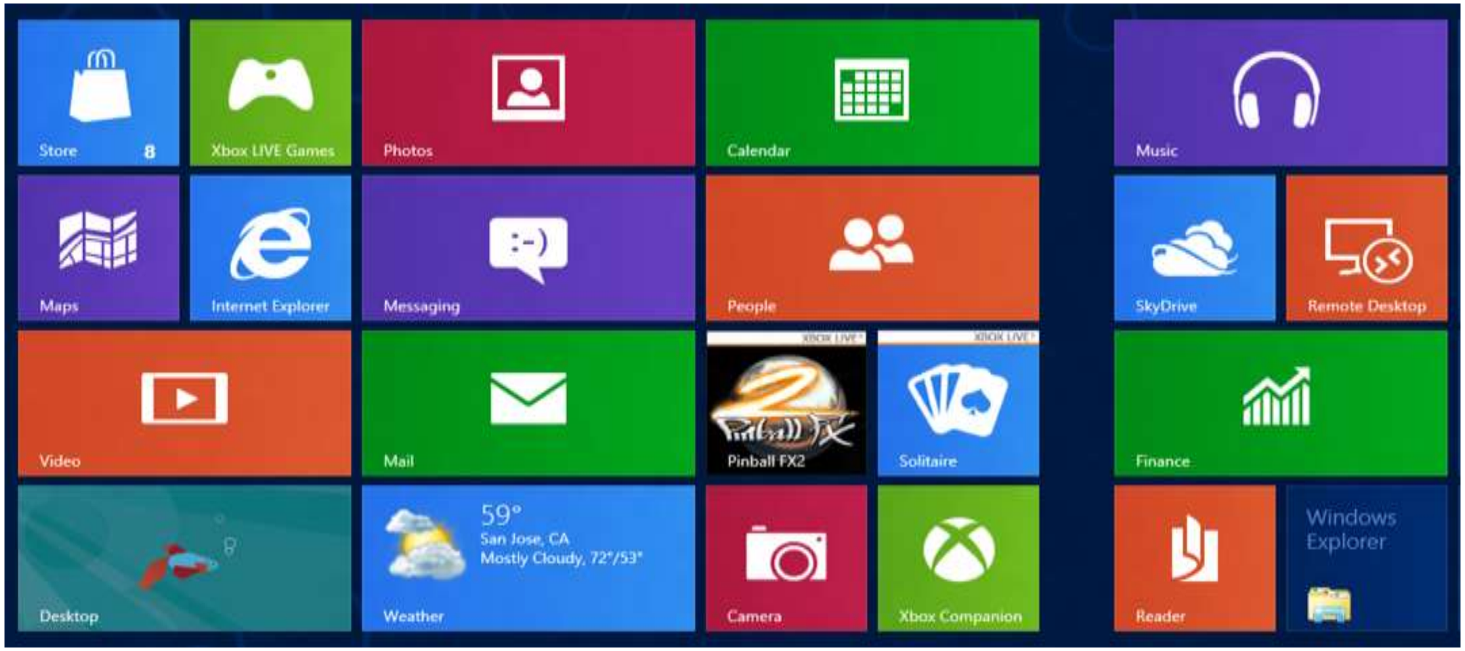
Objectives

- GUI and its brief history
- Build simple GUIs with containers and components
- Event handling
- Layout management

What is GUI?

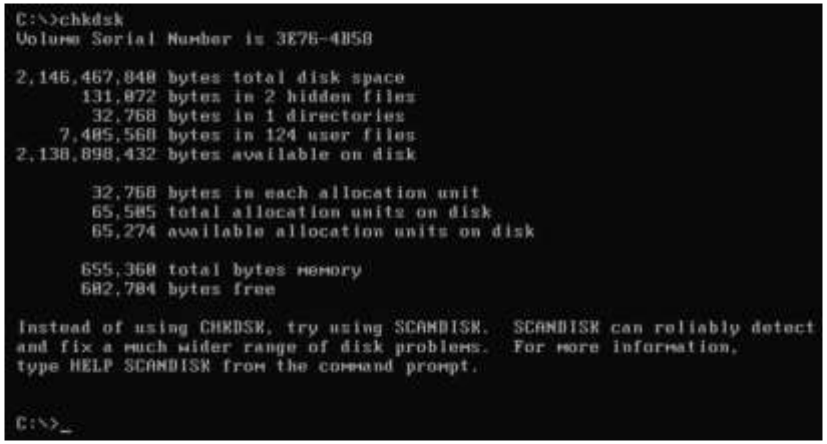
- The **G**raphical **U**ser **I**nterface (GUI, 图形用户界面), is a type of user interface that allows users to interact with electronic devices through graphical icons and visual indicators.



Windows 10

GUI vs. CLI

- Before GUI became popular, text-based **C**ommand-**L**ine **I**nterface (CLI, 命令行界面) was widely-used (mainly in 1970s and 1980s).
- Because CLIs consume little resources, they are still available in modern computers with GUIs and are widely-used by professionals.



```
C:\>chkdsk
Volume Serial Number is 3E76-4858

2,146,467,840 bytes total disk space
      131,072 bytes in 2 hidden files
       32,768 bytes in 1 directories
    7,405,568 bytes in 124 user files
2,138,898,432 bytes available on disk

       32,768 bytes in each allocation unit
       65,505 total allocation units on disk
       65,274 available allocation units on disk

      655,360 total bytes memory
      602,784 bytes free

Instead of using CHKDSK, try using SCANDISK.  SCANDISK can reliably detect
and fix a much wider range of disk problems.  For more information,
type HELP SCANDISK from the command prompt.


C:\>_
```

MS-DOS

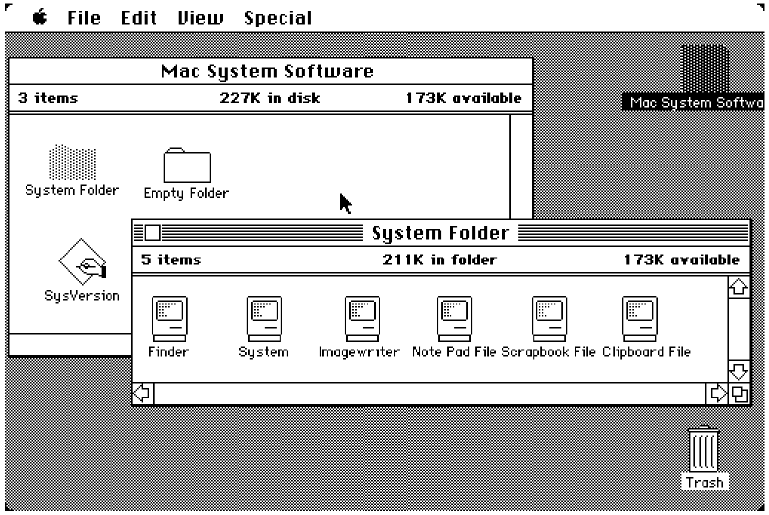
A bit history about GUI

In 1973, Xerox PARC developed **Alto**, the first personal computer with GUI (not commercialized)

In 1981, **Xerox Star** workstation introduced the first commercial GUI OS (did not achieve market success)

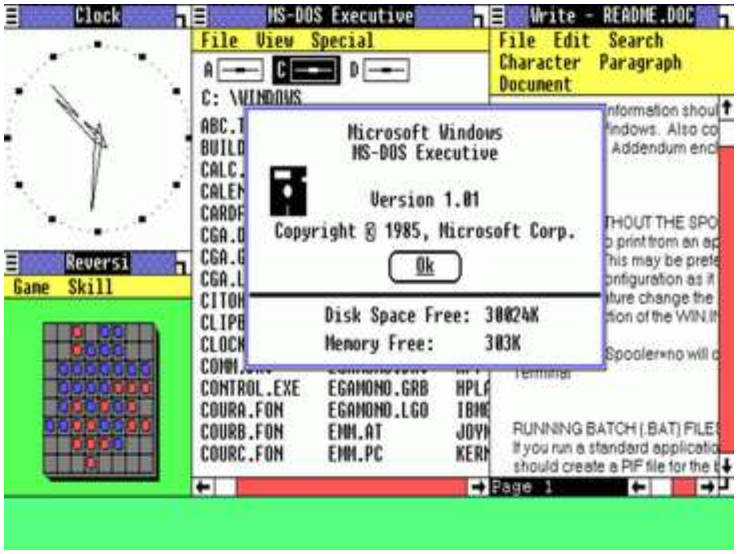
A bit history about GUI

Apple Lisa (1983) and **Macintosh (1984)**
(Steve Jobs visited Xerox PARC and was amazed by Alto)

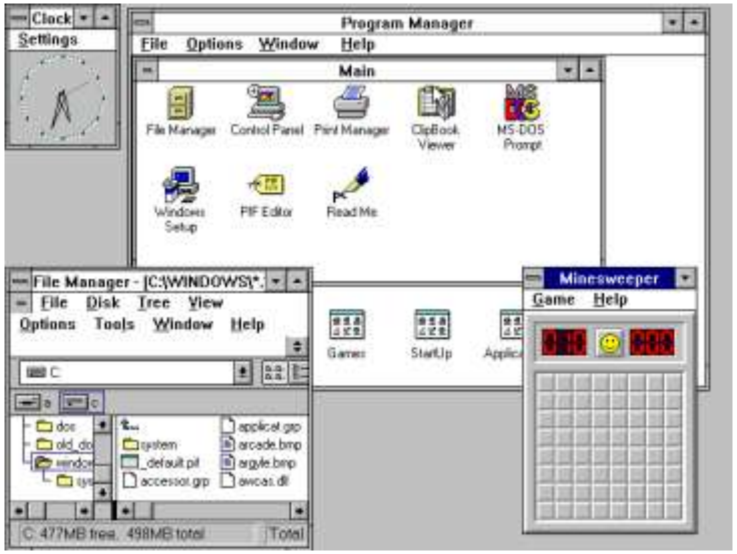


Macintosh GUI (1984)

A bit history about GUI



Windows 1.0, a GUI for the MS-DOS operating system was released in **1985**. The market's response was not so good.



The Windows OS becomes popular with the **1990** launch of **Windows 3.0**

Java GUI History

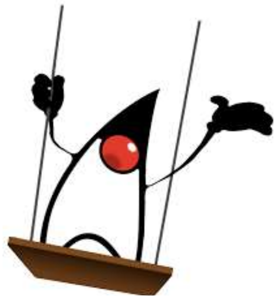
- Abstract Window Toolkit (AWT)
  - JDK 1.0 (1995)
  - Most of AWT's UI components have become obsolete
- Swing
  - JDK 1.2 (1997)
  - Enhancement of AWT
- JavaFX
  - JDK 8 (2008), replacement to Swing
  - Actively maintained and expected to grow in future

Java GUI Programming APIs

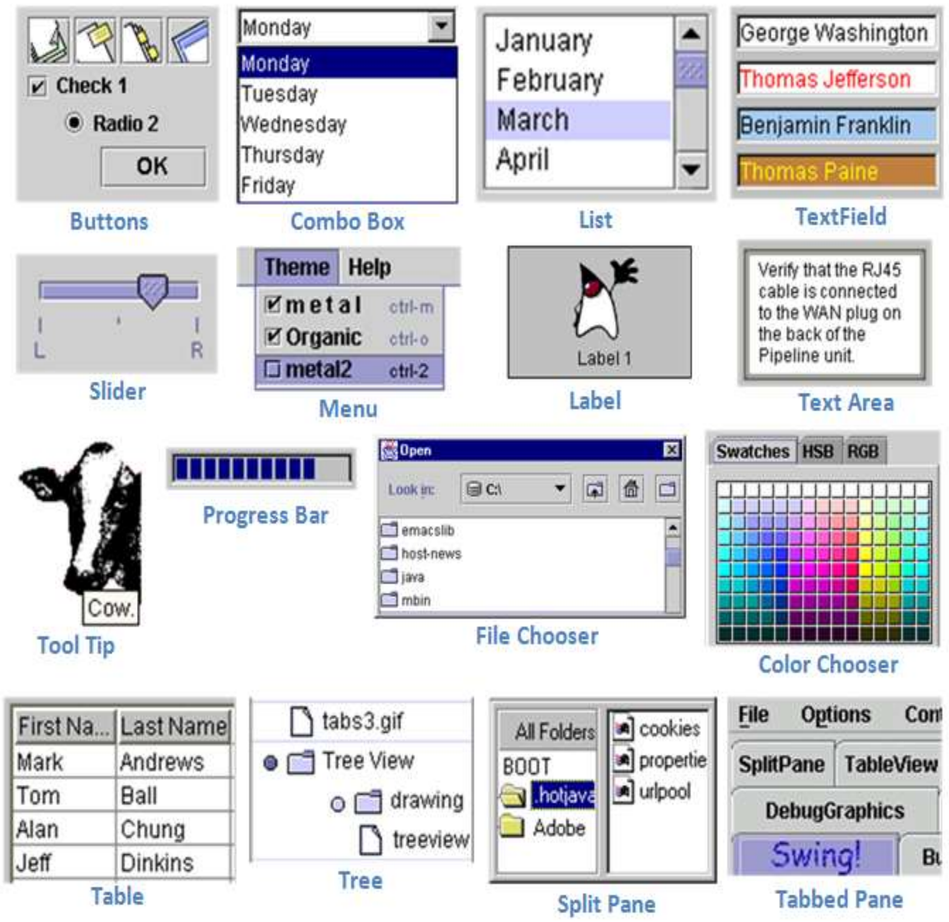
- **AWT** (**A**bstract **W**indowing **T**oolkit): introduced in JDK 1.0
- AWT components are **platform-dependent**. Their creation relies on the operating system's high-level user interface module.
  - For example, creating an AWT check box would cause AWT directly to call the underlying native subroutine that creates a check box.
  - This makes GUI programs written in AWT look like native applications
- AWT contains 12 packages of 370 classes (Swing and FX are more complex, 650+ classes)
  - They are developed by expert programmers with advanced design patterns.
  - Writing your own graphics classes (re-inventing the wheels) is mission impossible!

