Building Graphical User Interfaces

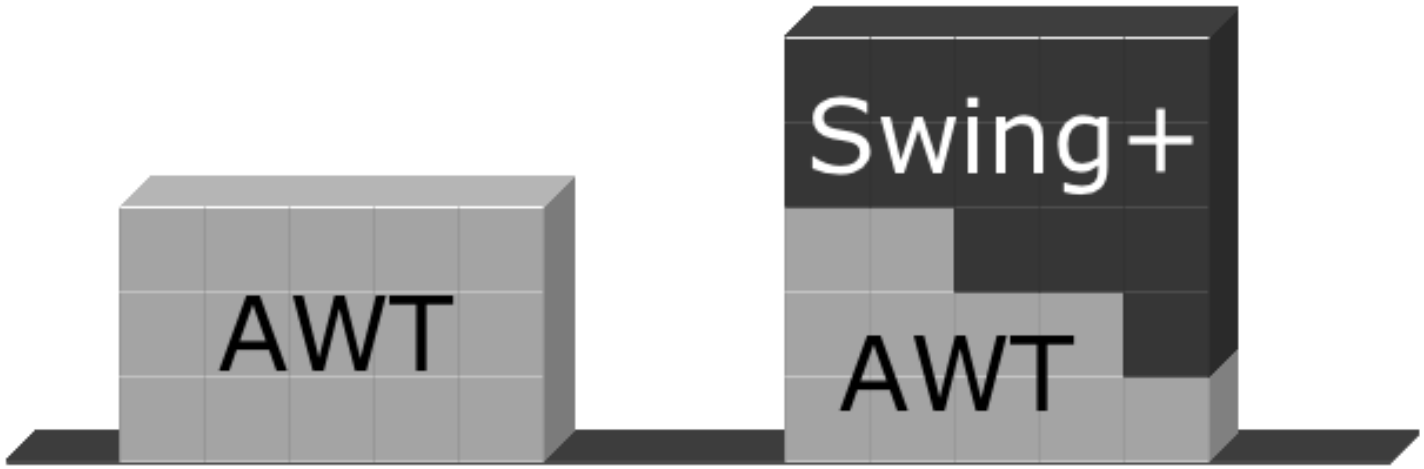
Overview

- Constructing GUIs
- Interface components
- GUI layout
- Event handling

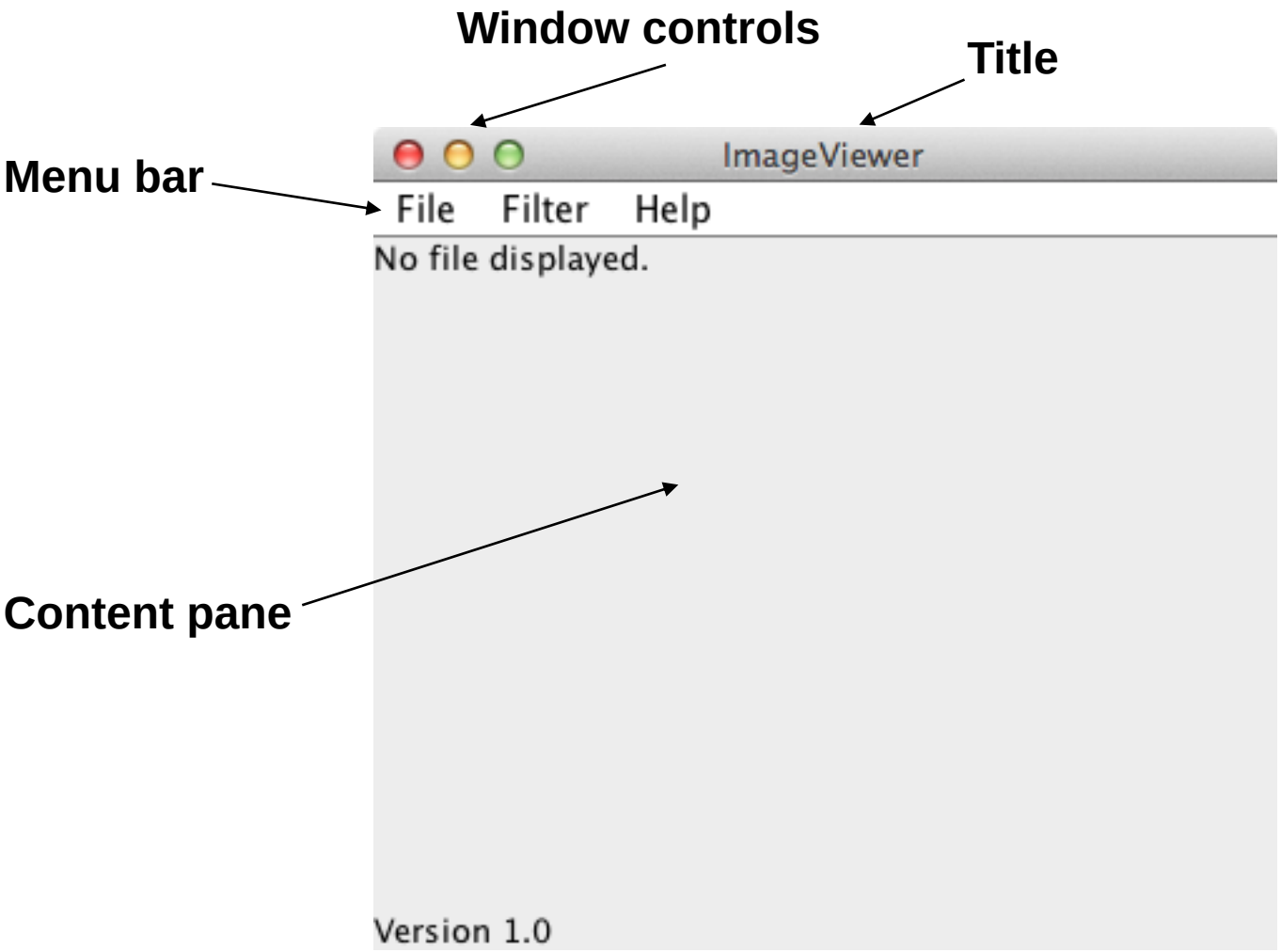
GUI Principles

- Components: GUI building blocks.
  - Buttons, menus, sliders, etc.
- Layout: arranging components to form a usable GUI.
  - Using layout *managers*.
- Events: reacting to user input.
  - Button presses, menu selections, etc.

AWT and Swing



Elements of a frame



Creating a frame

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

public class ImageViewer
{
    private JFrame frame;

    /**
     * Create an ImageViewer show it on screen.
     */
    public ImageViewer()
    {
            makeFrame();
    }

    // rest of class omitted.
}
```

The content pane

```
/**
 * Create the Swing frame and its content.
 */
private void makeFrame()
{
    frame = new JFrame("ImageViewer");
    Container contentPane = frame.getContentPane();

    JLabel label = new JLabel("I am a label.");
    contentPane.add(label);

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

Adding menus

- **`JMenuBar`**
  - Displayed below the title.
  - Contains the menus.
- **`JMenu`**
  - e.g. *File*. Contains the menu items.
- **`JMenuItem`**
  - e.g. *Open*. Individual items.

```
private void makeMenuBar(JFrame frame)
{
    JMenuBar menubar = new JMenuBar();
    frame.setJMenuBar(menubar);

    // create the File menu
    JMenu fileMenu = new JMenu("File");
    menubar.add(fileMenu);

    JMenuItem openItem = new JMenuItem("Open");
    fileMenu.add(openItem);

    JMenuItem quitItem = new JMenuItem("Quit");
    fileMenu.add(quitItem);
}
```

Event handling

- Events correspond to user interactions with components.
- Components are associated with different event types.
  - Frames are associated with **`WindowEvent`**.
  - Menus are associated with **`ActionEvent`**.
- Objects can be notified when an event occurs.
  - Such objects are called *listeners*.

Centralized event receipt

- A single object handles all events.
  - Implements the **`ActionListener`** interface.
  - Defines an **`actionPerformed`** method.
- It registers as a listener with each component.
  - **`item.addActionListener(this)`**
- It has to work out which component has dispatched the event.

