CSE 331

Event-driven Programming and Graphical User Interfaces (GUIs) with Swing/AWT

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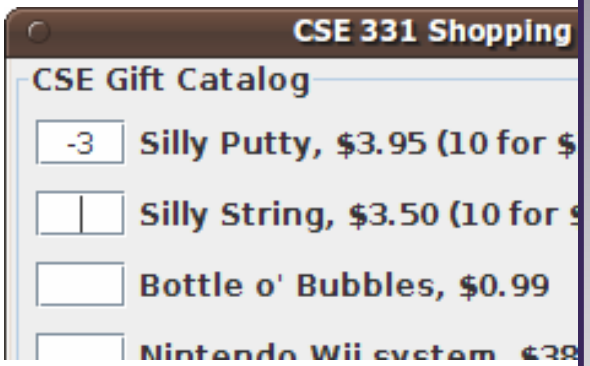
based on materials by M. Ernst, S. Reges, D. Notkin, R. Mercer, Wikipedia
http://www.cs.washington.edu/331/

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:
  - model-view separation
  - design patterns
  - refactoring vs. reimplementing an ailing API
- Because GUIs are neat!

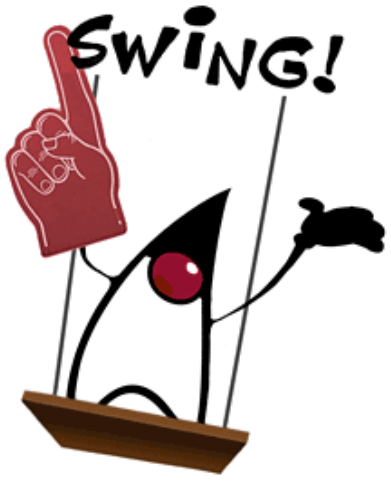


- *Caution*: There is way more here than you can memorize.
  - Part of learning a large API is "letting go."
  - You won't memorize it all; you will look things up as you need them.
  - But you can learn the fundamental concepts and general ideas.

Java GUI History

- **Abstract Windowing Toolkit** (**AWT**): Sun's initial effort to create a set of cross-platform GUI classes. *(JDK 1.0 - 1.1)*
  - Maps general Java code to each operating system's real GUI system.
  - *Problems:* Limited to lowest common denominator; clunky to use.