https://www.ntu.edu.sg/home/ehchua/programming/java/J4a_GUI.html

Java GUI Programming APIs

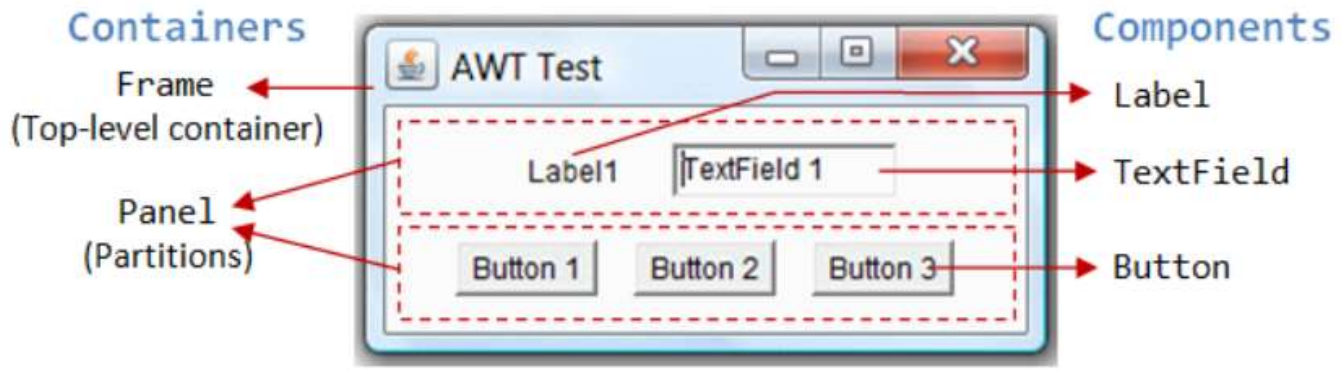


- **Swing**, introduced in 1997 after the release of JDK 1.1, provides a much more comprehensive set of UI widgets than AWT
- Unlike AWT's UI widgets, Swing's are not implemented by platform-specific code. They are written entirely in Java and **platform-independent**.
    - In Swing, user interface elements, such as buttons, menus, and so on, were painted onto blank windows.
- **Pluggable look and feel:** Swing component can have the native platform's "look and feel" or a cross-platform look and feel (the "Java Look and Feel")



Java GUI Core Concepts

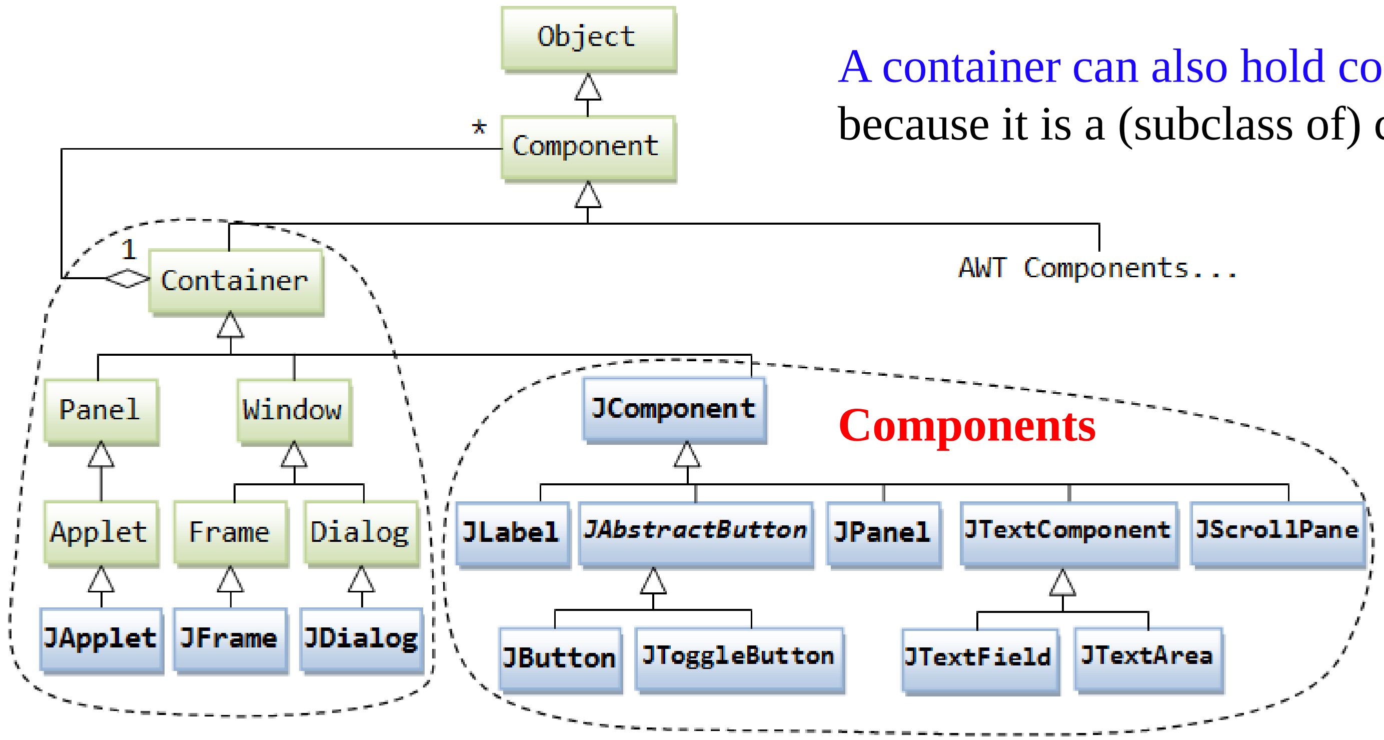
- **Component** (组件): Components are elementary GUI entities, such as Button, Label, and TextField.
- **Container** (容器): used to hold components in a specific layout
- **Event handling** (事件处理): decides what should happen if an event occurs (e.g., a button is clicked)



https://www3.ntu.edu.sg/home/ehchua/programming/java/j4a_gui.html

Java GUI Class Hierarchy

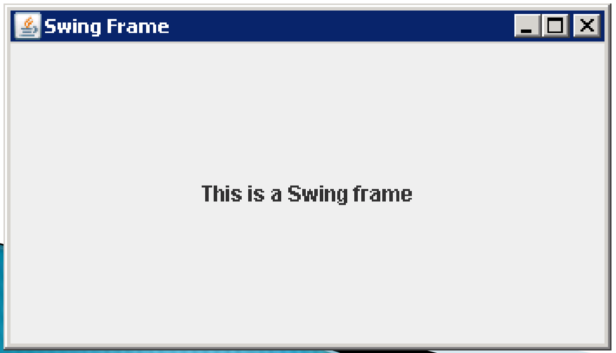
- There are two groups of classes (in package `javax.swing`): **containers** and **components**. A container is used to hold components.



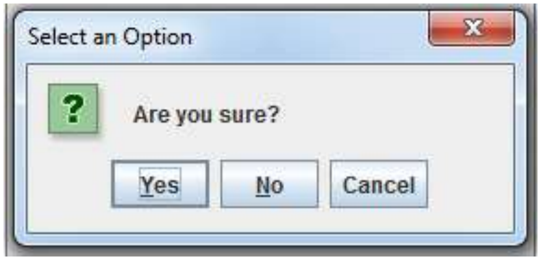
A container can also hold containers because it is a (subclass of) component

Containers: top level container

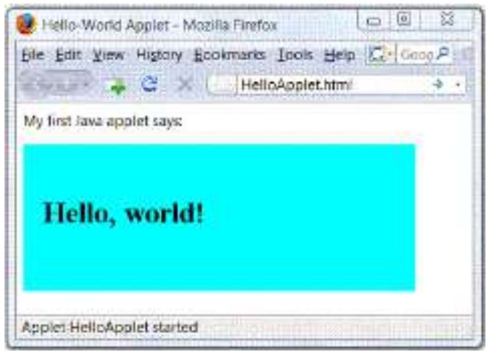
- A Swing application requires a **top-level container** (a window that is not contained inside another window)
- There are three top-level containers in Swing:
  - `JFrame` **(主窗体)**: used for the application's main window (with an icon, a title, minimize/maximize/close buttons, an optional menu-bar, and a content-pane)
  - `JDialog` **(对话框)**: used for secondary pop-up window (with a title, a close button, and a content-pane).
  - `JApplet`: used for the applet's display-area (content-pane) inside a browser's window.



This is a Swing frame



Are you sure?


Hello-World Applet - Mozilla Firefox
File Edit View History Bookmarks Tools Help
HelloApplet.html

My first Java applet says:

Hello, world!

Applet HelloApplet started

Containers: top level container

- A Swing application requires a **top-level container** (a window that is not contained inside another window)
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  - **`JApplet`**: used for the applet's display-area (content-pane) inside a browser’s window.
- There are secondary containers (such as `JPanel`面板) which can be used to group and layout relevant components (布局).

Secondary containers are placed inside a top-level container or another secondary container

Building Our First Swing Program

```
import javax.swing.JFrame;

public class HelloWorld extends JFrame {
    public HelloWorld() {
        super("Our first Swing program");
    }

    public static void main(String[] args) {
        HelloWorld gui = new HelloWorld();
        gui.setDefaultCloseOperation( JFrame.EXIT_ON_CLOSE );
        gui.setSize(800, 600);
        gui.setVisible(true);
    }
}
```

Select a top-level container (mostly JFrame)

Creates a new, initially invisible Frame with the specified title.

Exit the application (process) when the close button is clicked.
Default value HIDE_ON_CLOSE hides the JFrame, but keeps the application running.

Building Our First Swing Program

```
import javax.swing.JFrame;

public class HelloWorld extends JFrame {
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        super("Our first Swing program");
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    public static void main(String[] args) {
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        gui.setVisible(true);
    }
}
```
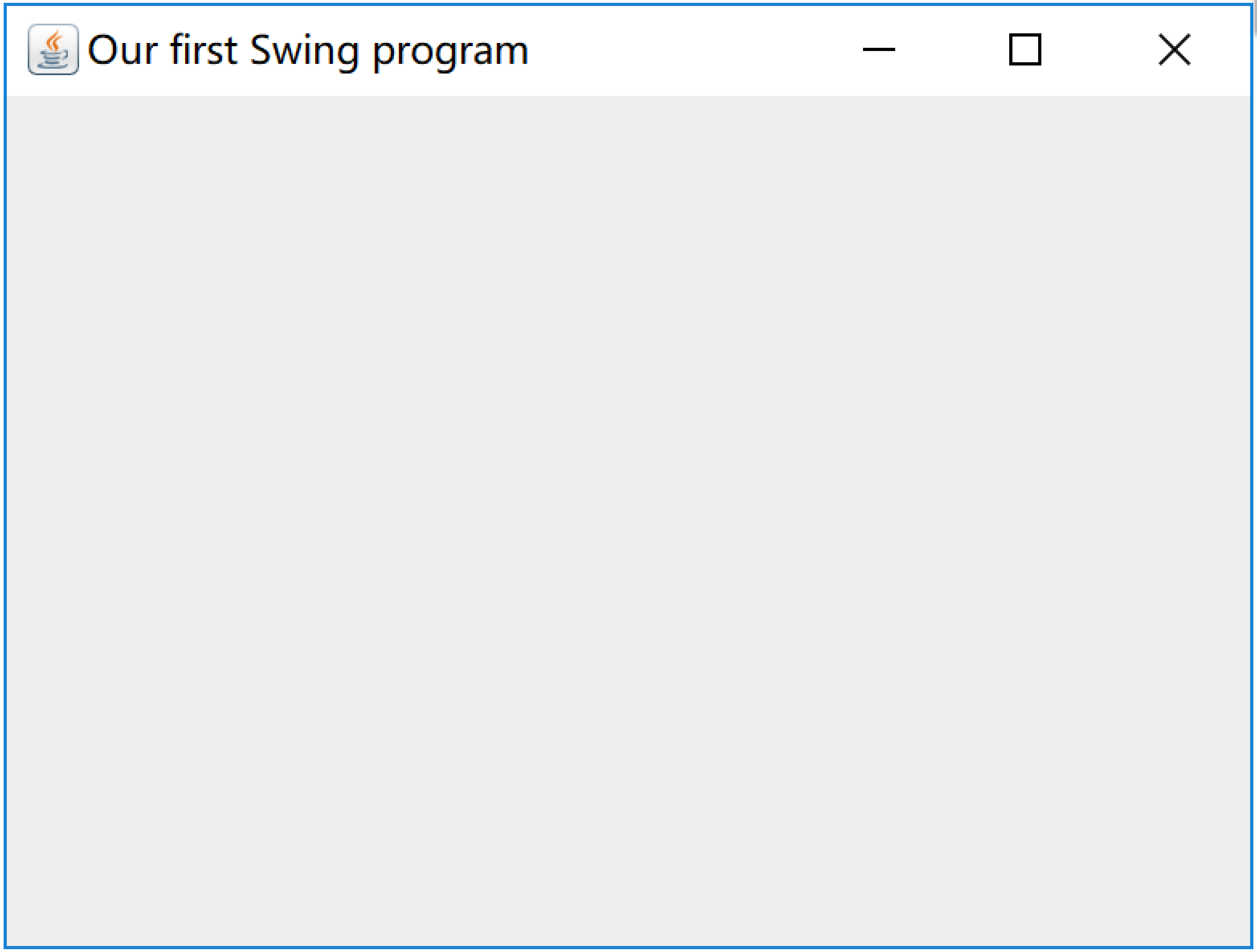
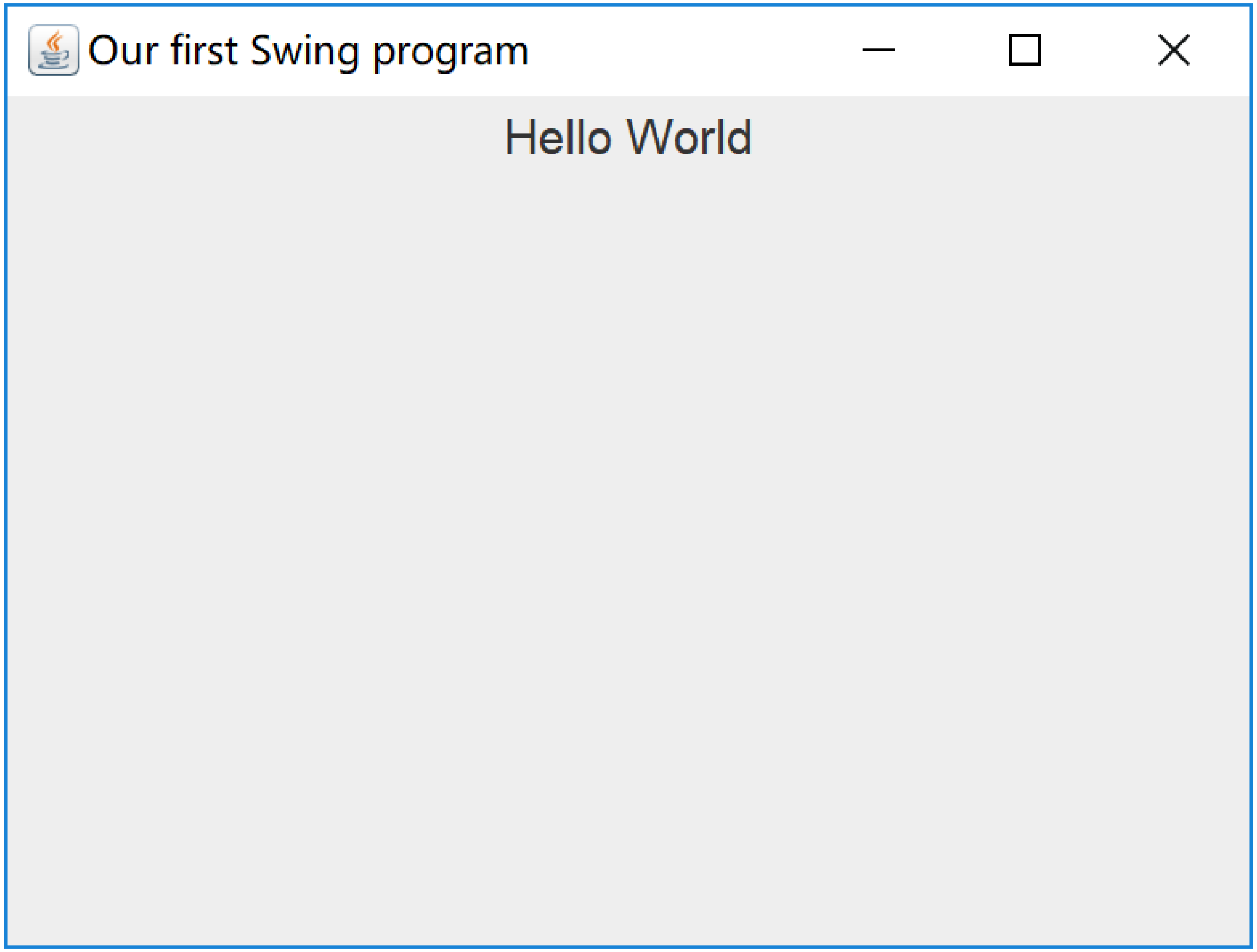

