Graphical User Interface (GUI)
Java's AWT and Swing APIs

Lecture 7

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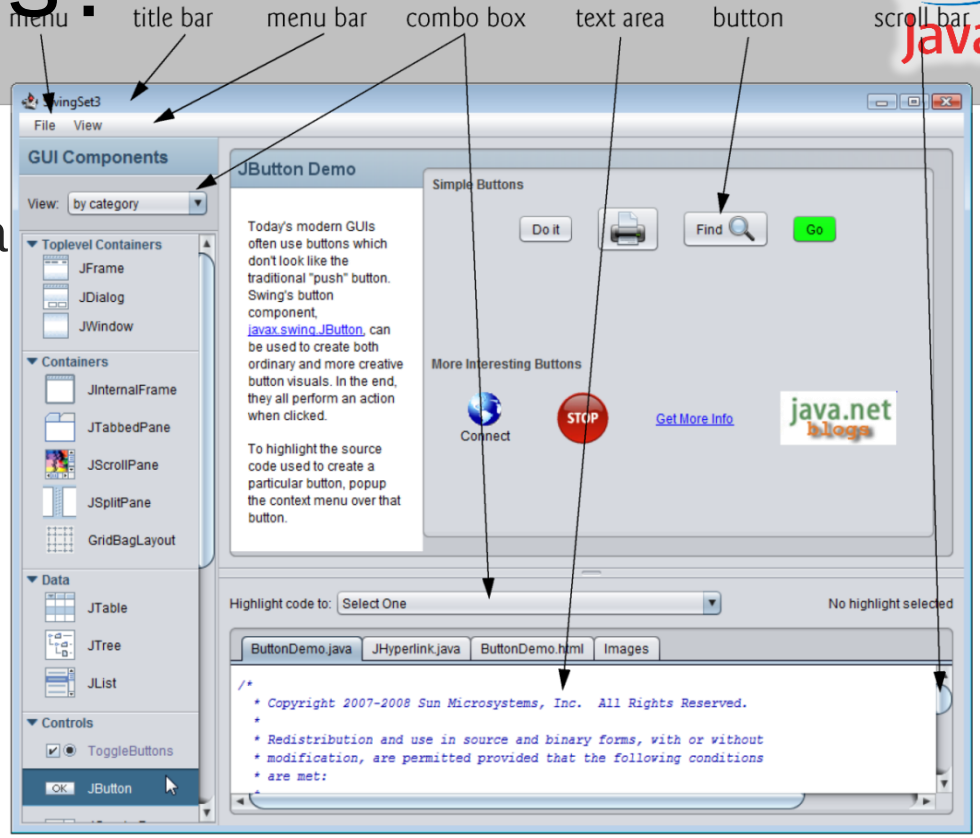
Outline

- Introduction to Java GUI
- AWT and Swing
- GUI Terminology
  - Swing Components
  - GUI Window: JFrame
  - GUI Component: Jbutton
- GUI Sizing and positioning
  - Containers and Layout
- Graphical Events
- Event Listeners
  - Action Events
  - Implementing a listener

Why Learn GUIs?

- Learn about *event-driven programming* techniques
- Practice learning and using a large, complex API
- A chance to see how it is designed and learn from it



Caution: There is here more than you can memorize.

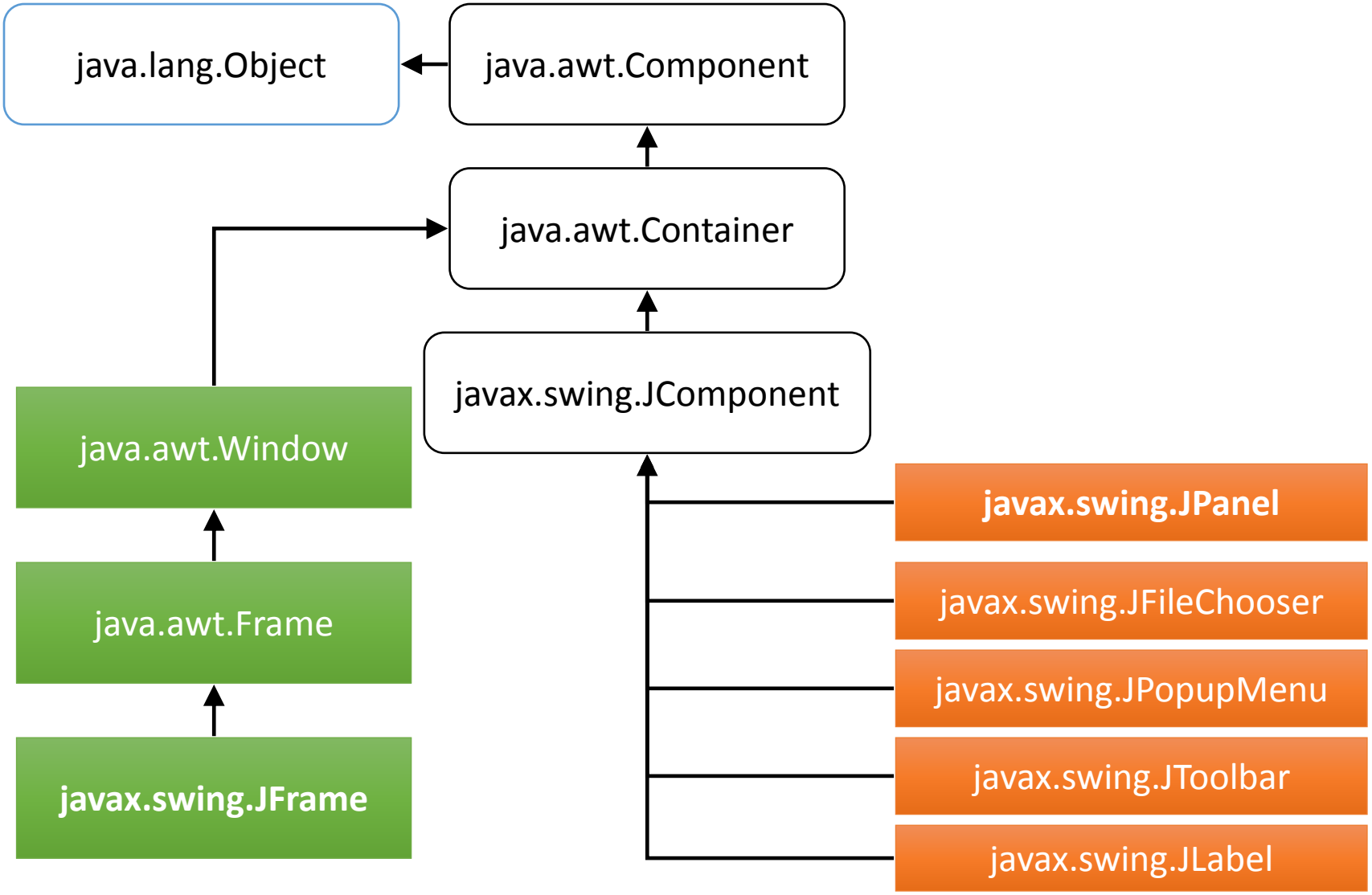
- Part of learning a large API is "letting go."
- You won't memorize it all; you will look things up as you need them.
- But you can learn the **fundamental** concepts and **general ideas**.