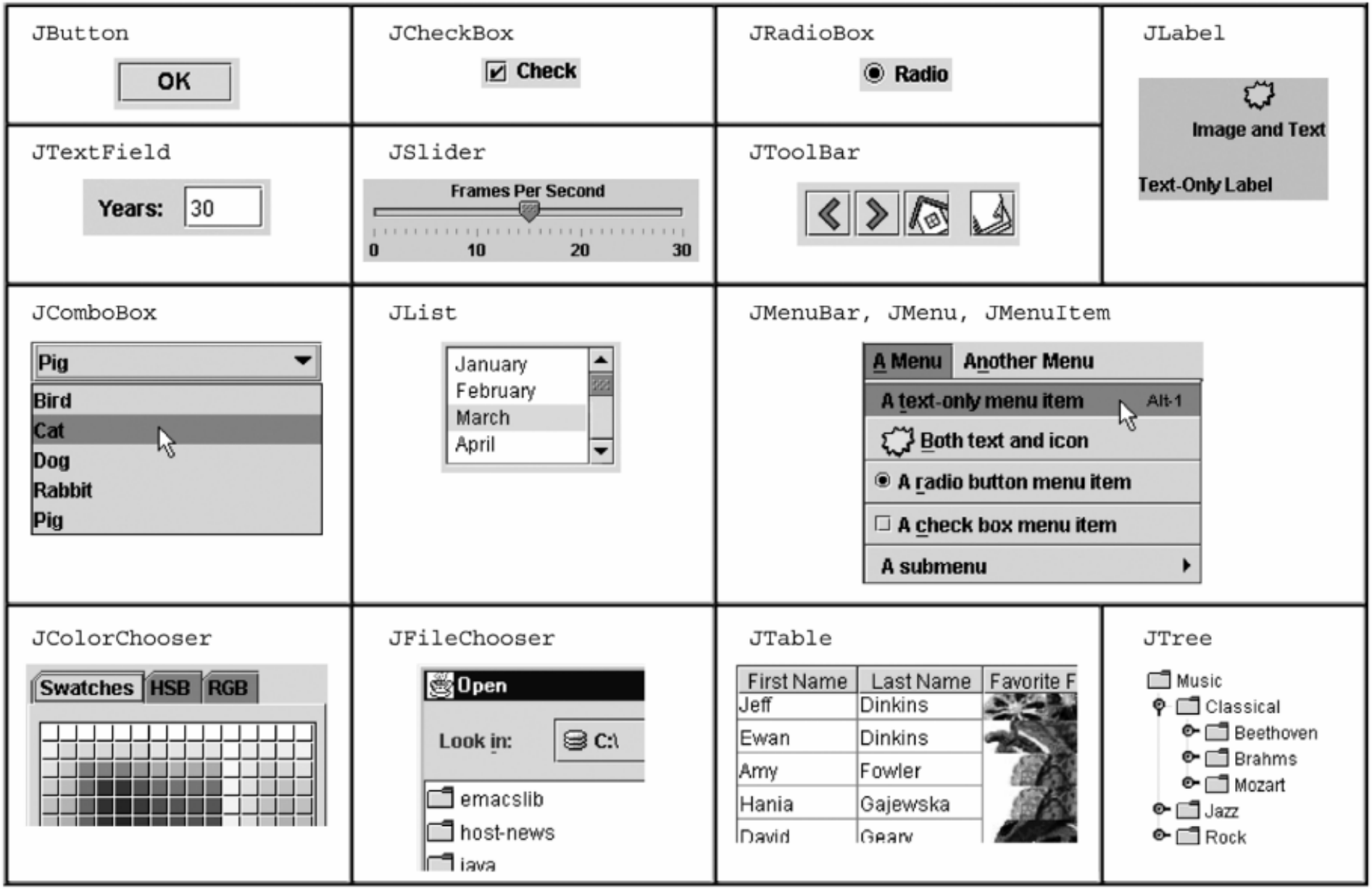
- **Swing**: A newer GUI library written from the ground up that allows much more powerful graphics and GUI construction. *(JDK 1.2+)*
  - Paints GUI controls itself pixel-by-pixel rather than handing off to OS.
  - *Benefits:* Features; compatibility; OO design.
  - *Problem:* Both exist in Java now; easy to get them mixed up; still have to use both in various places.



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

Components


JButton
OK
JCheckBox
Check
JRadioBox
Radio
JLabel
Image and Text
Text-Only Label
JTextField
Years:
30
JSlider
Frames Per Second
0
10
20
30
JToolBar
JComboBox
Pig
Bird
Cat
Dog
Rabbit
Pig
JList
January
February
March
April
JMenuBar, JMenu, JMenuItem
A Menu
Another Menu
A text-only menu item
Alt-1
Both text and icon
A radio button menu item
A check box menu item
A submenu
JColorChooser
Swatches
HSB
RGB
JFileChooser
Open
Look in:
C:\
emacslib
host-news
java
JTable
First Name
Last Name
Favorite F
Jeff
Dinkins
Ewan
Dinkins
Amy
Fowler
Hania
Gajewska
David
Geary
JTree
Music
Classical
Beethoven
Brahms
Mozart
Jazz
Rock

Swing inheritance hierarchy

- Component (AWT)
  - Window
    - Frame
      - **JFrame** (Swing)
      - **JDialog**
  - Container
    - JComponent (Swing)
      - **JButton**
      - **JComboBox**
      - **JMenuBar**
      - **JPopupMenu**
      - **JScrollPane**
      - **JSplitPane**
      - **JToolbar**
      - **JTextField**
      - **JColorChooser**
      - **JLabel**
      - **JOptionPane**
      - **JProgressBar**
      - **JSlider**
      - **JTabbedPane**
      - **JTree**
      - ...
      - **JFileChooser**
      - **JList**
      - **JPanel**
      - **JScrollbar**
      - **JSpinner**
      - **JTable**
      - **JTextArea**