ActionListener

```
public interface ActionListener
{
    public void actionPerformed(ActionEvent ev);
}
```

```
public class ImageViewer implements ActionListener
{
    …
    public void actionPerformed(ActionEvent e)
    {
        String command = e.getActionCommand();
        if(command.equals("Open")) {
            …
        }
        else if (command.equals("Quit")) {
            …
        }
        …
    }
    …
    private void makeMenuBar(Jframe frame)
    {
        …
        openItem.addActionListener(this);
        …
    }
}
```

Centralized event handling

- The approach works.
- It is used, so you should be aware of it.
- However …
  - It does not scale well.
  - Identifying components by their text is fragile.
- An alternative approach is preferred.

Nested class syntax

- Class definitions may be nested.
  -
```
public class Enclosing
{
    …
    private class Inner
    {
        …
    }
}
```

Inner classes

- Instances of the inner class are localized within the enclosing class.
- Instances of the inner class have access to the private members of the enclosing class.

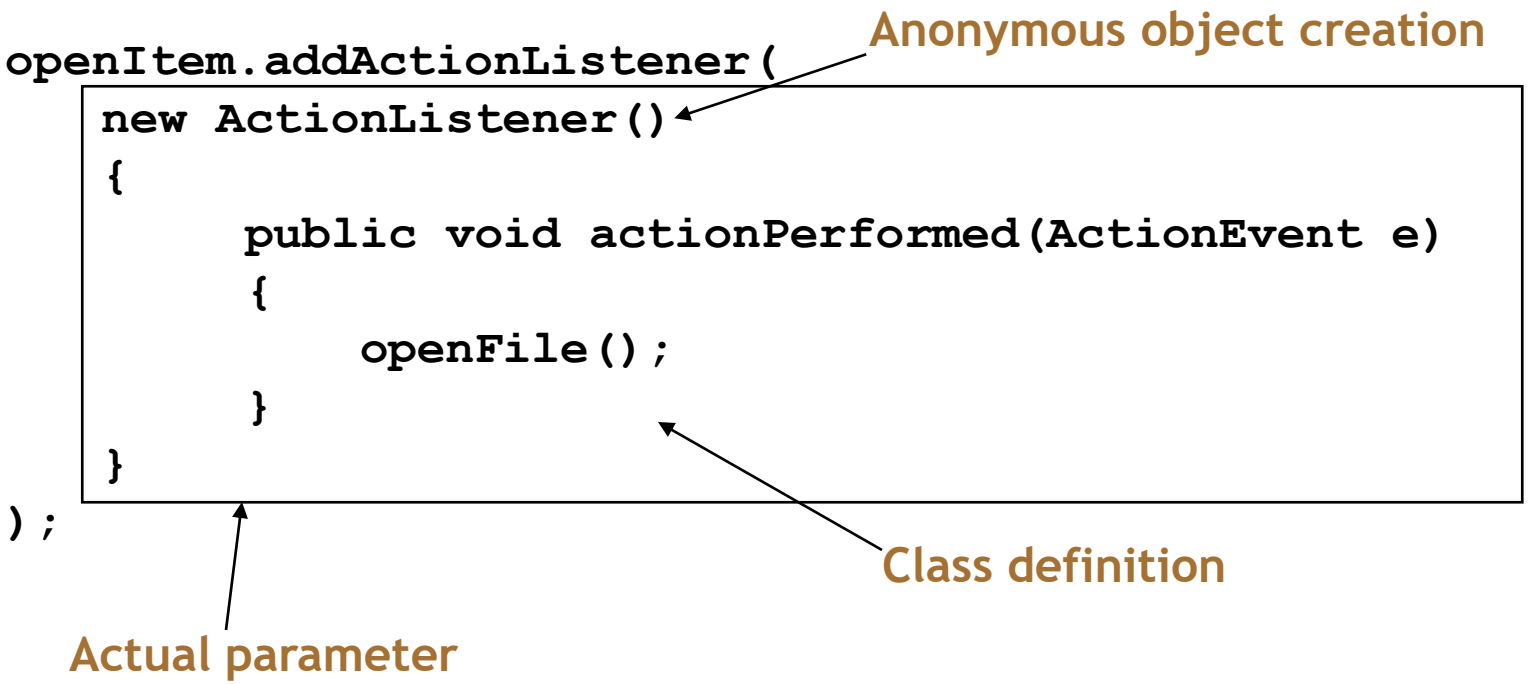
Anonymous inner classes

- Obey the rules of inner classes.
- Used to create one-off objects for which a class name is not required.
- Use a special syntax.
- The instance is always referenced via its supertype, as it has no subtype name.