AWT and Swing

- Java provides two sets of components for GUI programming:
  - AWT: classes in the **`java.awt`** package *(JDK 1.0 - 1.1)*
  - Swing: classes in the **`javax.swing`** package *(JDK 1.2+)*

- AWT components depend on underling system native GUI to handle their functionality. Thus, these components are often called ***heavyweight*** components.
- Swing is implemented entirely in Java and its components do not depend on system native GUI to handle their functionality. Thus, these components are often called ***lightweight*** components

Some AWT and Swing Classes



AWT: Pros and Cons

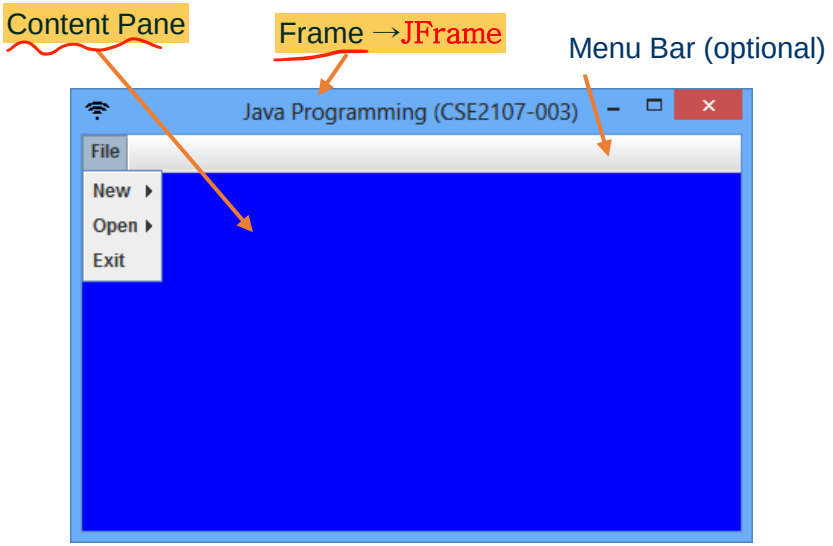
- Pros
  - Speed: native components speed performance.
  - Look and feel: AWT components more closely reflect the look and feel of the OS they run on.
- Cons
  - Portability: use of native peers creates platform specific limitations.
  - Features: AWT supports only the lowest common denominator—e.g. no tool tips or icons.

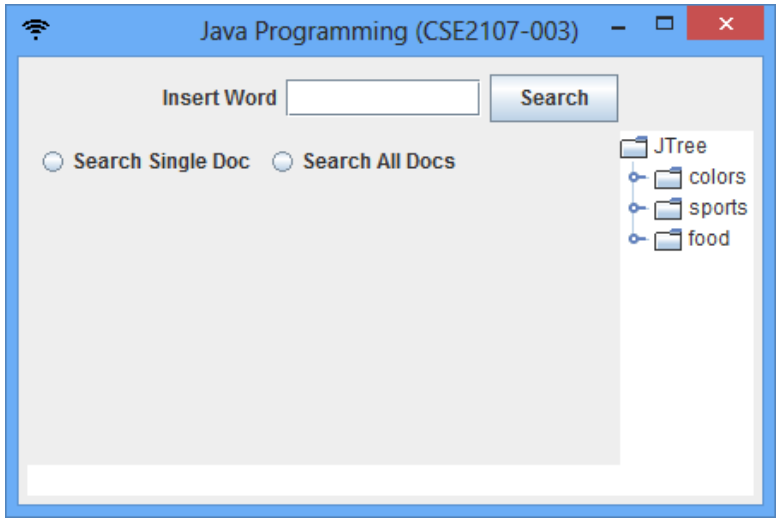
Swing: Pros and Cons

- Pros
  - Portability: Pure Java implementation.
  - Features: Not limited by native components.
  - Look and Feel: Pluggable look and feel. Components automatically have the look and feel of the OS their running on.
- Cons
  - Performance: Swing components handle their own painting (instead of using APIs like DirectX on Windows).
  - Look and Feel: May look slightly different than native components.