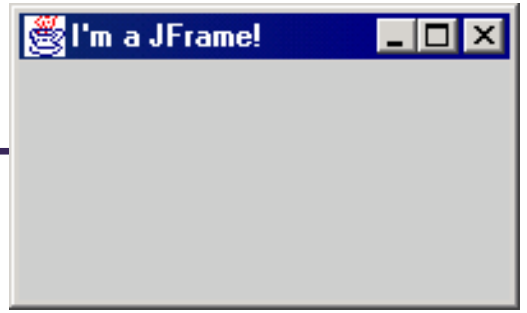
```
import java.awt.*;
import javax.swing.*;
```

Component properties

- Each 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

JFrame

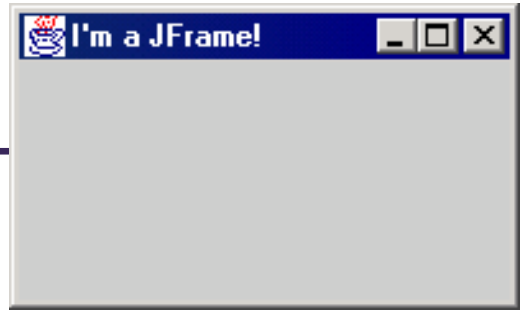


a graphical window to hold other components

- `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.