Select a top-level container (mostly JFrame)

Creates a new, initially invisible Frame with the specified title.

By default, a frame has a rather useless size of 0 × 0 pixels, which need to be resized properly

Display the JFrame


Our first Swing program



```
Hello World
```

How to add the component?

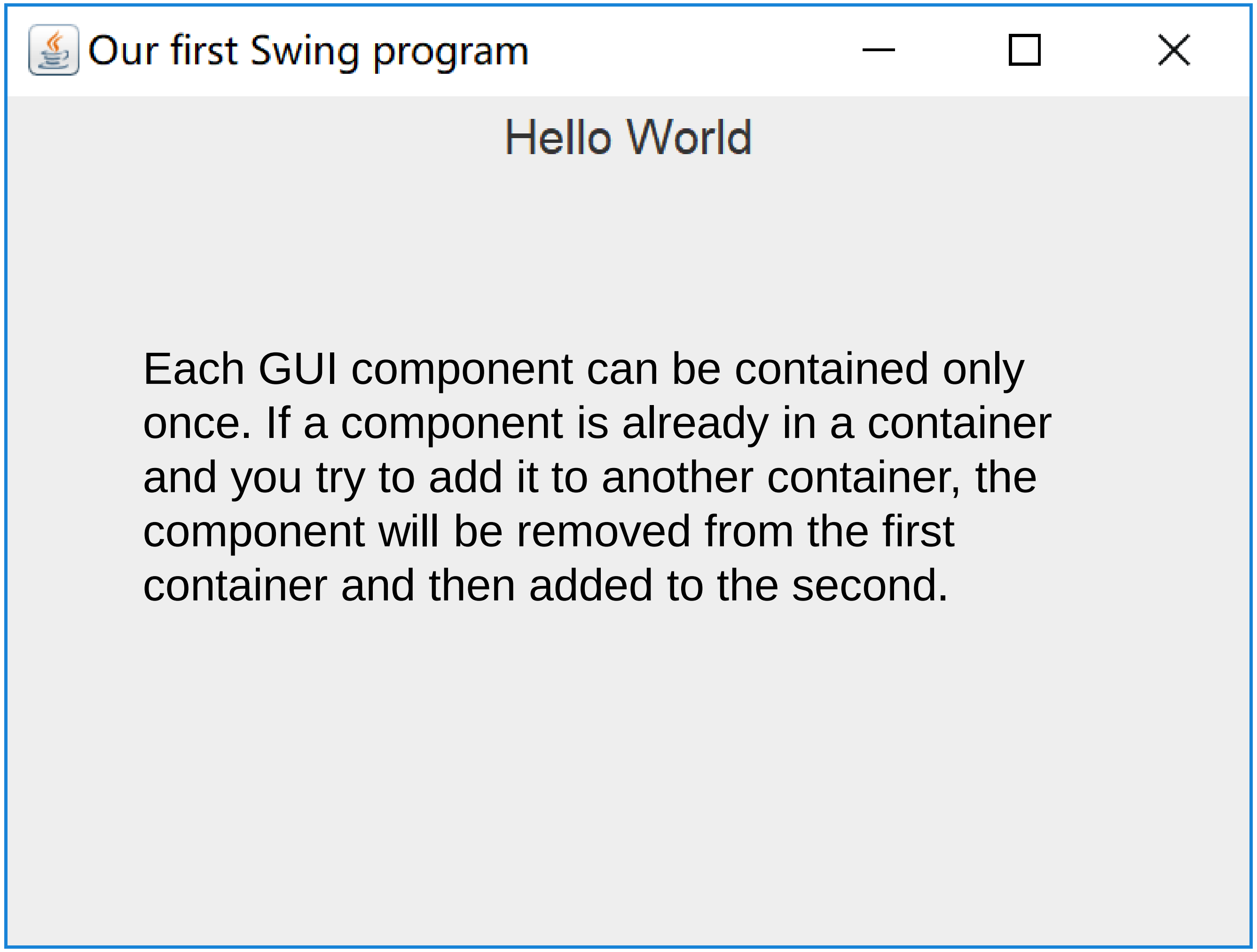
Building Our First Swing Program

```
public class HelloWorld extends JFrame {

    private JLabel label;

    public HelloWorld() {
        super("Our first Swing program");
        setLayout(new FlowLayout());
        label = new JLabel("Hello World");
        label.setFont(new Font("San Serif", Font.PLAIN, 30));
        add(label);
    }

    public static void main(String[] args) { // same as earlier }
}
```

Declaring GUI components as fields makes it easier to interact with the corresponding objects

Specifying layout (how to position GUI components)

Creating GUI component (a label here) and add it to the JFrame (actually its content pane)

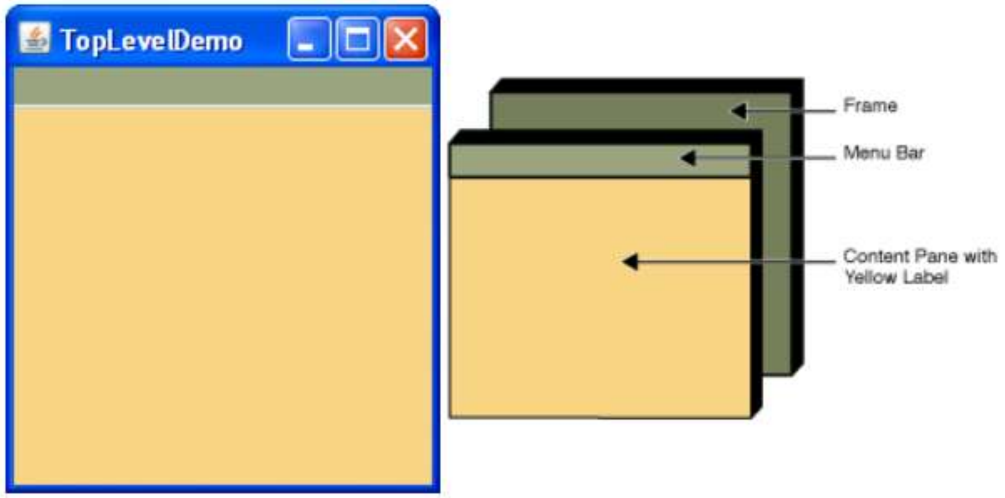


Hello World

Each GUI component can be contained only once. If a component is already in a container and you try to add it to another container, the component will be removed from the first container and then added to the second.

Content Pane

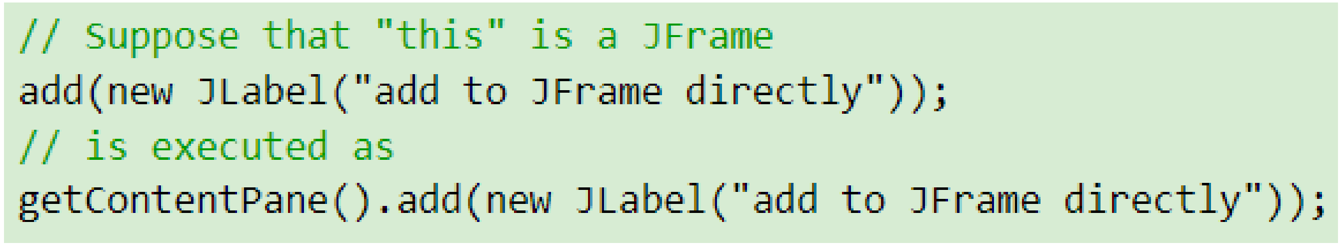
- `JComponents` shall not be added onto the top-level container (e.g., `JFrame, JApplet`) directly
- `JComponents` must be added onto the so-called content pane (`java.awt.Container`) of the top-level container



You can optionally add a menu bar to a top-level container. The menu bar is by convention positioned within the top-level container, but outside the content pane.

Content Pane

- `JComponents` shall not be added onto the top-level container (e.g., `JFrame, JApplet`) directly
- `JComponents` must be added onto the so-called content pane (`java.awt.Container`) of the top-level container
- If a component is added "directly" into a `JFrame`, it is actually added into the content-pane of `JFrame` instead



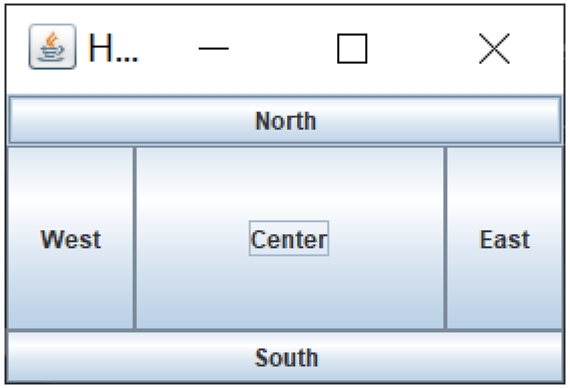
```
// Suppose that "this" is a JFrame
add(new JLabel("add to JFrame directly"));
// is executed as
getContentPane().add(new JLabel("add to JFrame directly"));
```

https://www3.ntu.edu.sg/home/ehchua/programming/java/j4a_gui.html#zz-8.

JPanel

JPanel is a container that can store a group of components and organize components in various layouts

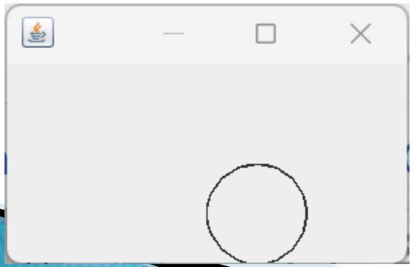
```
public class JPanelTest {
   public static void main(String[] args) {
      JFrame frame = new JFrame("Hello World");

      //Create a panel and add components to it.
      JPanel panel = new JPanel(new BorderLayout());
      panel.add(new JButton("North"), BorderLayout.NORTH);
      panel.add(new JButton("South"), BorderLayout.SOUTH);
      panel.add(new JButton("West"), BorderLayout.WEST);
      panel.add(new JButton("East"), BorderLayout.EAST);
      panel.add(new JButton("Center"), BorderLayout.CENTER);

      frame.setContentPane(panel);
      frame.setSize(300,200);
      frame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
      frame.setVisible(true);
   }
```



Draw a Component

- To draw on a component, you define a class that extends `JComponent` and override the `paintComponent` method in that class.
- The `paintComponent` method takes one parameter of type `Graphics`, which has methods that draw patterns, images, and text.

Measurement on a Graphics object for screen display is done in pixels. The (0, 0) coordinate denotes the top left corner of the component on whose surface you are drawing.



```
public class GraphicsDemo {
   public static void main(String[] args) {
         JFrame frame = new JFrame();
         MyCircle circle = new MyCircle();
         frame.add(circle);
         frame.pack();
         frame.setVisible(true);
   }
}

class MyCircle extends JComponent{
   int X = 100;
   int Y = 50;

   @Override
   public void paintComponent(Graphics g){
      g.drawOval(X,Y,50,50);
   }

   @Override
   public Dimension getPreferredSize(){
      return new Dimension(200, 100);
   }
}
```

Draw a Component

- Never call the `paintComponent` method yourself. It is called automatically whenever a part of your application needs to be redrawn, and you should not interfere with this automatic process.

- What sorts of actions trigger this automatic response? For example,
  - Painting occurs when the user increases the size of the window
  - When users minimizes and then restores the window.

```
public class GraphicsDemo {
    public static void main(String[] args) {
          JFrame frame = new JFrame();
          MyCircle circle = new MyCircle();
          frame.add(circle);
          frame.pack();
          frame.setVisible(true);
    }
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class MyCircle extends JComponent{
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    @Override
    public Dimension getPreferredSize(){
        return new Dimension(200, 100);
    }
}
```

Draw a Component

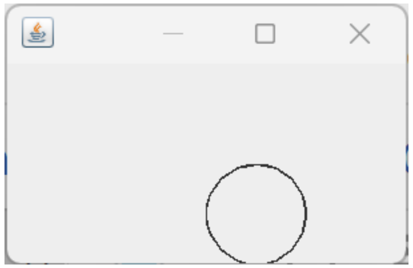
- Never call the `paintComponent` method yourself. It is called automatically whenever a part of your application needs to be redrawn, and you should not interfere with this automatic process.