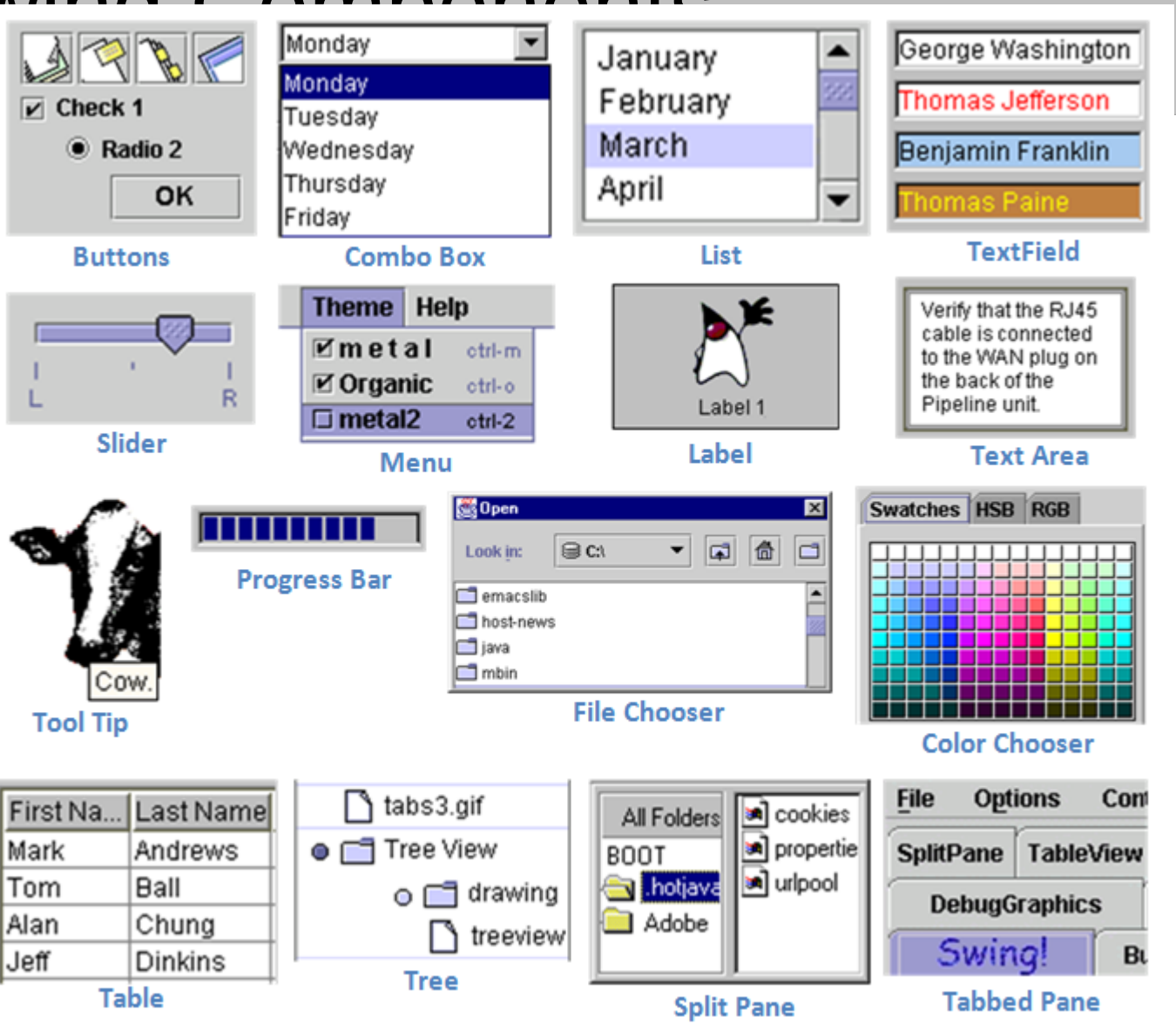
GUI Terminology

- **window**: A first-class citizen of the graphical desktop.
  - Also called a *top-level container*.
  - examples: **frame**, dialog box, applet
- **component**: A GUI widget that resides in a window.
  - Also called *controls* in many other languages.
  - examples: **button, text box, label**
- **container**: A logical grouping for storing components.
  - examples: **panel**, box





Swing Components



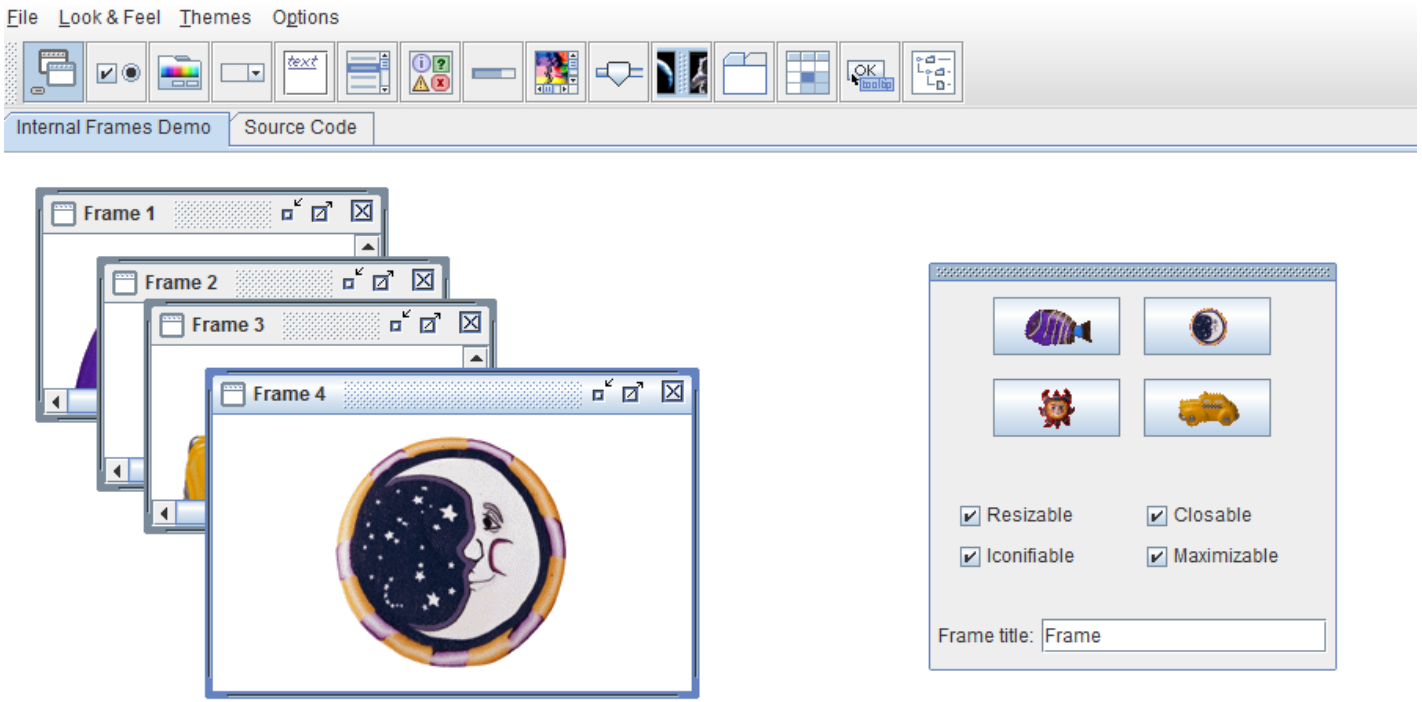
Component Properties

- Each component has a `get` (or `is`) accessor and a `set` modifier method.
  - examples: `getColor()`, `setFont()`, `setEnabled()`, `isVisible()`

name	type	description
background	`Color`	background color behind component
border	`Border`	border line around component
enabled	`boolean`	whether it can be interacted with
focusable	`boolean`	whether key text can be typed on it
font	`Font`	font used for text in component
foreground	`Color`	foreground color of component
height, width	`int`	component's current size in pixels
visible	`boolean`	whether component can be seen
tooltip text	`String`	text shown when hovering mouse
size, minimum / maximum / preferred size	`Dimension`	various sizes, size limits, or desired sizes that the component may take

Pluggable Look-and-Feel

The look-and-feel at swing is implemented in Java, but could mimic Windows, Motif, Classic, Aqua, etc.