Anonymous action listener

```
JMenuItem openItem = new JMenuItem("Open");

openItem.addActionListener(new ActionListener() {
     public void actionPerformed(ActionEvent e) {
         openFile();
     }
});
```

Anonymous class elements



Exit on window close

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

`WindowAdapter` provides a no-op implementation of the `WindowListener` interface.

The imageviewer project

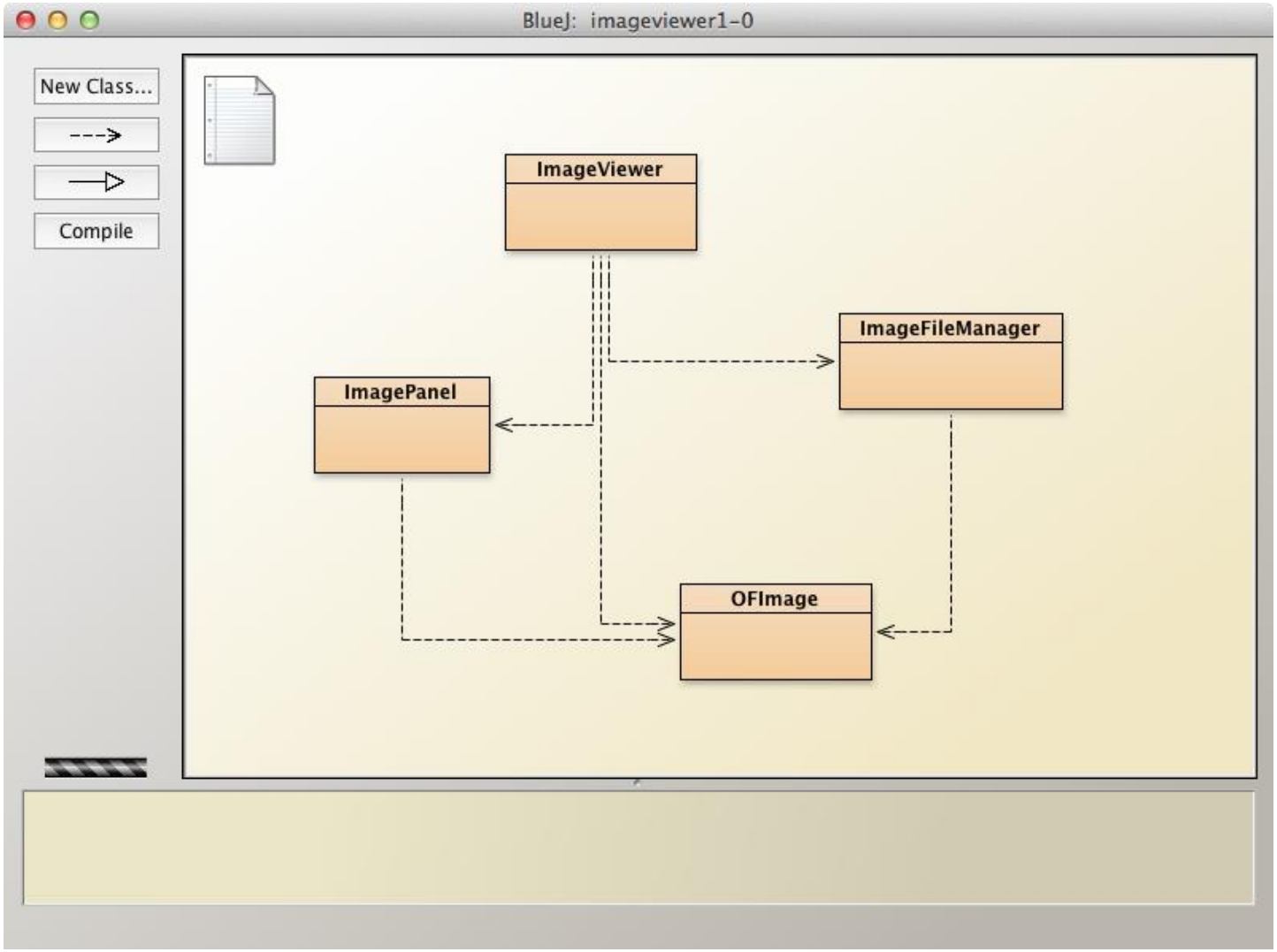


Image processing

Class responsibilities

- **`ImageViewer`**
  - Sets up the GUI structure.
- **`ImageFileManager`**
  - Static methods for image file loading and saving.
- **`ImagePanel`**
  - Displays the image within the GUI.
- **`OFImage`**
  - Models a 2D image.

OFImage

- Our subclass of **`BufferedImage`**.
- Represents a 2D array of pixels.
- Important methods:
  - **`getPixel`**, **`setPixel`**
  - **`getWidth`**, **`getHeight`**
- Each pixel has a color.
  - We use **`java.awt.Color`**.

Adding an ImagePanel

```
public class ImageViewer
{
    private JFrame frame;
    private ImagePanel imagePanel;

    …

    private void makeFrame()
    {
        Container contentPane = frame.getContentPane();
        imagePanel = new ImagePanel();
        contentPane.add(imagePanel);
    }

    …
}
```

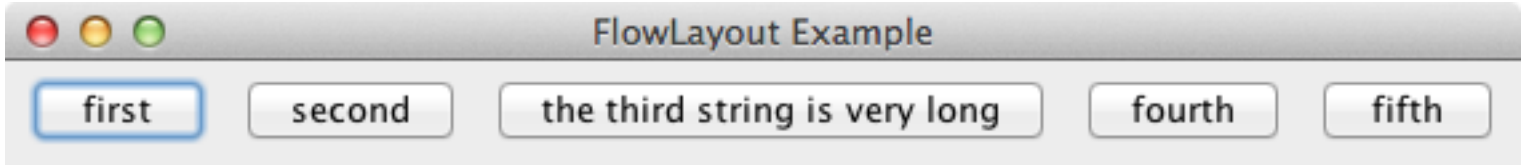
Loading an image

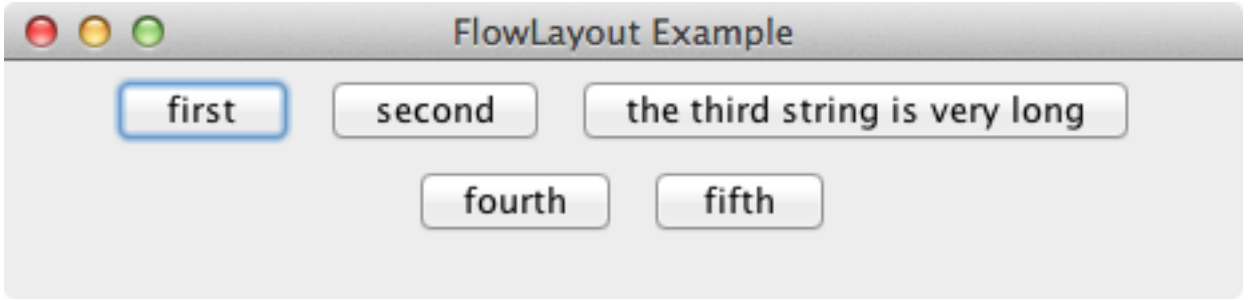
```
public class ImageViewer
{
    private JFrame frame;
    private ImagePanel imagePanel;

    …

    private void openFile()
    {
        File selectedFile = …;
        OFImage image =
            ImageFileManager.loadImage(selectedFile);
        imagePanel.setImage(image);
        frame.pack();
    }

    …
}
```