- If you need to force repainting of the screen, call the `repaint()` method instead of paintComponent. The `repaint()` method will cause paintComponent to be called for all components, with a properly configured Graphics object.

```
public class GraphicsDemo {
    public static void main(String[] args) {
        JFrame frame = new JFrame();
        MyCircle circle = new MyCircle();
        frame.add(circle);
        frame.pack();
        frame.setVisible(true);
    }
}

class MyCircle extends JComponent{
    int X = 100;
    int Y = 50;

    @Override
    public void paintComponent(Graphics g){
        g.drawOval(X,Y,50,50);
    }

    @Override
    public Dimension getPreferredSize(){
        return new Dimension(200, 100);
    }
}
```

Draw a Component

- A component should tell its users how big it would like to be. Override the `getPreferredSize` method and return an object of the `Dimension` class with the preferred width and height
- When you fill a frame with one or more components, and you simply want to use their preferred size, call the `pack` method instead of the setSize method



```
public class GraphicsDemo {
    public static void main(String[] args) {
          JFrame frame = new JFrame();
          MyCircle circle = new MyCircle();
          frame.add(circle);
          frame.pack();
          frame.setVisible(true);
    }
}

class MyCircle extends JComponent{
    int X = 100;
    int Y = 50;

    @Override
    public void paintComponent(Graphics g){
        g.drawOval(X,Y,50,50);
    }

    @Override
    public Dimension getPreferredSize(){
        return new Dimension(200, 100);
    }
}
```

Dialogs (对话框)

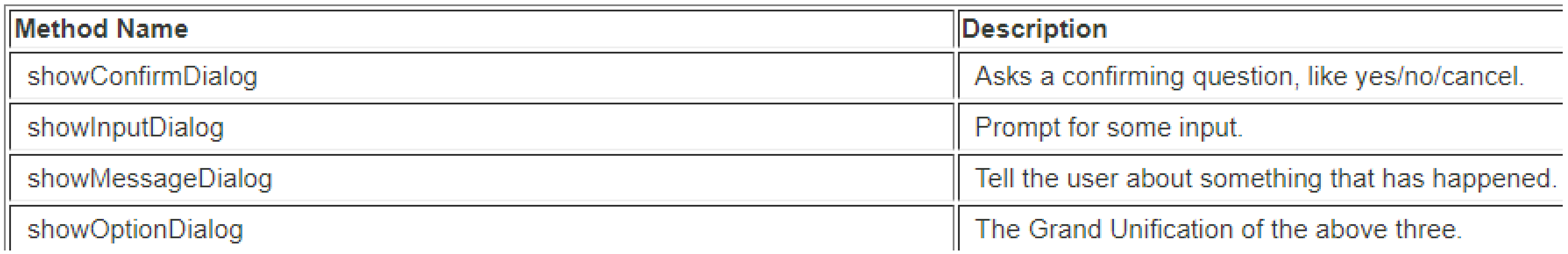
- A Dialog window is an independent sub window meant to carry temporary notice apart from the main Swing Application Window
- Most Dialogs present an error message or warning to a user, but Dialogs can present images, directory trees, or just about anything compatible with the main Swing Application that manages them.

- To create simple, standard dialogs (标准对话框), you use the `JOptionPane` class
- To create a custom dialog (自定义对话框), use the `JDialog` class directly.

https://docs.oracle.com/javase/tutorial/uiswing/components/dialog.html

JOptionPane

- `JOptionPane` is a widely-used Swing class for popping up a dialog box that prompts users for a value or informs them of something.
- Commonly used static methods



Method Name	Description
showConfirmDialog	Asks a confirming question, like yes/no/cancel.
showInputDialog	Prompt for some input.
showMessageDialog	Tell the user about something that has happened.
showOptionDialog	The Grand Unification of the above three.

JOptionPane

- `JOptionPane` is a widely-used Swing class for popping up a dialog box that prompts users for a value or informs them of something.

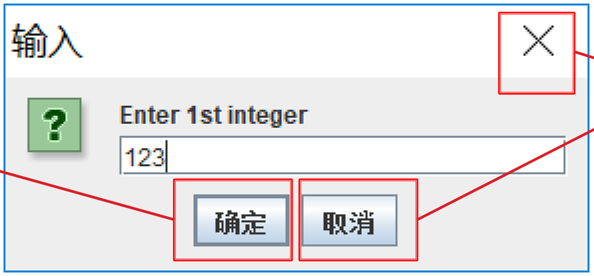
```
public static void main(String[] args) {
    String str1 = JOptionPane.showInputDialog("Enter 1st integer");
    String str2 = JOptionPane.showInputDialog("Enter 2nd integer");
    int num1 = Integer.parseInt(str1);
    int num2 = Integer.parseInt(str2);
    int sum = num1 + num2;
    JOptionPane.showMessageDialog(null, num1 + " + " + num2 + " = " + sum);
}
```

JOptionPane

- `JOptionPane` is a widely-used Swing class for popping up a dialog box that prompts users for a value or informs them of something.

Static method `showInputDialog()` prompts for user input

```
public static void main(String[] args) {
    String str1 = JOptionPane.showInputDialog("Enter 1st integer");
    String str2 = JOptionPane.showInputDialog("Enter 2nd integer");
    int num1 = Integer.parseInt(str1);
    int num2 = Integer.parseInt(str2);
    int sum = num1 + num2;
    JOptionPane.showMessageDialog(null, num1 + " + " + num2 + " = " + sum);
}
```



"123" will be read as a string

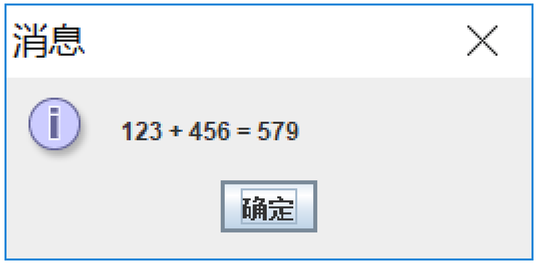
`null` will be read

JOptionPane

- JOptionPane is a widely-used Swing class for popping up a dialog box that prompts users for a value or informs them of something.

```
public static void main(String[] args) {
    String str1 = JOptionPane.showInputDialog("Enter 1st integer");
    String str2 = JOptionPane.showInputDialog("Enter 2nd integer");
    int num1 = Integer.parseInt(str1);
    int num2 = Integer.parseInt(str2);
    int sum = num1 + num2;
    JOptionPane.showMessageDialog(null, num1 + " + " + num2 + " = " + sum);
}
```

Static method showMessageDialog()
tells user about something that has happened


消息
123 + 456 = 579

Events (in GUI Programming)

- All GUI applications are event-driven.
- In GUI programming, events describe the change in the state of a GUI component when users interact with it

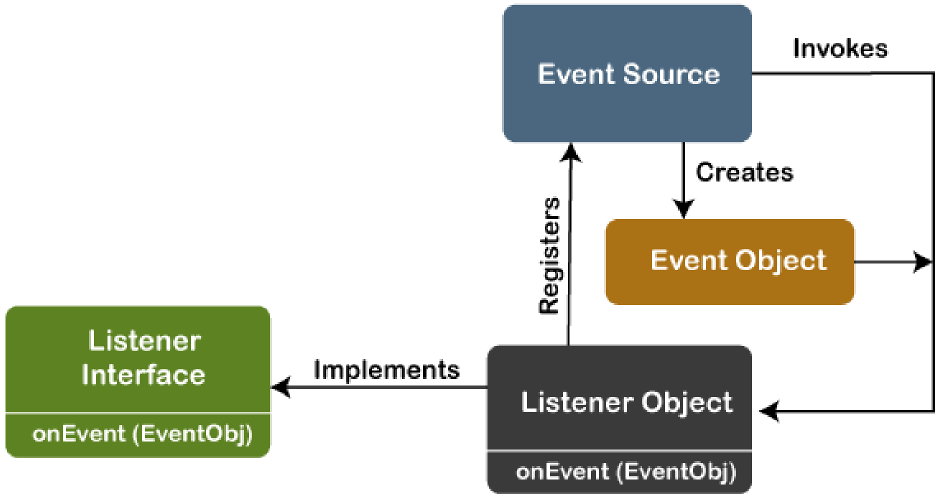
- For example, events will occur when
  - A button is clicked
  - The mouse is moved
  - A character is entered through keyboard
  - An item from a list is selected
  - …

Event Handling

- Event handling is the mechanism that controls the event and decides what should happen if an event occurs. Three key concepts:
  - **Event source (事件源):** the GUI component with which the user interacts (e.g., a button)
  - **Event object (or simply event):** encapsulate the information about the event that occurred (e.g., a MouseEvent)
  - **Event listener (事件监听器):** an object that is notified by the event source when an event occurs.
    - A method of the event listener receives an event object when the event listener is notified of the event.
    - The listener then uses the event object to respond to the event.

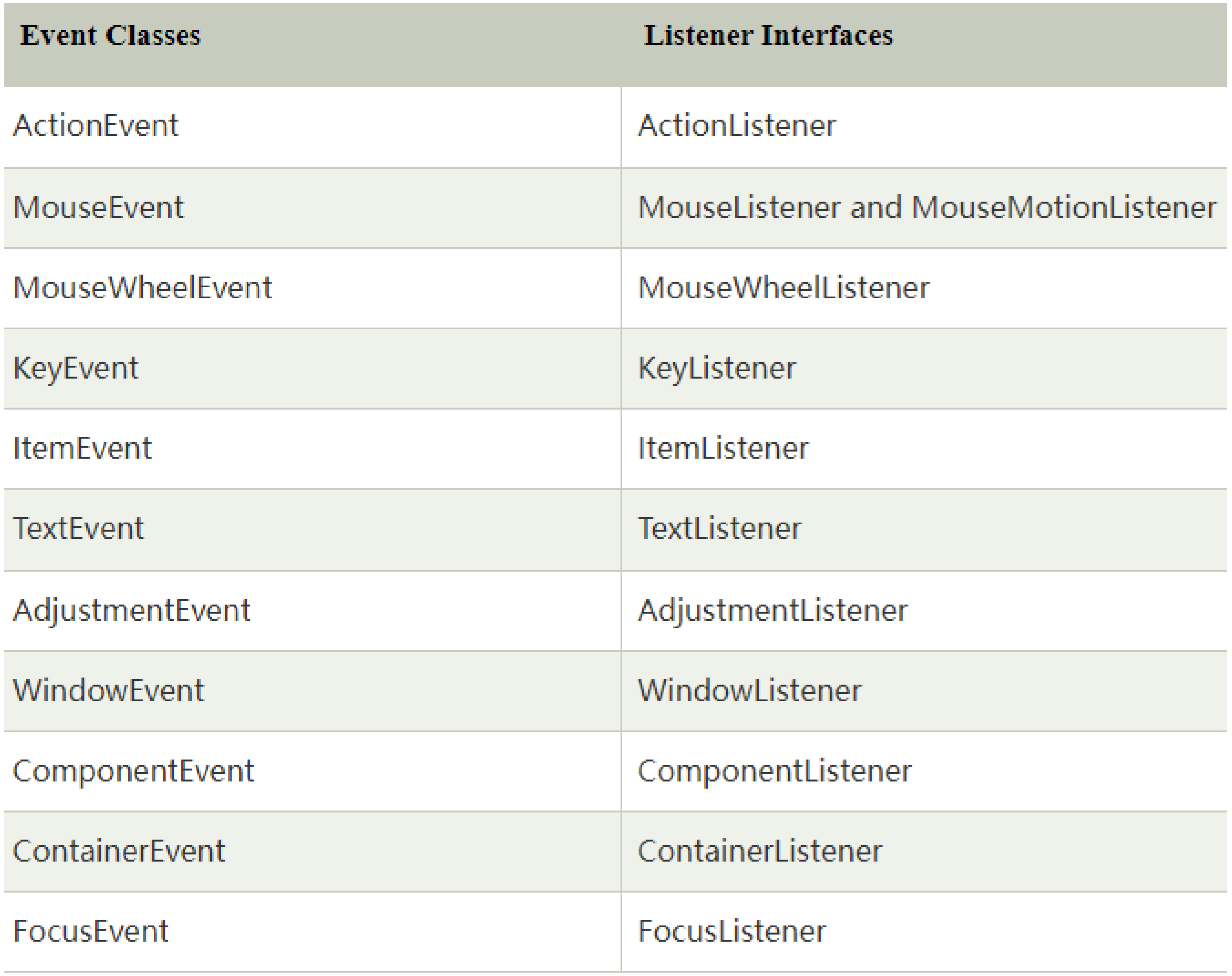
Delegation Event Model

- UI components delegate an event's processing to an event listener object
  - A source can register one or more listeners to receive notifications for specific events.
  - A source generates an event and forwards it to one or more listeners.
  - The listener waits until it receives an event, and react properly using the info in the event object



https://www.javatpoint.com/delegation-event-model-in-java

Event Classes and Listener Interfaces

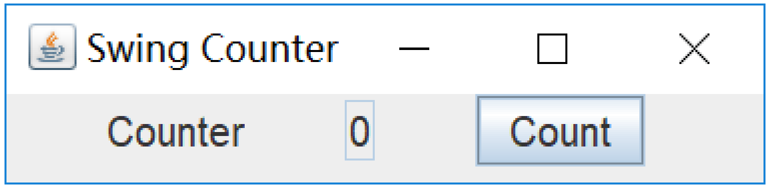


Event Classes	Listener Interfaces
ActionEvent	ActionListener
MouseEvent	MouseListener and MouseMotionListener
MouseWheelEvent	MouseWheelListener
KeyEvent	KeyListener
ItemEvent	ItemListener
TextEvent	TextListener
AdjustmentEvent	AdjustmentListener
WindowEvent	WindowListener
ComponentEvent	ComponentListener
ContainerEvent	ContainerListener
FocusEvent	FocusListener

Event Handling Example

- We use a counter program to illustrate the steps

```
public class SwingCounter extends JFrame {
    private JTextField tfCount;
    private JButton btnCount;
    private int count = 0;
    public SwingCounter() {
        setLayout(new FlowLayout(FlowLayout.LEFT, 50, 0));
        add(new JLabel("Counter"));
        tfCount = new JTextField("0");
        tfCount.setEditable(false); add(tfCount);
        btnCount = new JButton("Count"); add(btnCount);
    }
    public static void main(String[] args) { SwingCounter sc = new SwingCounter(); ... }
}
```



Nothing will happen when we click the button (we have not handled the event yet)

Event Handling Example

- **Step 1:** check what event will occur when JButton is clicked
- An `ActionEvent` (in `java.awt.event` package) will occur whenever the user performs a component-specific action on a GUI component
  - When user clicks a button
  - When user chooses a menu item
  - When user presses Enter after typing something in a text field…