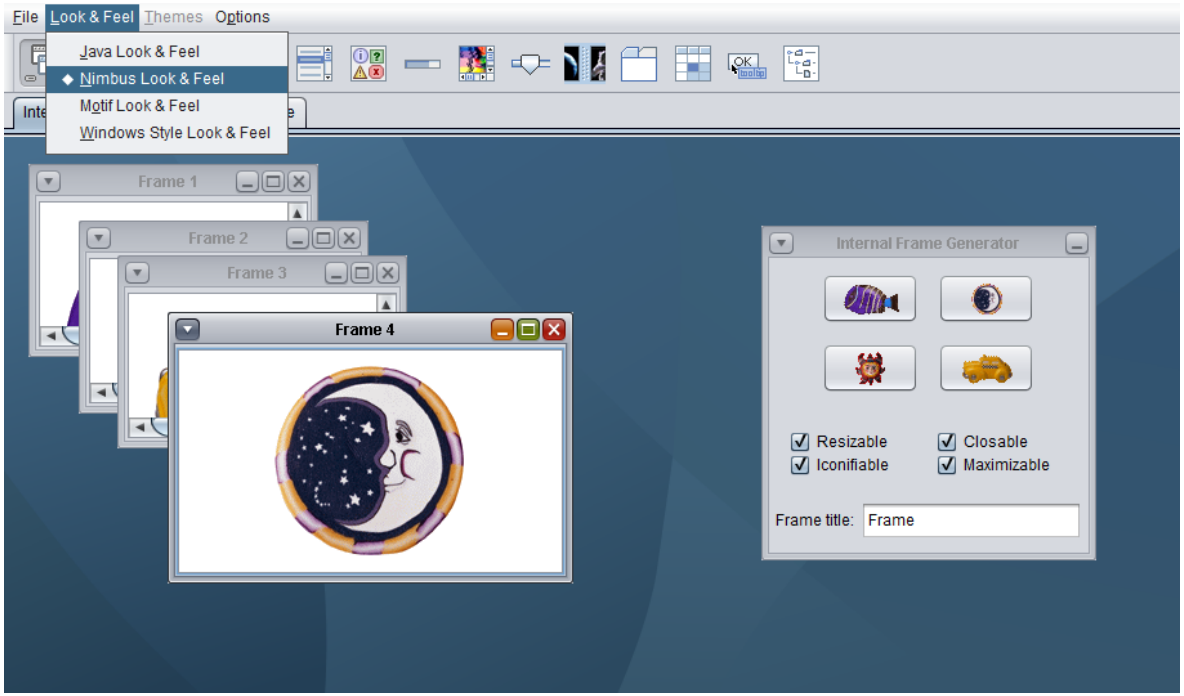
Default Java Swing look-and-feel

Pluggable Look-and-Feel

GUI Look-and-Feel can be assigned programmatically

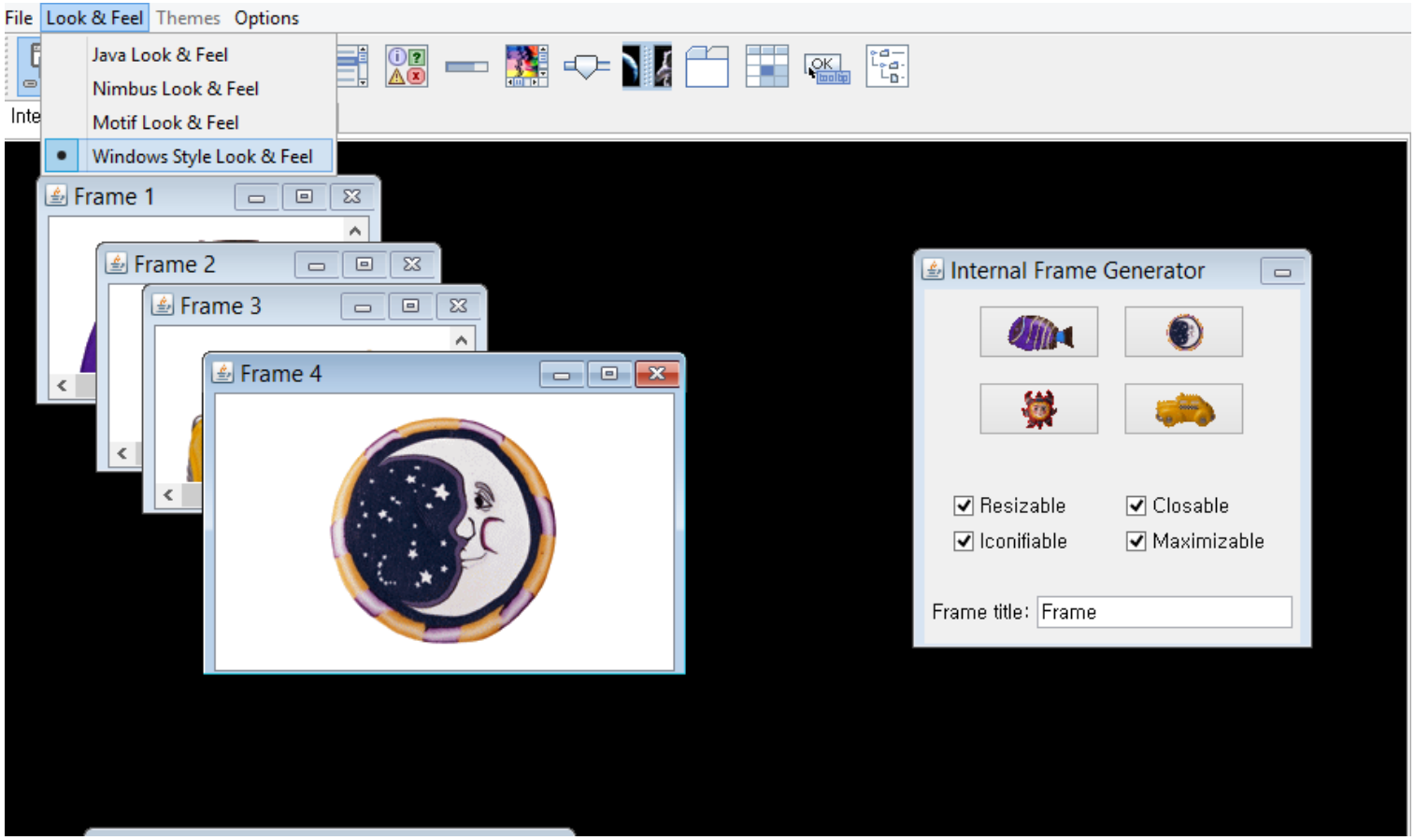
```
UIManager.setLookAndFeel(
"com.sun.java.swing.plaf.windows.WindowsLookAndFeel");

UIManager.setLookAndFeel(
"javax.swing.plaf.metal.MetalLookAndFeel");
```