Layout managers

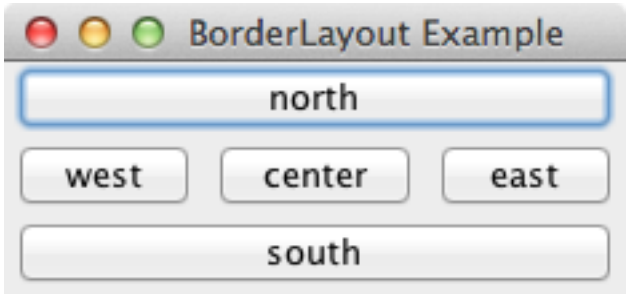
- Manage limited space for competing components.
  - **`FlowLayout`**, **`BorderLayout`**, **`GridLayout`**, **`BoxLayout`**, **`GridBagLayout`**.
- Manage **`Container`** objects, e.g. a content pane.
- Each imposes its own style.

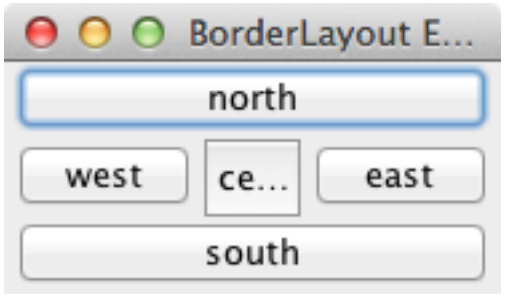
FlowLayout

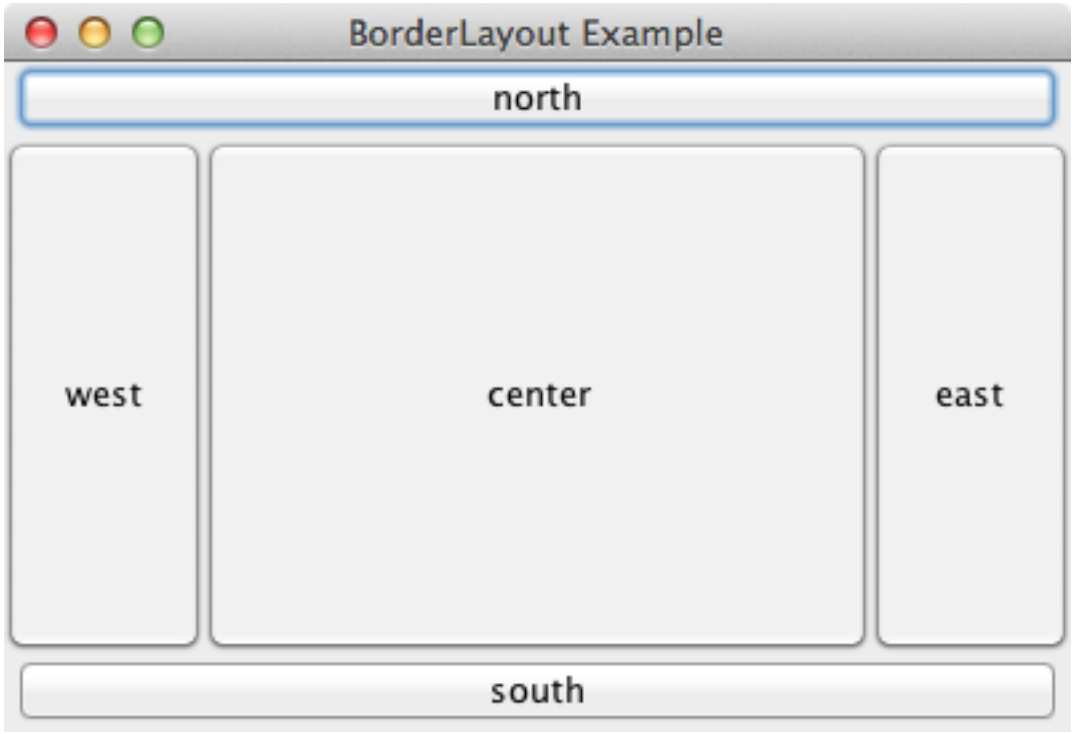

FlowLayout Example
first
second
the third string is very long