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);
    }
}
```

Sizing and positioning

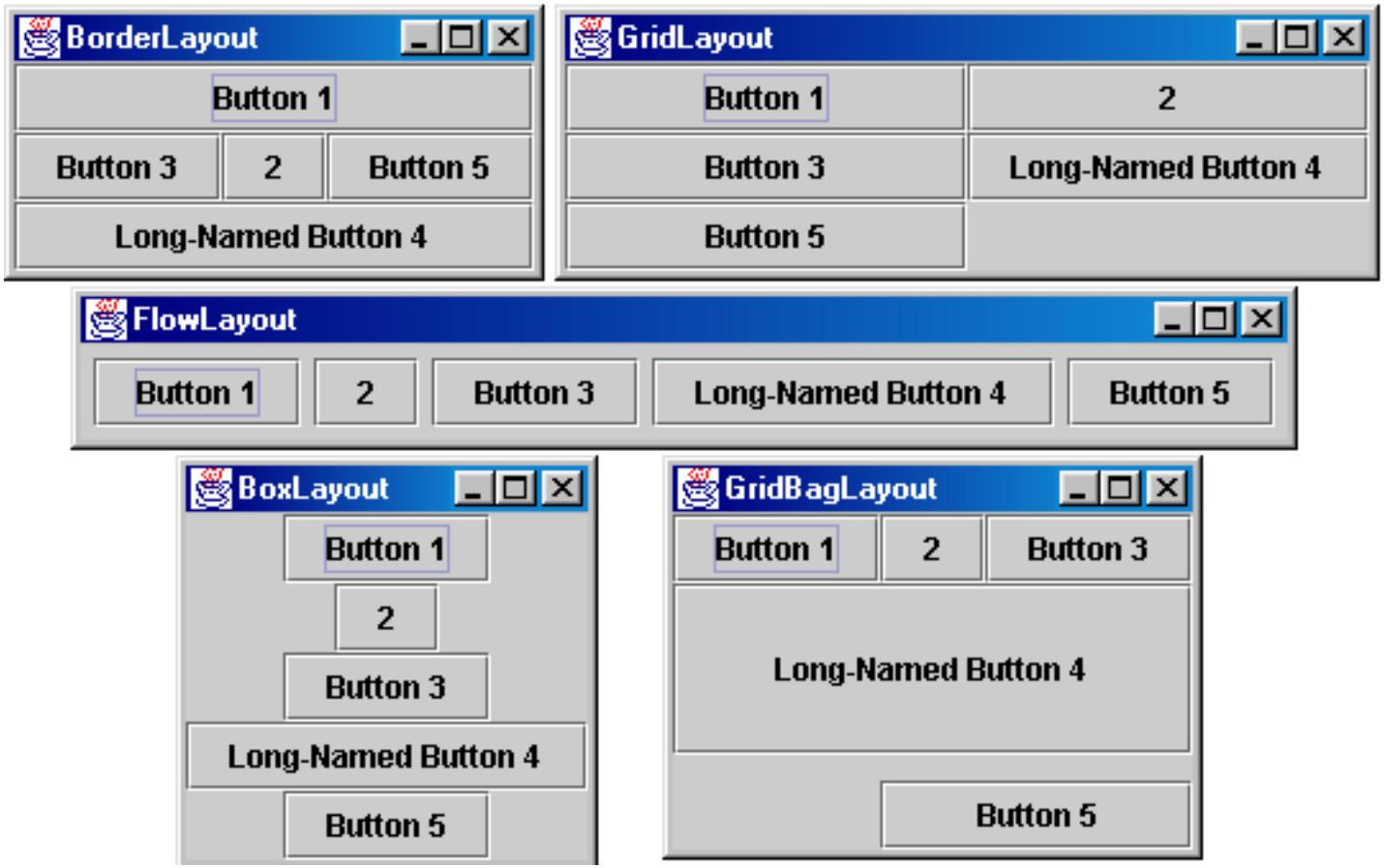
How does the programmer specify where each component appears, how big each component should be, and what the component should do if the window is resized / moved / maximized / etc.?

- **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.

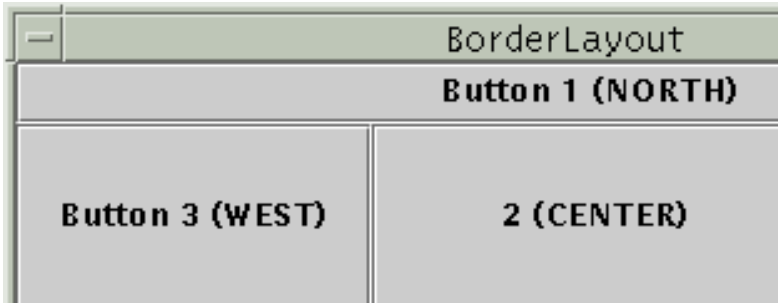
- `public void` **`validate`**`()`
  Refreshes the layout (if it changes after the container is onscreen).

Preferred sizes

- Swing component objects each have a certain size they would "like" to be: Just large enough to fit their contents (text, icons, etc.).
  - This is called the *preferred size* of the component.
  - Some types of layout managers (e.g. `FlowLayout`) choose to size the components inside them to the preferred size.
  - Others (e.g. `BorderLayout`, `GridLayout`) disregard the preferred size and use some other scheme to size the components.

Buttons at preferred size:

Not preferred size:



FlowLayout

```
public FlowLayout()
```

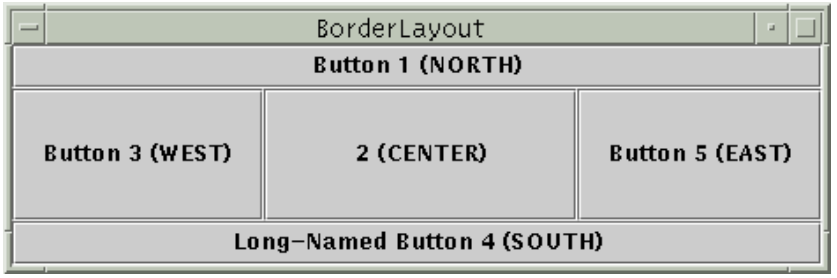
- treats container as a left-to-right, top-to-bottom "paragraph".
  - Components are given preferred size, horizontally and vertically.
  - Components are positioned in the order added.
  - If too long, components wrap around to the next line.

```
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.