Nimbus Look-and-Feel

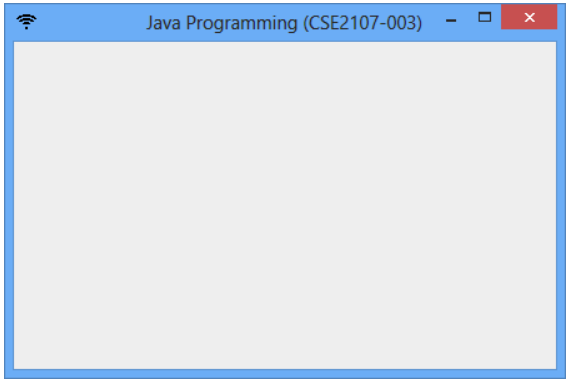
Pluggable Look-and-Feel



Windows Look-and-Feel

GUI Window: JFrame

a graphical window to hold other components



- `public JFrame()`
  `public JFrame(String title)`
  Creates a frame with an optional title.
  - Call `setVisible(true)` to make a frame appear on the screen after creating it.

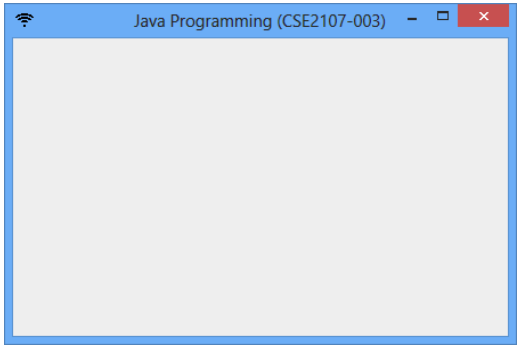
- `public void add(Component comp)`
  Places the given component or container inside the frame.

More JFrame

`public void setDefaultCloseOperation(int op)`
Makes the frame perform the given action when it closes.

- Common value passed: `JFrame.EXIT_ON_CLOSE`
- If not set, the program will never exit even if the frame is closed.

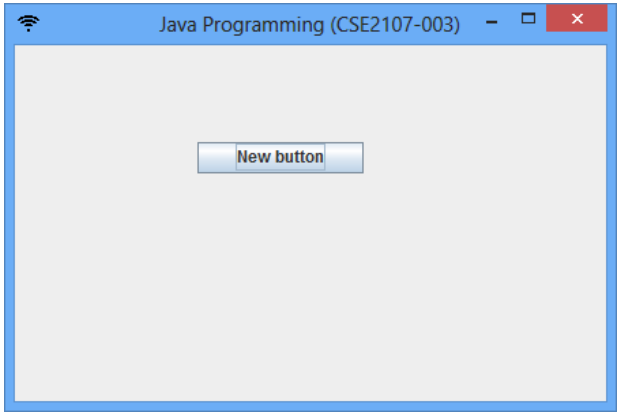
- `public void setSize(int width, int height)`
  Gives the frame a fixed size in pixels.



- `public void pack()`
  Resizes the frame to fit the components inside it snugly.

GUI Component: JButton

a clickable region for causing actions to occur



- `public JButton(String text)`
  Creates a new button with the given string as its text.

- `public String getText()`
  Returns the text showing on the button.

- `public void setText(String text)`
  Sets button's text to be the given string.

GUI Example

```
import java.awt.*;      // Where is the other button?
import javax.swing.*;

public class GuiExample1 {
    public static void main(String[] args) {
        JFrame frame = new JFrame();
        frame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
        frame.setSize(new Dimension(300, 100));
        frame.setTitle("A frame");

        JButton button1 = new JButton();
        button1.setText("I'm a button.");
        button1.setBackground(Color.BLUE);
        frame.add(button1);

        JButton button2 = new JButton();
        button2.setText("Click me!");
        button2.setBackground(Color.RED);
        frame.add(button2);

        frame.setVisible(true);
    }
}
```