fourth
fifth


FlowLayout Example
first
second
the third string is very long
fourth
fifth

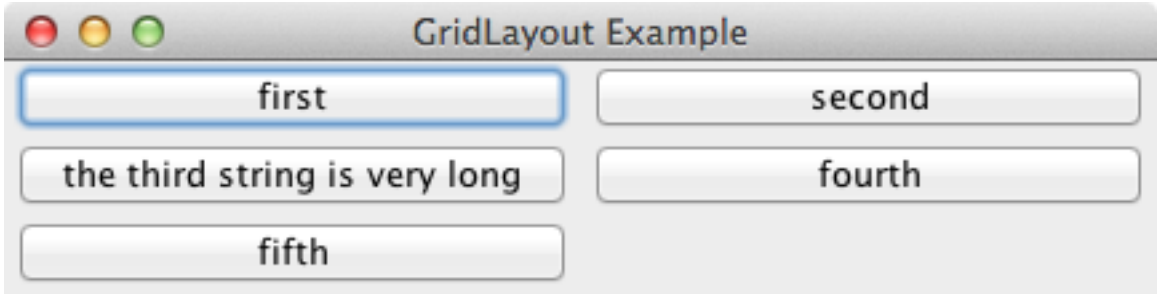
BorderLayout

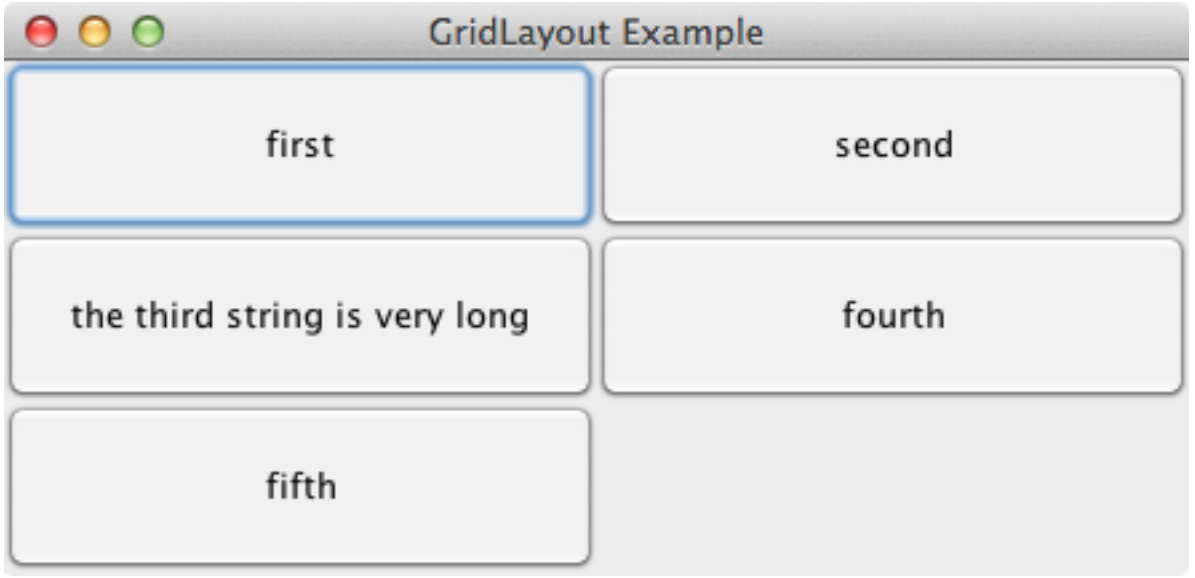




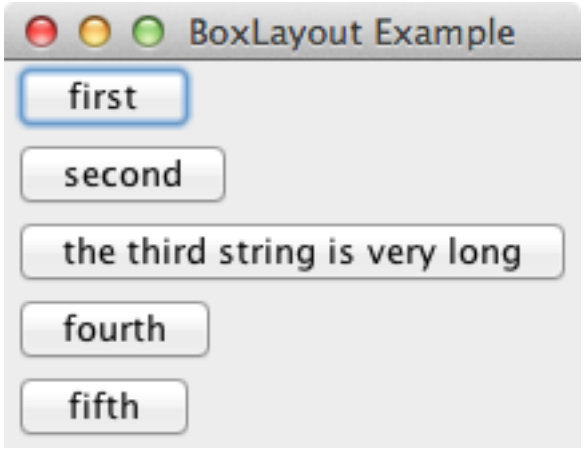


GridLayout


GridLayout Example
first
second
the third string is very long
fourth
fifth


GridLayout Example
first
second
the third string is very long
fourth
fifth

BoxLayout



Note: no component resizing.