Event Handling Example

- **Step 2:** define the event listener class by implementing the corresponding listener interface

```
public class ButtonClickListener implements ActionListener {

    @Override
    public void actionPerformed(ActionEvent arg0) {
        // code to react to the event
    }

}
```

`ActionListener` is from the package `java.awt.event`

Event Handling Example

- The event listener class is often declared as an inner class

```
public class SwingCounter extends JFrame {

    private JTextField tfCount;
    private JButton btnCount;
    private int count = 0;

    public class ButtonClickListener implements ActionListener {
        @Override
        public void actionPerformed(ActionEvent arg0) {
            ++count;  tfCount.setText(count + "");
        }

    }
}
```

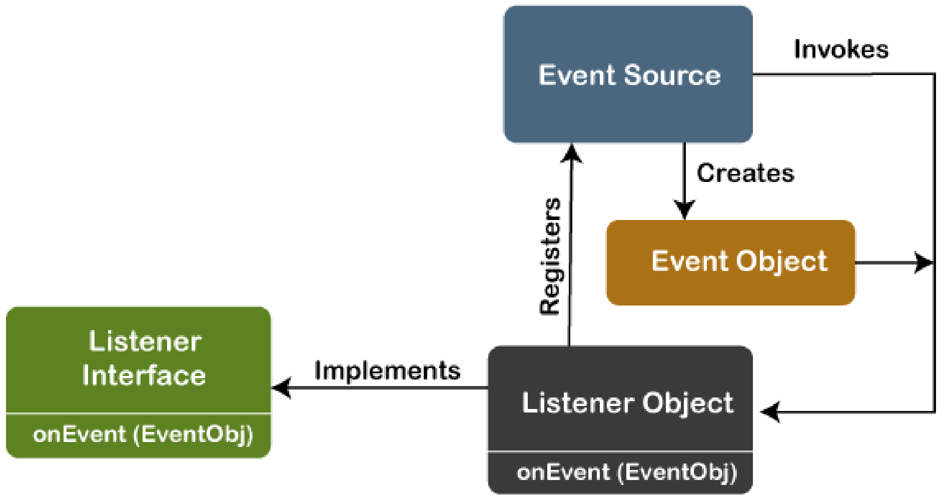
An inner class is a proper class. It can have constructors, fields, methods …

An inner class is a member of the outer class. Therefore, it can access the private members of the outer class **(this is very useful)**

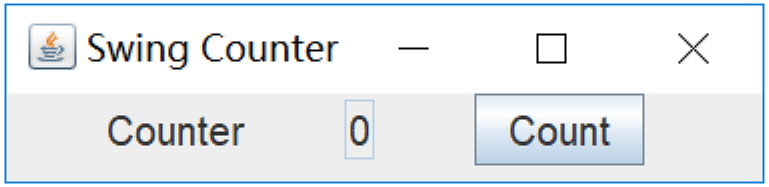
Event Handling Example

- **Step 3:** register an instance of the event listener class as a listener on the corresponding GUI component (event source)

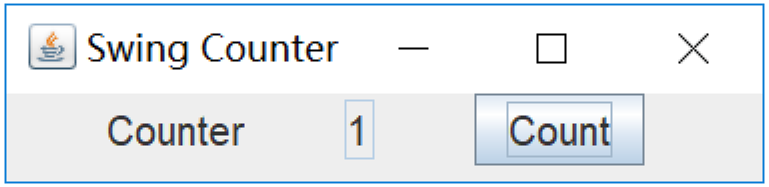
```
btnCount.addActionListener(new ButtonClickListener());
```



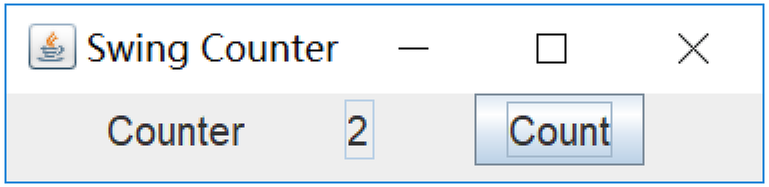
```
public class SwingCounter extends JFrame {
    private JTextField tfCount;
    private JButton btnCount;  ←—— Event source
    private int count = 0;
    public SwingCounter() {
        setLayout(new FlowLayout(FlowLayout.LEFT, 50, 0));
        add(new JLabel("Counter"));
        tfCount = new JTextField("0");
        tfCount.setEditable(false); add(tfCount);
        btnCount = new JButton("Count"); add(btnCount);
        btnCount.addActionListener(new ButtonClickListener());←—— Event listener
    }
    public class ButtonClickListener implements ActionListener {
        @Override
        public void actionPerformed(ActionEvent arg0) {
            count++; tfCount.setText(count + "");          ↑
        }
                                                Event object will be passed here
    }
    public static void main(String[] args) { … }
}
```



Initial state

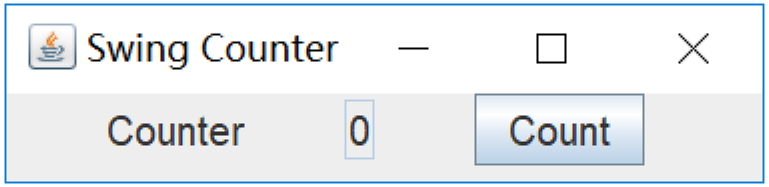


After one click

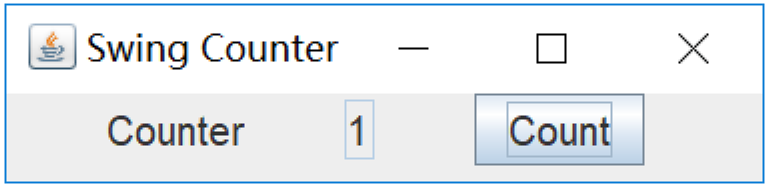


After two clicks

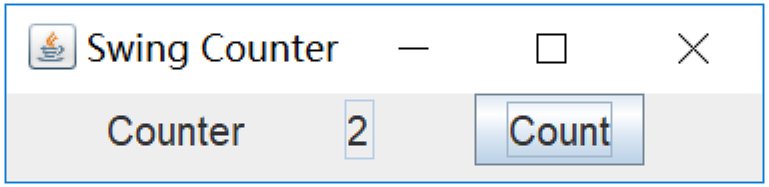
. . .



After 10 clicks



After 11 clicks



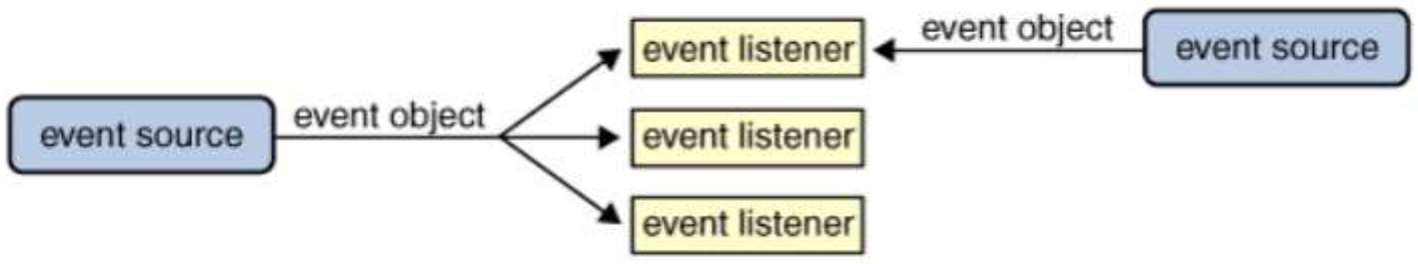
After 12 clicks

. . .

What's the problem?

Event Listeners

- A program can have one or more listeners for a single kind of event from a single event source.
- A program might have a single listener for all events from all sources (e.g., the calculator buttons).



https://docs.oracle.com/javase/tutorial/uiswing/events/intro.html

Implementing Event Listeners

- Inner class
  - A class defined within another class (outer class)
  - If a class is useful to only one other class, then it is logical to embed it in that class and keep the two together. Nesting such "helper classes" makes their package more streamlined.
  - An inner class can access private members of the outer class
- Anonymous class
- Lambda expression

Implementing Event Listeners

- Anonymous class
  - Anonymous classes are inner classes with no name
  - We need to declare and instantiate anonymous classes in a single expression at the point of use.

$$\text{new } \underbrace{\text{InterfaceName}()}_{\text{name of the interface to implement}}\ \underbrace{\{...\}}_{\text{methods' implementations}}$$

```
btnCount.addActionListener(new ButtonClickListener());


public class ButtonClickListener implements ActionListener {
    @Override
    public void actionPerformed(ActionEvent arg0) {
        ++count;
        tfCount.setText(count + "");
    }
}
```

```
btnCount.addActionListener(new ActionListener() {
    @Override
    public void actionPerformed(ActionEvent e) {
        ++count;
        tfCount.setText(count + "");
    }
});
```

Implementing Event Listeners

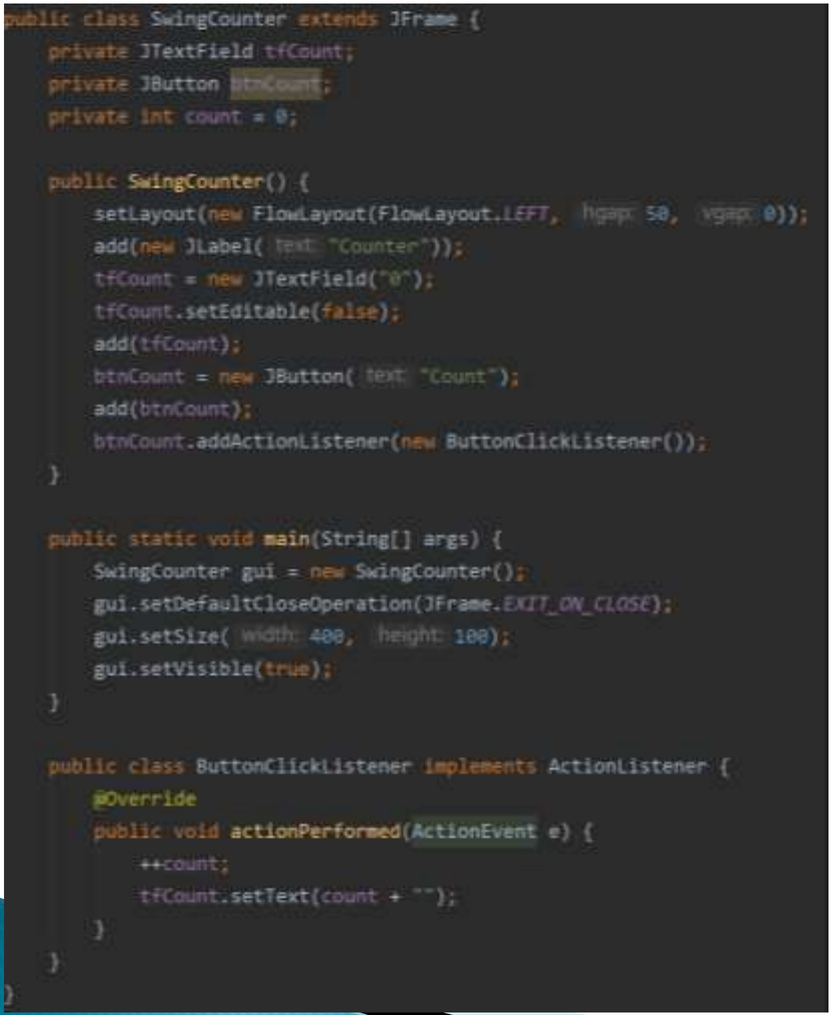
- Lambda Expression
  - To implement interfaces that have just one method, we could use lambda expressions

```
public interface ActionListener extends EventListener {

    public void actionPerformed(ActionEvent e);

}
```

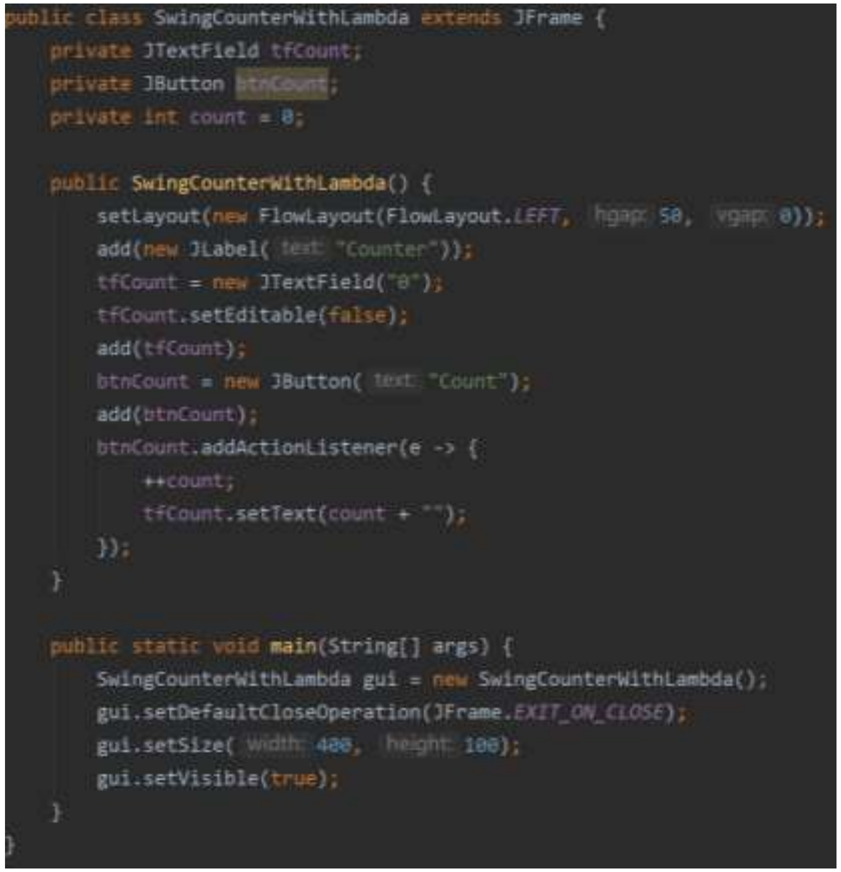
```
btnCount.addActionListener(new ActionListener() {
    @Override
    public void actionPerformed(ActionEvent e) {
        ++count;
        tfCount.setText(count + "");
    }
});
```

```
btnCount.addActionListener(e -> {
    ++count;
    tfCount.setText(count + "");
});
```