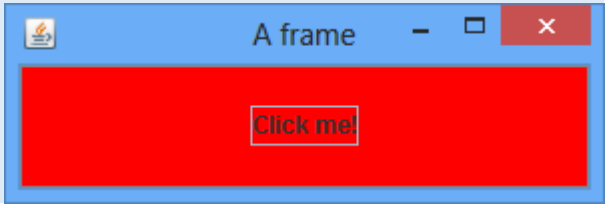
Import Swing packages

Create Frame

Frame settings

Create a Jbutton Component

Add Jbutton to the Frame



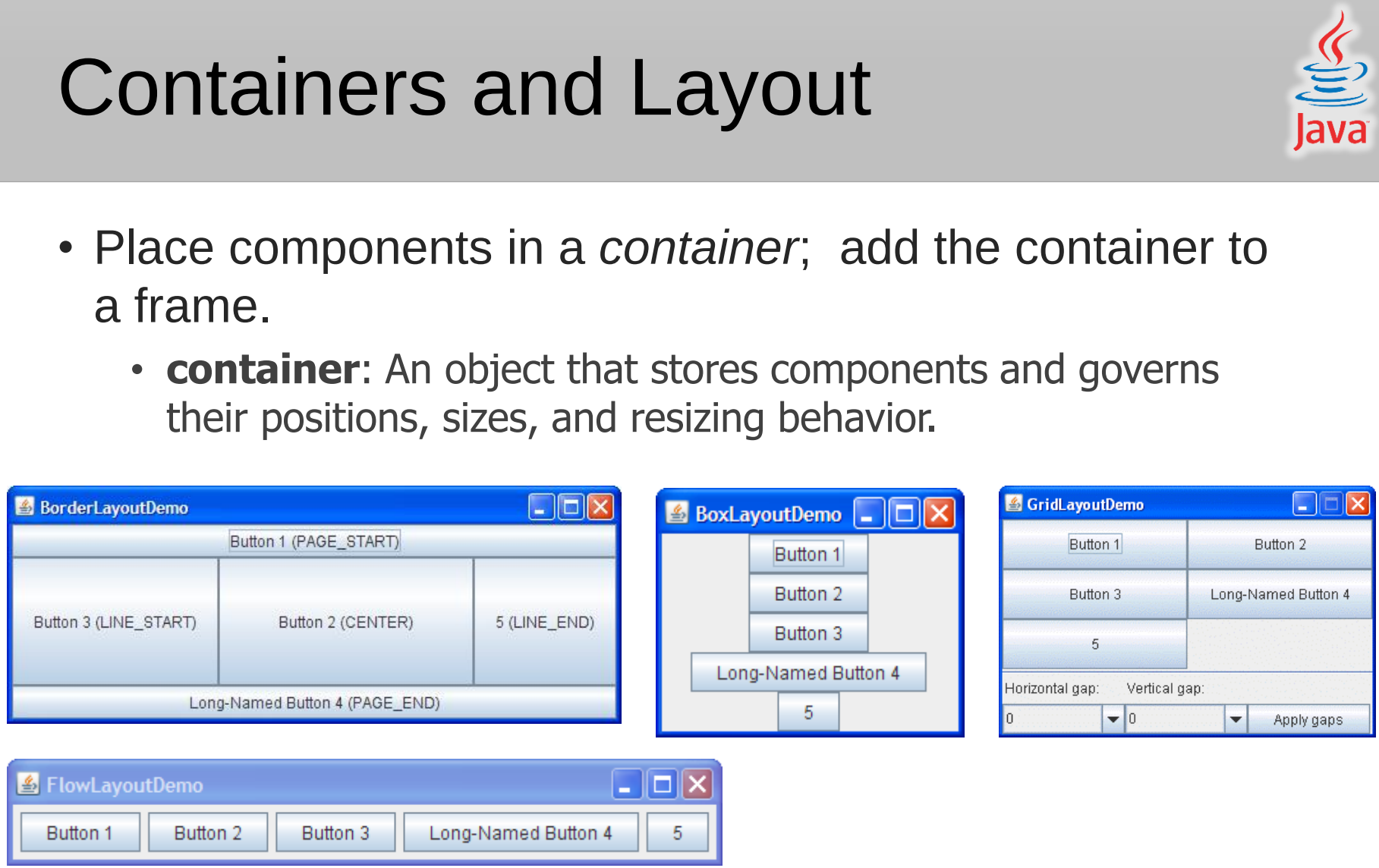
GUI Sizing and Positioning

How does the programmer specify where each component appears, how big each component should be, and what the component should do if the window is resized / moved / maximized / etc.?

- **Absolute positioning** (C++, C#, others):
  Programmer specifies exact pixel coordinates of every component.
  - "Put this button at (x=15, y=75) and make it 70x31 px in size."

- **Layout managers** (Java):
  Objects that decide where to position each component based on some general rules or criteria.
  - "Put these four buttons into a 2x2 grid and put these text boxes in a horizontal flow in the south part of the frame."

Containers and Layout



- Place components in a *container*; add the container to a frame.
  - **container**: An object that stores components and governs their positions, sizes, and resizing behavior.

JFrame as Container

A `JFrame` is a container. Containers have these methods:

- `public void` **`add`**`(Component comp)`
  `public void` **`add`**`(Component comp, Object info)`
  Adds a component to the container, possibly giving extra information about where to place it.

- `public void` **`remove`**`(Component comp)`

- `public void` **`setLayout`**`(LayoutManager mgr)`
  Uses the given layout manager to position components.

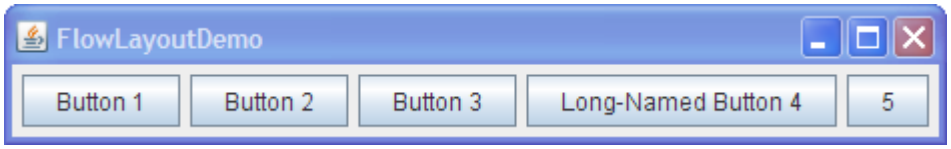
- `public void` **`validate`**`()`
  Refreshes the layout (if it changes after the container is onscreen).

FlowLayout

`public FlowLayout()`

- Treats container as a left-to-right, top-to-bottom "paragraph".
  - Components are given preferred size, horizontally and vertically.
  - Components are positioned in the order added.
  - If too long, components wrap around to the next line.

```
myFrame.setLayout(new FlowLayout());
myFrame.add(new JButton("Button 1"));
```



- The default layout for containers other than `JFrame` (seen later).