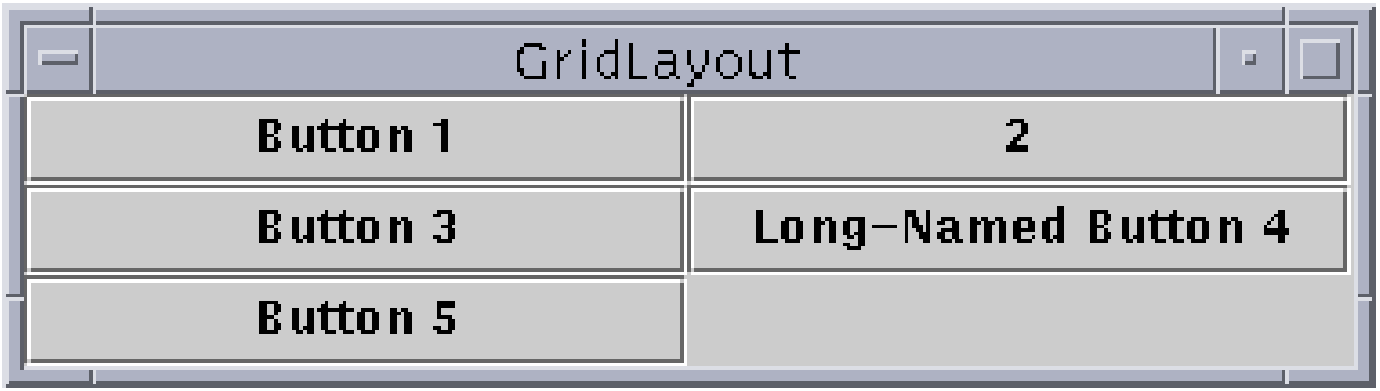
```
myFrame.setLayout(new BorderLayout());
myFrame.add(new JButton("Button 1"), BorderLayout.NORTH);
```

  - 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.