Simplifying code with lambda expressions



```
public class SwingCounter extends JFrame {
    private JTextField tfCount;
    private JButton btnCount;
    private int count = 0;

    public SwingCounter() {
        setLayout(new FlowLayout(FlowLayout.LEFT,  hgap: 50,  vgap: 0));
        add(new JLabel( text: "Counter"));
        tfCount = new JTextField("0");
        tfCount.setEditable(false);
        add(tfCount);
        btnCount = new JButton( text: "Count");
        add(btnCount);
        btnCount.addActionListener(new ButtonClickListener());
    }

    public static void main(String[] args) {
        SwingCounter gui = new SwingCounter();
        gui.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
        gui.setSize( width: 400,  height: 100);
        gui.setVisible(true);
    }

    public class ButtonClickListener implements ActionListener {
        @Override
        public void actionPerformed(ActionEvent e) {
            ++count;
            tfCount.setText(count + "");
        }
    }
}
```



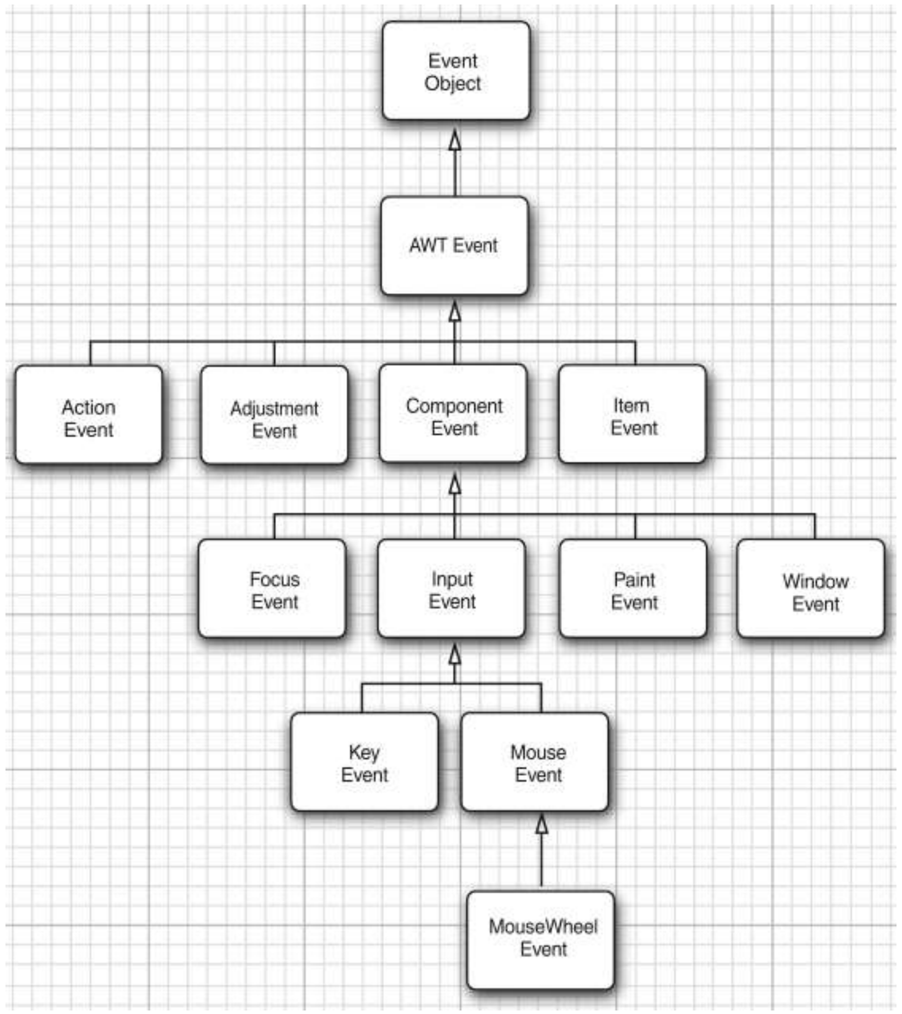
```
public class SwingCounterWithLambda extends JFrame {
    private JTextField tfCount;
    private JButton btnCount;
    private int count = 0;

    public SwingCounterWithLambda() {
        setLayout(new FlowLayout(FlowLayout.LEFT,  hgap: 50,  vgap: 0));
        add(new JLabel( text: "Counter"));
        tfCount = new JTextField("0");
        tfCount.setEditable(false);
        add(tfCount);
        btnCount = new JButton( text: "Count");
        add(btnCount);
        btnCount.addActionListener(e -> {
            ++count;
            tfCount.setText(count + "");
        });
    }

    public static void main(String[] args) {
        SwingCounterWithLambda gui = new SwingCounterWithLambda();
        gui.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
        gui.setSize( width: 400,  height: 100);
        gui.setVisible(true);
    }
}
```

In Java, you can use Lambda expressions to simplify classes that implement interfaces that have just one method

The AWT Event Hierarchy

- The event objects encapsulate information about the event that the event source communicates to its listeners.

- When necessary, you can then analyze the event objects that were passed to the listener object



Reference: Core Java, Volume I. Chapter 10.4

Semantic & Low-level Events

- Semantic events: expresses what the user is doing
  - `ActionEvent`: e.g., button click, menu selection
  - `AdjustmentEvent`: e.g., adjust a scrollbar
  - `ItemEvent`: e.g., selecting from a list item or checkbox

- Low-level events: events that make semantic events possible
  - `KeyEvent`: e.g., a key is pressed or released
  - `MouseEvent`: e.g., a mouse is pressed, moved, or dragged
  - `MouseWheelEvent`
  - `FocusEvent`
  - `WindowEvent`

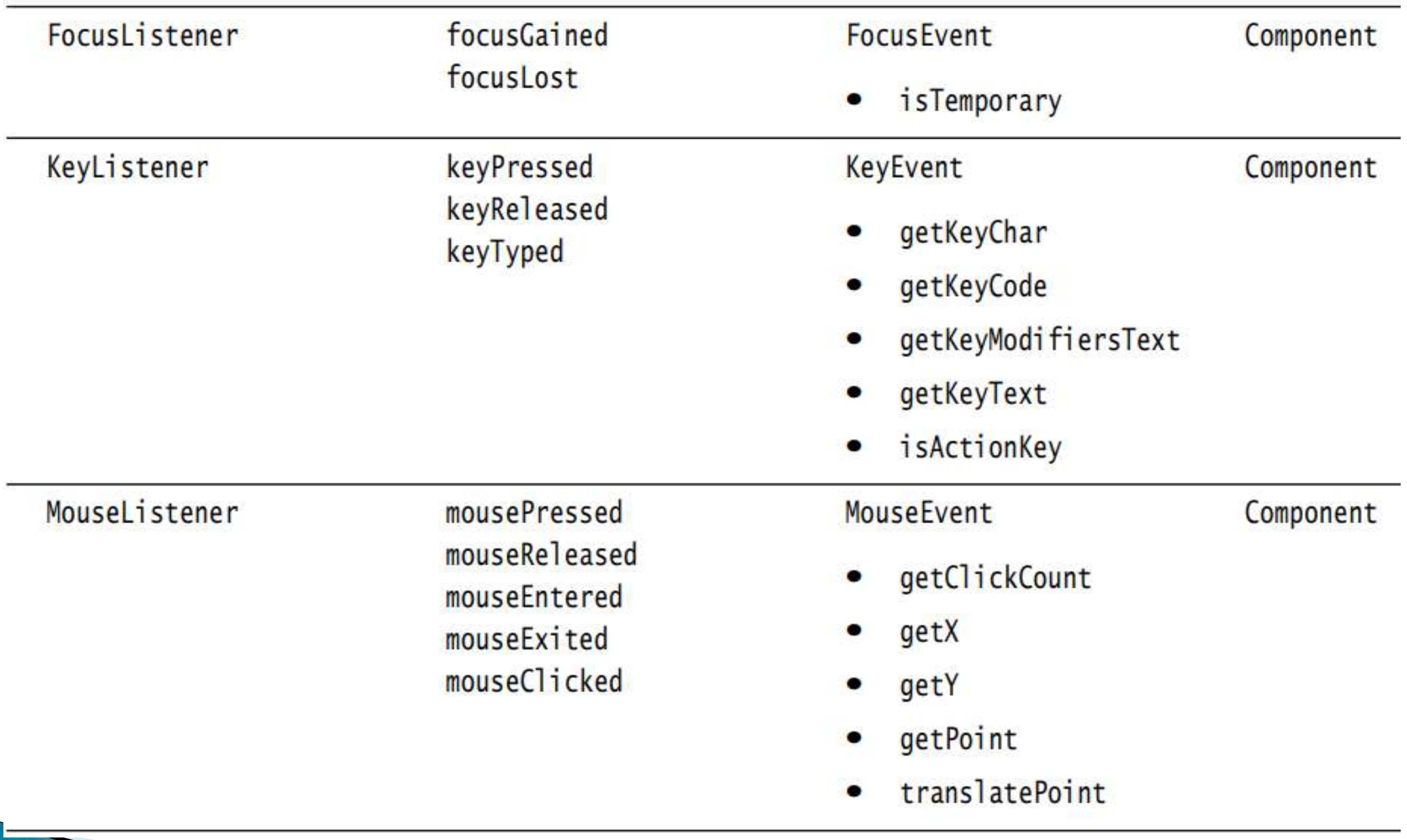
Reference: Core Java, Volume I. Chapter 10.4

Semantic & Low-level Events

Interface	Methods	Parameter/Accessors	Events Generated By
ActionListener	actionPerformed	ActionEvent • getActionCommand • getModifiers	AbstractButton JComboBox JTextField Timer
AdjustmentListener	adjustmentValueChanged	AdjustmentEvent • getAdjustable • getAdjustmentType • getValue	JScrollbar
ItemListener	itemStateChanged	ItemEvent • getItem • getItemSelectable • getStateChange	AbstractButton JComboBox

Reference: Core Java, Volume I. Chapter 10.4

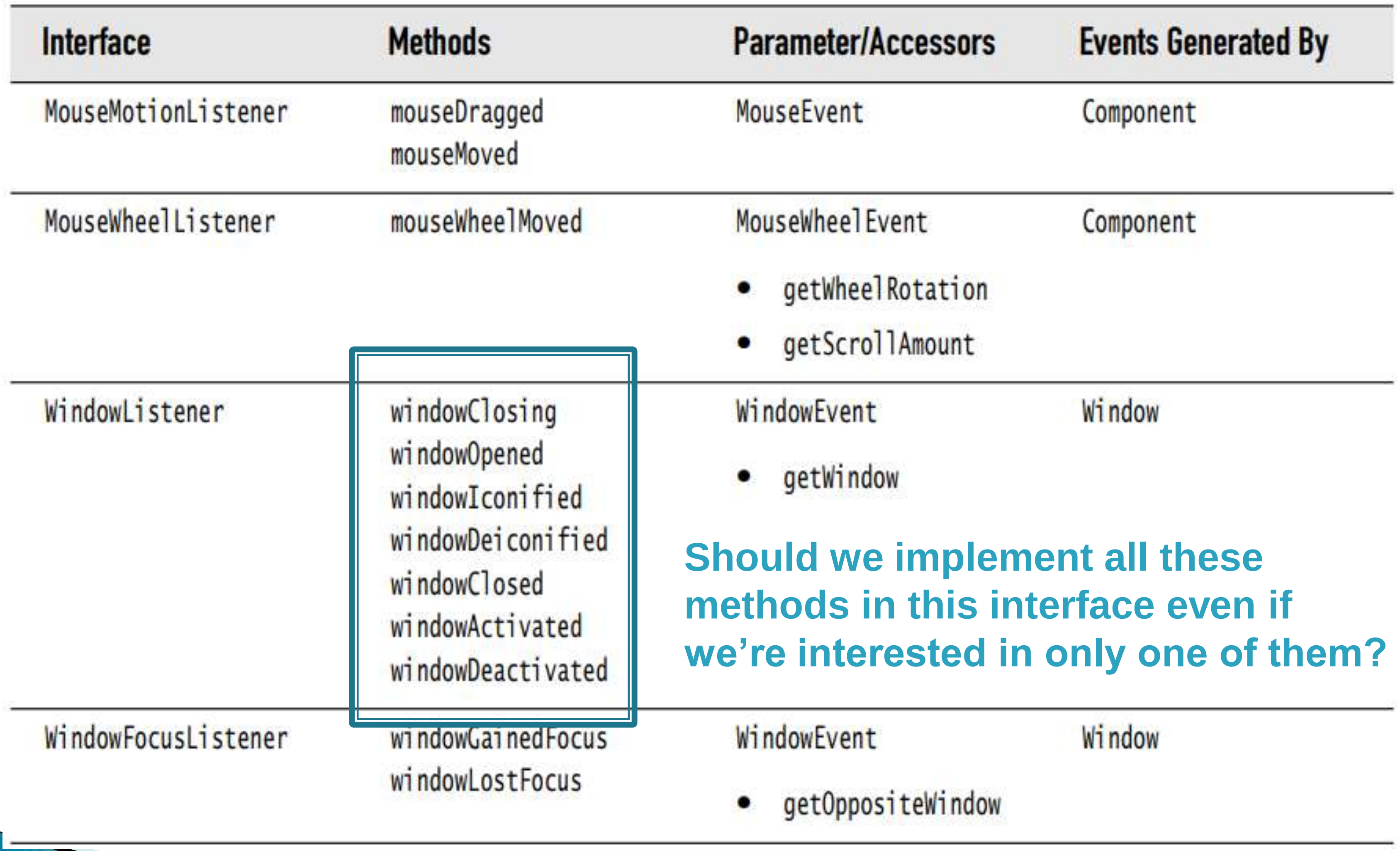
Semantic & Low-level Events



FocusListener	focusGained focusLost	FocusEvent • isTemporary	Component
KeyListener	keyPressed keyReleased keyTyped	KeyEvent • getKeyChar • getKeyCode • getKeyModifiersText • getKeyText • isActionKey	Component
MouseListener	mousePressed mouseReleased mouseEntered mouseExited mouseClicked	MouseEvent • getClickCount • getX • getY • getPoint • translatePoint	Component

Reference: Core Java, Volume I. Chapter 10.4

Semantic & Low-level Events



Interface	Methods	Parameter/Accessors	Events Generated By
MouseMotionListener	mouseDragged mouseMoved	MouseEvent	Component
MouseWheelListener	mouseWheelMoved	MouseWheelEvent • getWheelRotation • getScrollAmount	Component
WindowListener	windowClosing windowOpened windowIconified windowDeiconified windowClosed windowActivated windowDeactivated	WindowEvent • getWindow	Window
WindowFocusListener	windowGainedFocus windowLostFocus	WindowEvent • getOppositeWindow	Window

Should we implement all these methods in this interface even if we're interested in only one of them?