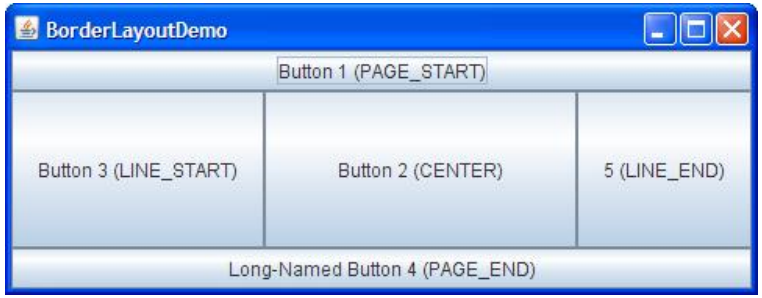
BorderLayout

`public BorderLayout()`

- Divides container into five regions:
  - `NORTH` and `SOUTH` regions expand to fill region horizontally, and use the component's preferred size vertically.
  - `WEST` and `EAST` regions expand to fill region vertically, and use the component's preferred size horizontally.
  - `CENTER` uses all space not occupied by others.

```
myFrame.setLayout(new BorderLayout());
myFrame.add(new JButton("Button 1"), BorderLayout.NORTH);
```

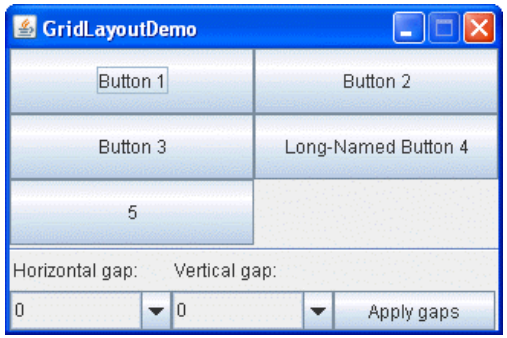
- This is the default layout for a `JFrame`.



GridLayout


```
public GridLayout(int rows, int columns)
```

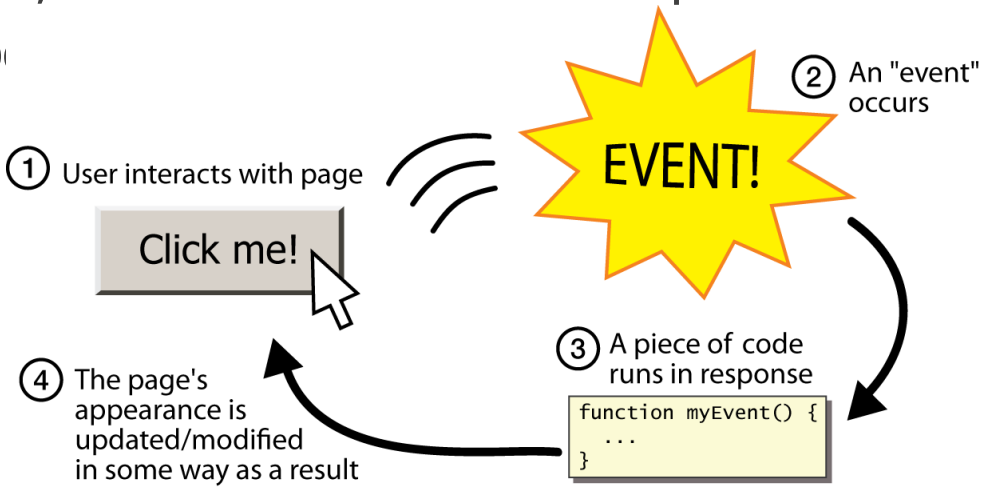
- Treats container as a grid of equally-sized rows and columns.
- Components are given equal horizontal / vertical size, disregarding preferred size.
- Can specify 0 rows or columns to indicate expansion in that direction as needed.



Graphical Events

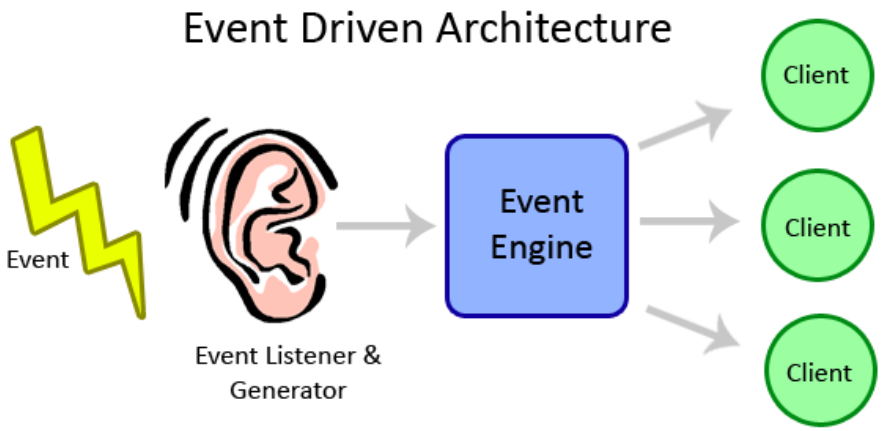
- **event**: An object that represents a user's interaction with a GUI component; can be "handled" to create interactive components.

- **listener**: An object that waits for events and responds to them.
  - To handle an event, attach a *listener* to a component.
  - The listener will b
    button click).



Event-driven Programming

- **event-driven programming**: A style of coding where a program's overall flow of execution is dictated by events.
  - Rather than a central "main" method that drives execution, the program loads and waits for user input events.
  - As each event occurs, the program runs particular code to respond.
  - The overall flow of what code is executed is determined by the series of e order.



Event Hierarchy

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

- EventObject
  - AWTEvent (AWT)
    - **ActionEvent**
    - TextEvent
    - ComponentEvent
      - FocusEvent
      - WindowEvent
      - InputEvent
        - KeyEvent
        - MouseEvent

- EventListener
  - AWTEventListener
  - **ActionListener**
  - TextListener
  - ComponentListener
  - FocusListener
  - WindowListener
  - KeyListener
  - MouseListener

Action Events

- **action event**: An action that has occurred on a GUI component.
  - The most common, general event type in Swing. Caused by:
    - button or menu clicks,
    - check box checking / unchecking,
    - pressing Enter in a text field, ...
  - Represented by a class named `ActionEvent`
  - Handled by objects that implement interface `ActionListener`

Implementing a listener

interface

```
public class name implements ActionListener {
    public void actionPerformed(ActionEvent event)
{
        //code to handle the event;
    }
}
```

꼭 정의해야함 <- interface이기 때문

- `JButton` and other graphical components have this method:
  - `public void addActionListener(ActionListener al)`
    Attaches the given listener to be notified of clicks and events that occur on this component.