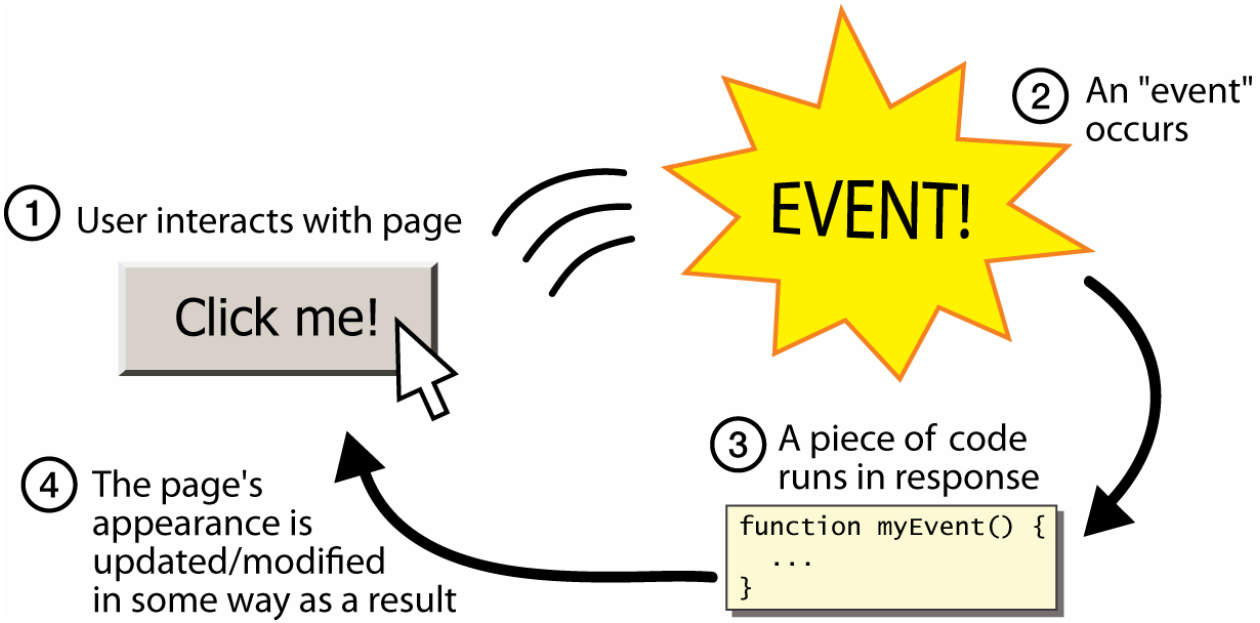


Event Listeners

Graphical events

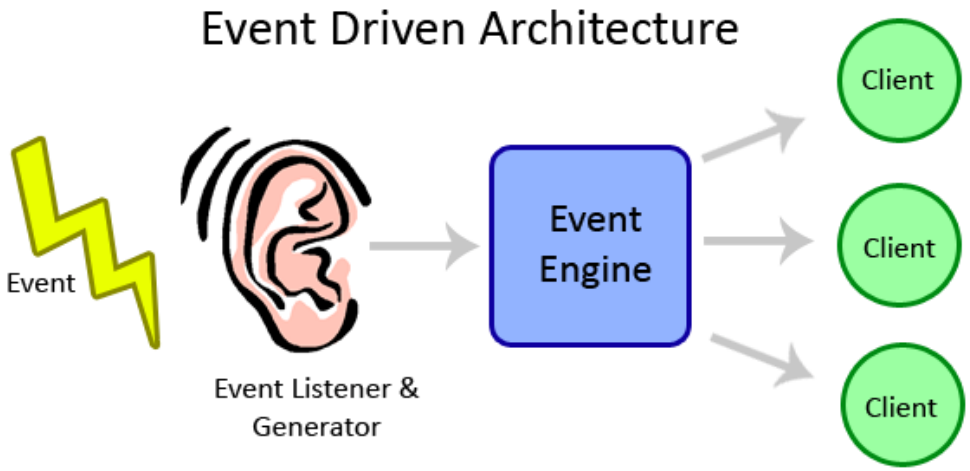
- **event**: An object that represents a user's interaction with a GUI component; can be "handled" to create interactive components.

- **listener**: An object that waits for events and responds to them.
  - To handle an event, attach a *listener* to a component.
  - The listener will be notified when the event occurs (e.g. 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 events that occur, not a pre-determined 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

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

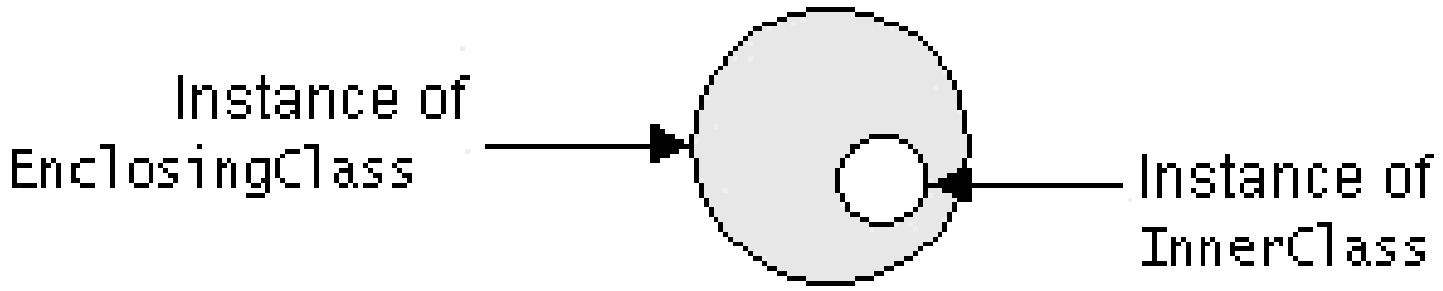
- `JButton` and other graphical components have this method:
  - `public void addActionListener(ActionListener al)`
    Attaches the given listener to be notified of clicks and events that occur on this component.

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);
        }
    }
}
```