Reference: Core Java, Volume I. Chapter 10.4

Adapter Class

- Each AWT listener interface that has more than one method comes with a companion adapter class, which implements all methods in the interface but does nothing with them

- For example, `WindowAdapter` is an abstract adapter class for receiving window events. The methods in this class are empty. This class exists as convenience for creating listener objects.

Reference: Core Java, Volume I. Chapter 10.4

Adapter Class

- Extend this class to create a `WindowEvent` listener and override the methods for the events of interest.

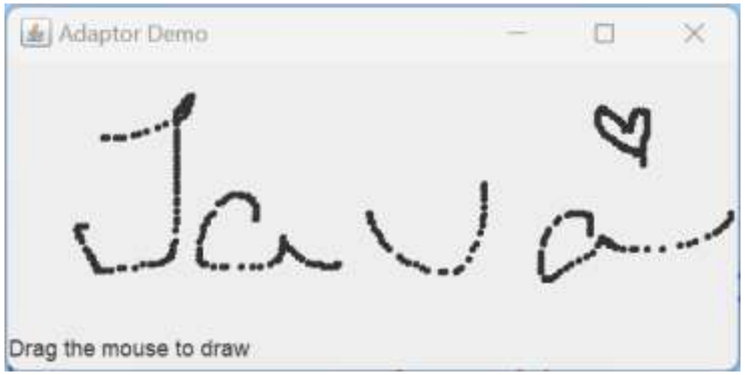
- If you implement the `WindowListener` interface, you have to define all of the methods in it. This abstract class defines null methods for them all, so you can only have to define methods for events you care about.

```
class Terminator extends WindowAdapter
{
   public void windowClosing(WindowEvent e)
   {
      if (user agrees)
         System.exit(0);
   }
}
```

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

Reference: Core Java, Volume I. Chapter 10.4

Adaptor Example



Drag the mouse to draw

```
public class AdaptorDemo {
    public static void main(String[] args) {
        JFrame frame = new JFrame("Adaptor Demo");

        PaintPanel paintPanel = new PaintPanel();
        frame.add(paintPanel, BorderLayout.CENTER);

        frame.add(new Label("Drag the mouse to draw"),
                                          BorderLayout.SOUTH);

        frame.setSize(400,200);
        frame.setVisible(true);
    }
}
```

Adaptor Example

- Class `PaintPanel` extends `JPanel` to create the dedicated drawing area.
- We use an `ArrayList` of `Point (java.awt)` to store the location at which each mouse drag event occurs

```
class PaintPanel extends JPanel{
    private ArrayList<Point> points = new ArrayList<>();

    PaintPanel(){
        addMouseMotionListener(new MouseMotionAdapter() {
            @Override
            public void mouseDragged(MouseEvent e) {
                points.add(e.getPoint());
                repaint();
            }
        });
    }

    @Override
    public void paintComponent(Graphics g){

        super.paintComponent(g);

        for(Point point: points){
            g.fillOval(point.x, point.y,4,4);
        }
    }
}
```

Adaptor Example

```
class PaintPanel extends JPanel{
    private ArrayList<Point> points = new ArrayList<>();

    PaintPanel(){
        addMouseMotionListener(new MouseMotionAdapter() {
            @Override
            public void mouseDragged(MouseEvent e) {
                points.add(e.getPoint());
                repaint();
            }
        });
    }

    @Override
    public void paintComponent(Graphics g){

        super.paintComponent(g);

        for(Point point: points){
            g.fillOval(point.x, point.y,4,4);
        }
    }
}
```

Register a `MouseMotionListener` to listen for the `PaintPanel`'s mouse motion events.

Override method `mouseDragged`: invoke the `MouseEvent`'s `getPoint()` to obtain the Point where the event occurred and stores it in the ArrayList.

Create an object of an anonymous inner class that extends the adapter class `MouseMotionAdapter` which implements `MouseMotionListener`

Adaptor Example

Calls `repaint()` (inherited indirectly from class `Component`) to indicate that the `PaintPanel` should be refreshed on the screen as soon as possible with a call to the `PaintPanel`'s `paintComponent` method.

Invoke the superclass version of `paintComponent` to clear the `PaintPanel`'s background

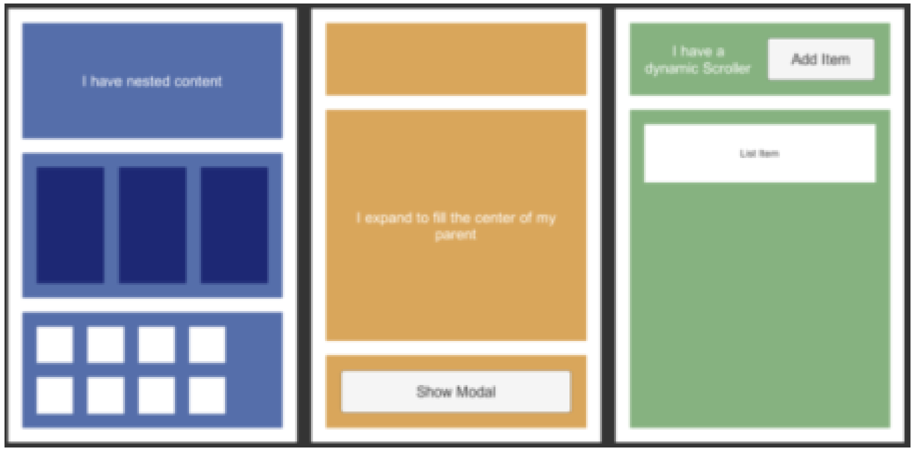
Draw a solid oval at the location specified by each Point in the ArrayList.

```
class PaintPanel extends JPanel{
    private ArrayList<Point> points = new ArrayList<>();

    PaintPanel(){
        addMouseMotionListener(new MouseMotionAdapter() {
            @Override
            public void mouseDragged(MouseEvent e) {
                points.add(e.getPoint());
                repaint();
            }
        });
    }

    @Override
    public void paintComponent(Graphics g){

        super.paintComponent(g);

        for(Point point: points){
            g.fillOval(point.x, point.y,4,4);
        }
    }
}
```

Layout Management (布局管理)

- Layout managers control how to place the GUI components (containers can also be treated as components) in a container for presentation purposes.

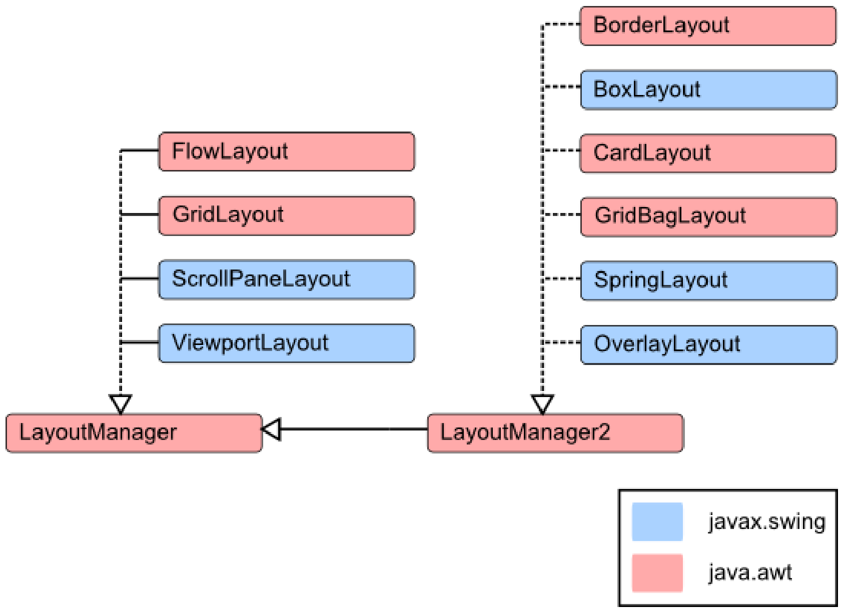
- You can use the layout manager for basic layout capabilities instead of determine every GUI component's exact position and size (which is non-trivial and error-prone)


I have nested content
I expand to fill the center of my parent
Show Modal
I have a dynamic Scroller
Add Item
List Item

Layout Management (布局管理)

- All layout managers in Java implement the interface `LayoutManager` (in the package `java.awt`)

- Commonly-used layout managers: `FlowLayout`, `BorderLayout`, `GridLayout`

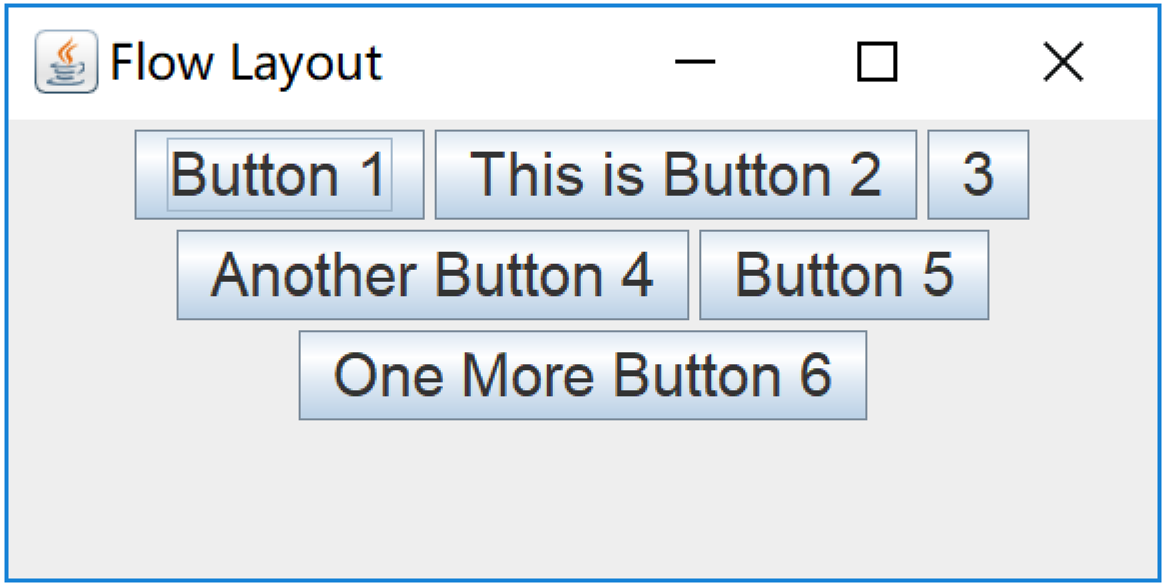


https://www.mathematik.uni-marburg.de/~thormae/lectures/graphics1/graphics_2_2_eng_web.html#1

FlowLayout

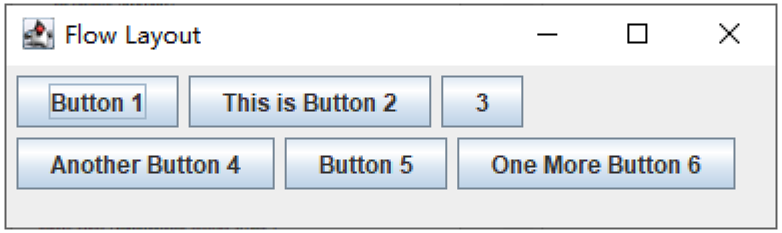
```
public class FlowLayoutDemo extends JFrame {
    private JButton btn1, btn2, btn3, btn4, btn5, btn6;

    public FlowLayoutDemo() {
        super("Flow Layout");
        setLayout(new FlowLayout());
        btn1 = new JButton("Button 1"); add(btn1);
        btn2 = new JButton("This is Button 2"); add(btn2);
        btn3 = new JButton("3"); add(btn3);
        btn4 = new JButton("Another Button 4"); add(btn4);
        btn5 = new JButton("Button 5"); add(btn5);
        btn6 = new JButton("One More Button 6"); add(btn6);
    }

    public static void main(String[] args) { ... }
}
```

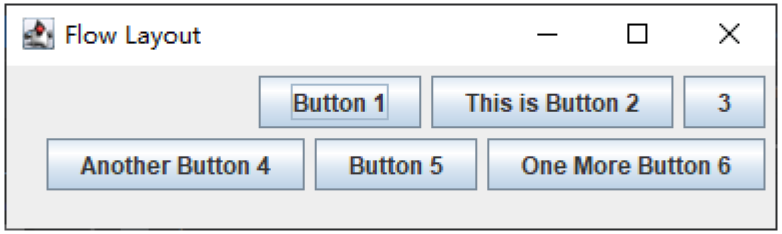
FlowLayout



- Default layout manager for the secondary container `javax.swing.JPanel`
- Places components in a straight horizontal line. If there is no enough space to fit all component into one line, simply move the next line

FlowLayout: Alignment





```
setLayout(new FlowLayout(FlowLayout.LEFT));
```

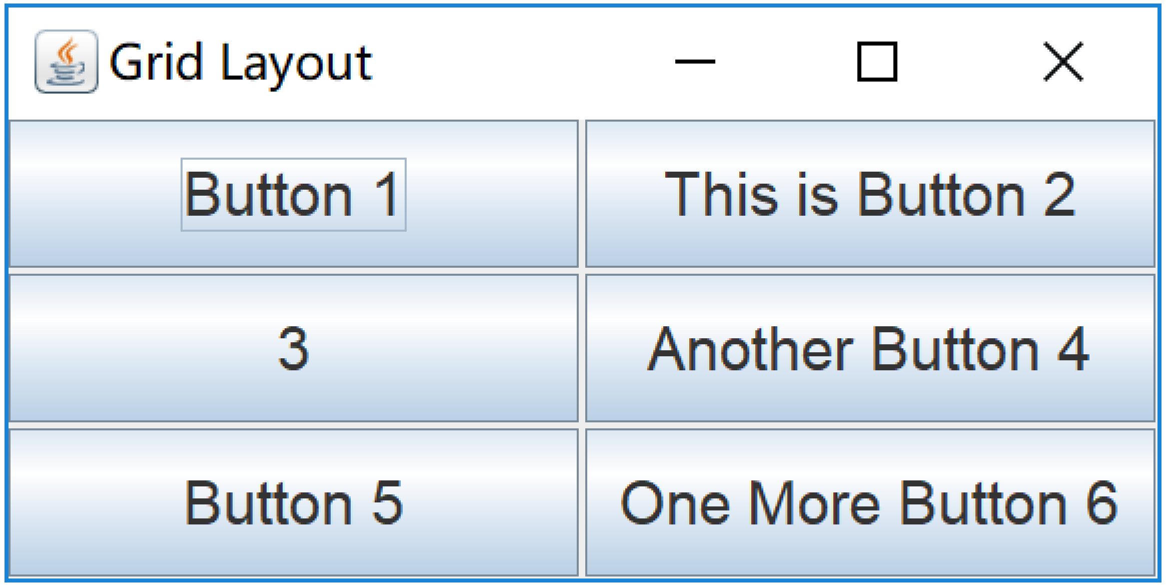
```
setLayout(new FlowLayout(FlowLayout.RIGHT));
```