텍스트

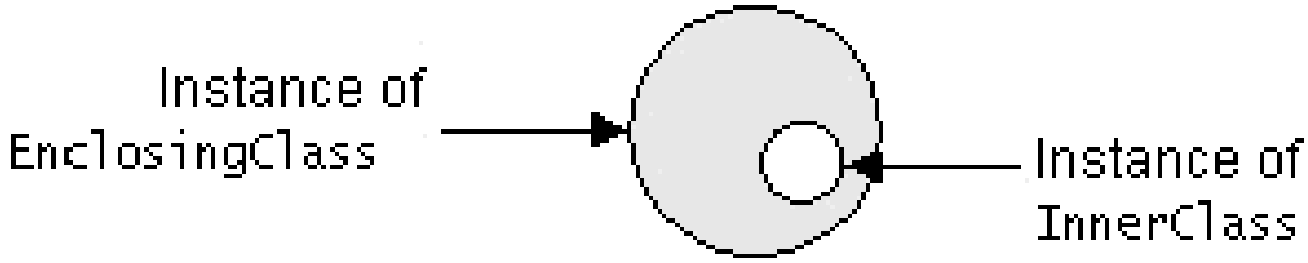
doSomething object = new doSomething();
button1.addActionListener(object);
button1.addActionListener(new doSomething);
name 없이 ananomous object 가능
-> add 필수!
?ananomous면 안에 함수는? doSomething에서 수정

Nested Classes

- **nested class**: A class defined inside of another class.

- Usefulness:
  - Nested classes are hidden from other classes (encapsulated).
  - Nested objects can access/modify the fields of their outer object.

- Event listeners are often defined as nested classes inside a GUI.



Nested Class Syntax


```
// enclosing outer class
public class name {
    ...

    // nested inner class
    private class name {
        ...
    }
}
```

- Only the outer class can see the nested class or make objects of it.
- Each nested object is associated with the outer object that created it, so it can access/modify that outer object's methods/fields.
- If necessary, can refer to outer object as **OuterClassName**`.this`

Static Inner Classes


```
// enclosing outer class
public class name {
    ...

    // non-nested static inner class
    public static class name {
        ...
    }
}
```

- Static inner classes are *not* associated with a particular outer object.
- They cannot see the fields of the enclosing class.
- *Usefulness:* Clients can refer to and instantiate static inner classes:

```
Outer.Inner name = new Outer.Inner(params);
```

GUI Event Example


```
public class MyGUI {
    private JFrame frame;
    private JButton stutter;
    private JTextField textfield;

    public MyGUI() {
        ...
        stutter.addActionListener(new StutterListener());
    }
    ...

    // When button is clicked, doubles the field's text.
    private class StutterListener implements ActionListener {
        public void actionPerformed(ActionEvent event) {
            String text = textfield.getText();
            textfield.setText(text + text);
        }
    }
}
```

Buttons

- A *button* object is created from the class **`JButton`** and can be added to a **`JFrame`**
  - The argument to the **`JButton`** constructor is the string that appears on the button when it is displayed

```
JButton ExitButton = new
                JButton("Click to end program.");
frame.add(ExitButton);
```

Summary: Action Listeners and Action Events

- Clicking a button *fires an event*
- The event object is "sent" to another object called a listener
  - This means that a method in the listener object is invoked automatically
  - Furthermore, it is invoked with the event object as its argument
- In order to set up this relationship, a GUI program must do two things
  1. It must specify, for each button, what objects are its listeners, i.e., it must register the listeners
  2. It must define the methods that will be invoked automatically when the event is sent to the listener

Action Listeners and Action Events


```
EndingListener buttonEnd = new
                              EndingListener());
ExitButton.addActionListener(buttonEnd);
```

- Above, a listener object named **`buttonEnd`** is created and registered as a listener for the button named **`ExitButton`**
  - Note that a button fires events known as *action events*, which are handled by listeners known as *action listeners*

Action Listeners and Action Events

- Different kinds of components require different kinds of listener classes to handle the events they fire
- An action listener is an object whose class implements the **`ActionListener`** interface
  - The **`ActionListener`** interface has one method heading that must be implemented

```
public void actionPerformed(ActionEvent e)
```

JButton Example

Buttons events handling by ActionListener

```
import java.awt.FlowLayout;
import java.awt.event.ActionListener;
import java.awt.event.ActionEvent;
import javax.swing.JFrame;
import javax.swing.JButton;
import javax.swing.Icon;
import javax.swing.ImageIcon;
import javax.swing.JOptionPane;

public class ButtonFrame extends JFrame
{
   private JButton plainJButton; // button with just text
   private JButton fancyJButton; // button with icons

   // ButtonFrame adds JButtons to JFrame
   public ButtonFrame()
   {
      super( "Testing Buttons" );
   setLayout( new FlowLayout() ); // set frame layout

   plainJButton = new JButton( "Plain Button" ); // button with text
      add( plainJButton ); // add plainJButton to JFrame

   Icon bug1 = new ImageIcon( getClass().getResource( "bug1.gif" ) );
   Icon bug2 = new ImageIcon( getClass().getResource( "bug2.gif" ) );
   fancyJButton = new JButton( "Fancy Button", bug1 ); // set image
   fancyJButton.setRolloverIcon( bug2 ); // set rollover image
   add( fancyJButton ); // add fancyJButton to JFrame

      // create new ButtonHandler for button event handling
      ButtonHandler handler = new ButtonHandler();
      fancyJButton.addActionListener( handler );
      plainJButton.addActionListener( handler );
   } // end ButtonFrame constructor
```

```
// inner class for button event handling
   private class ButtonHandler implements ActionListener
   {
      // handle button event
      public void actionPerformed( ActionEvent event )
      {
        JOptionPane.showMessageDialog( ButtonFrame.this,
String.format("You pressed: %s", event.getActionCommand() ) );
      } // end method actionPerformed
   } // end private inner class ButtonHandler
} // end class ButtonFrame
```

```
import javax.swing.JFrame;

public class ButtonTest

{

   public static void main( String[] args )

   {

      ButtonFrame buttonFrame = new ButtonFrame(); // create Frame

      buttonFrame.setDefaultCloseOperation( JFrame.EXIT_ON_CLOSE );

      buttonFrame.setSize( 300, 200 ); // set frame size

      buttonFrame.setVisible( true ); // display frame

   } // end main

} // end class ButtonTest
```

Output
Press here

Summary

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