GridLayout

```
public class GridLayoutDemo extends JFrame {
    private JButton btn1, btn2, btn3, btn4, btn5, btn6;

    public GridLayoutDemo() {
        super(“Grid Layout");
        setLayout(new GridLayout(3, 2, 3, 3));
        btn1 = new JButton("Button 1"); add(btn1);
        btn2 = new JButton("This is Button 2"); add(btn2);
        btn3 = new JButton("3"); add(btn3);
        btn4 = new JButton("Another Button 4"); add(btn4);
        btn5 = new JButton("Button 5"); add(btn5);
        btn6 = new JButton("One More Button 6"); add(btn6);
    }

    public static void main(String[] args) { ... }
}
```

3 x 2 grid layout (3 rows, 2 columns)
Horizontal and vertical gaps between components: 3 pixels

GridLayout



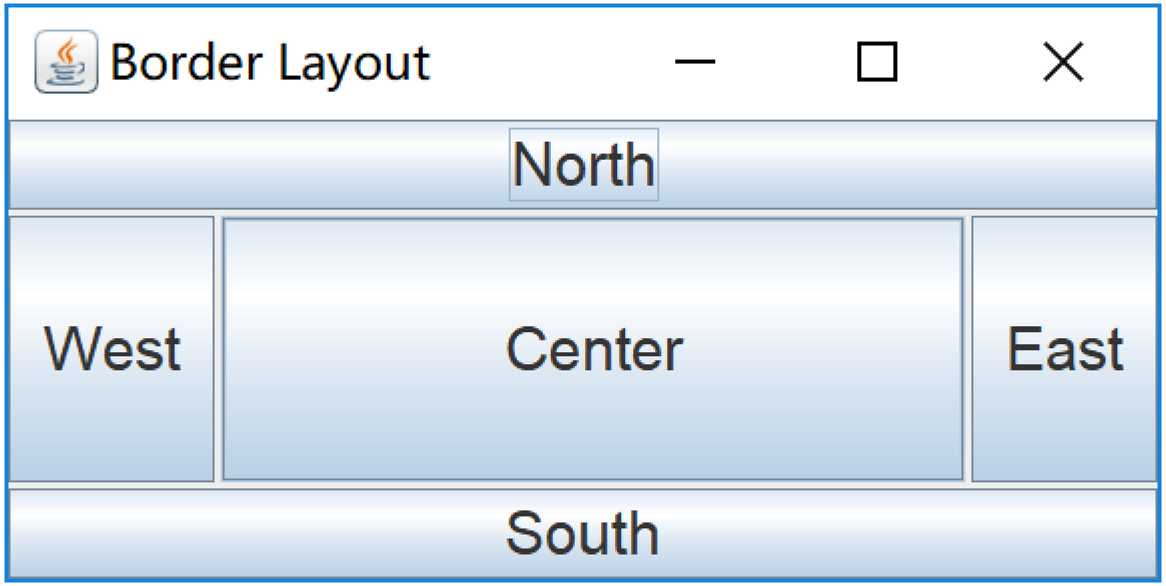
- Places components into rows and columns

BorderLayout

```
public class BorderLayoutDemo extends JFrame {
  private JButton btnNorth, btnSouth, btnCenter, btnEast, btnWest;

  public BorderLayoutDemo() {
    super("Border Layout");
    setLayout(new BorderLayout(3, 3));
    btnNorth = new JButton("North"); add(btnNorth, BorderLayout.NORTH);
    btnSouth = new JButton("South"); add(btnSouth, BorderLayout.SOUTH);
    btnCenter = new JButton("Center"); add(btnCenter, BorderLayout.CENTER);
    btnEast = new JButton("East"); add(btnEast, BorderLayout.EAST);
    btnWest = new JButton("West"); add(btnWest, BorderLayout.WEST);
  }

  public static void main(String[] args) { ... }
}
```

Horizontal and vertical gaps: 3 pixels

BorderLayout



- Default layout manager for the content pane of top level container `javax.swing.JFrame`
- Arranges the GUI components into five pre-defined areas: NORTH, SOUTH, EAST, WEST, CENTER

Using secondary containers for layout management

```
public class LayoutDemo extends JFrame {
    private JButton btn1, btn2, btn3, btn4, btn5, btn6;

    public LayoutDemo() {
        super("Layout demo");
        setLayout(new GridLayout(2, 1));
        JPanel panel1 = new JPanel(new FlowLayout());
        JPanel panel2 = new JPanel(new GridLayout(2, 2, 3, 3));
        add(panel1); add(panel2);
        btn1 = new JButton("Button 1"); panel1.add(btn1);
        btn2 = new JButton("This is Button 2"); panel1.add(btn2);
        btn3 = new JButton("Button 3"); panel2.add(btn3);
        btn4 = new JButton("Button 4"); panel2.add(btn4);
        btn5 = new JButton("Button 5"); panel2.add(btn5);
        btn6 = new JButton("Button 6"); panel2.add(btn6);
    }
    public static void main(String[] args) {...}
}
```

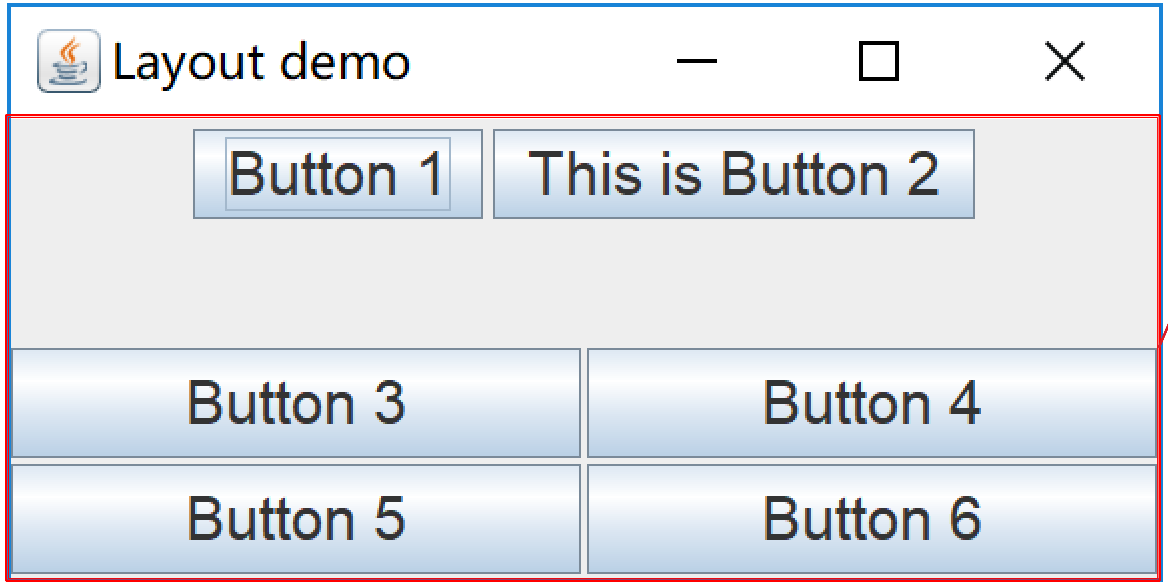
Create two `JPanel`s

Group buttons

Using secondary containers for layout management

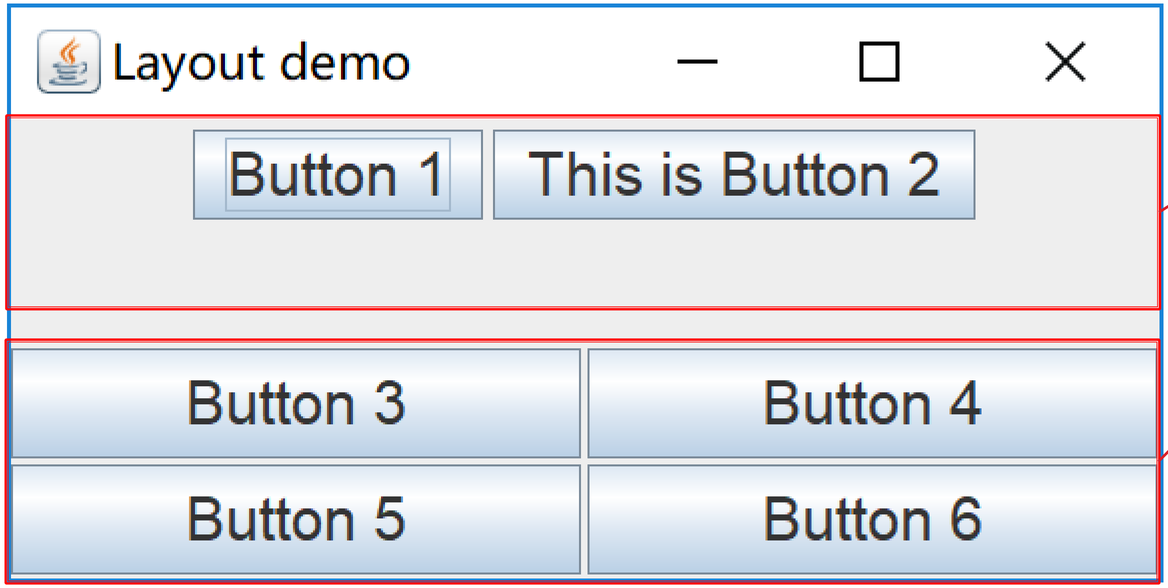
```
public class LayoutDemo extends JFrame {
    private JButton btn1, btn2, btn3, btn4, btn5, btn6;

    public LayoutDemo() {
        super("Layout demo");
        setLayout(new GridLayout(2, 1)); // Set the layout of JFrame's content pane
        JPanel panel1 = new JPanel(new FlowLayout());
        JPanel panel2 = new JPanel(new GridLayout(2, 2, 3, 3));    Set layout for the JPanels
        add(panel1); add(panel2);  // add the two JPanels to the JFrame
        btn1 = new JButton("Button 1"); panel1.add(btn1);
        btn2 = new JButton("This is Button 2"); panel1.add(btn2);
        btn3 = new JButton("Button 3"); panel2.add(btn3);
        btn4 = new JButton("Button 4"); panel2.add(btn4);
        btn5 = new JButton("Button 5"); panel2.add(btn5);
        btn6 = new JButton("Button 6"); panel2.add(btn6);
    }
    public static void main(String[] args) {...}
}
```

Using secondary containers for layout management



JFrame's content pane
(grid layout, 2 rows, 1 col)

Using secondary containers for layout management

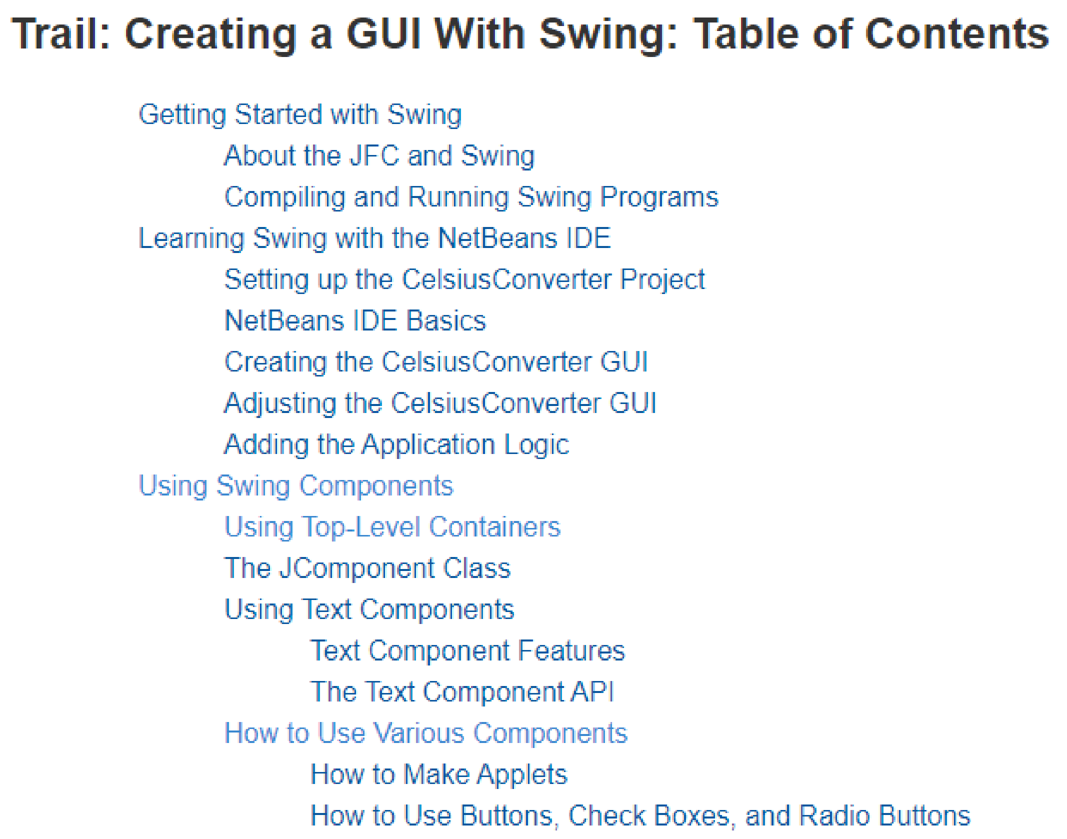


JPanel 1 contains two buttons (flow layout)

JPanel 2 contains 4 buttons (grid layout, 2 rows, 2 cols)

Read the Doc!

- https://docs.oracle.com/javase/tutorial/uiswing/TOC.html



Trail: Creating a GUI With Swing: Table of Contents

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  - Compiling and Running Swing Programs
- Learning Swing with the NetBeans IDE
  - Setting up the CelsiusConverter Project
  - NetBeans IDE Basics
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- Using Swing Components
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