Nested containers

- Sophisticated layouts can be obtained by nesting containers.
  - Use **`JPanel`** as a basic container.
- Each container will have its own layout manager.
- Often preferable to using a **`GridBagLayout`**.

Struts and Glue

- Invisible components used as spacing.
- Available from the **`Box`** class.
- Strut: fixed size.
  - **`Component createHorizontalStrut(int width)`**
  - **`Component createVerticalStrut(int height)`**
- Glue: fills available space.
  - **`Component createHorizontalGlue()`**
  - **`Component createVerticalGlue()`**

http://docs.oracle.com/javase/tutorial/uiswing/layout/box.html

Dialogs

- Modal dialogs block all other interaction.
  - Forces a response from the user.
- Non-modal dialogs allow other interaction.
  - This is sometimes desirable.
  - May be difficult to avoid inconsistencies.

JOptionPane standard dialogs

- Message dialog
  - Message text plus an OK button.
- Confirm dialog
  - Yes, No, Cancel options.
- Input dialog
  - Message text and an input field.
- Variations are possible.

A message dialog

```
private void showAbout()
{
    JOptionPane.showMessageDialog(frame,
                "ImageViewer\n" + VERSION,
                "About ImageViewer",
                JOptionPane.INFORMATION_MESSAGE);
}
```

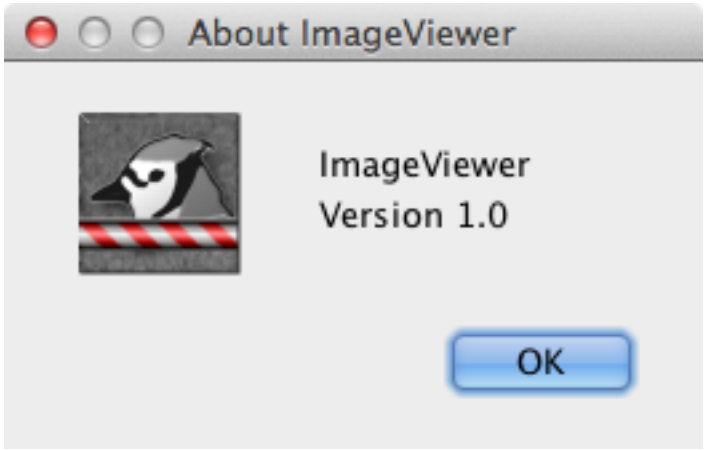


Image filters

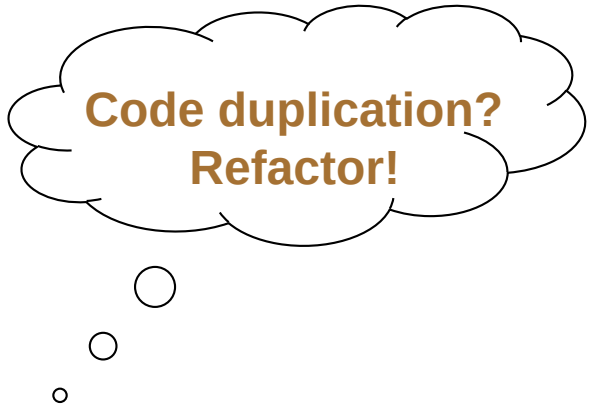
- Functions applied to the whole image.

```
int height = getHeight();
int width = getWidth();
for(int y = 0; y < height; y++) {
    for(int x = 0; x < width; x++) {
        Color pixel = getPixel(x, y);
        alter the pixel's color value;
        setPixel(x, y, pixel);
    }
}
```

Adding further filters

```
private void makeLighter()
{
    if(currentImage != null) {
        currentImage.lighter();
        frame.repaint();
        showStatus("Applied: lighter");
    }
    else {
        showStatus("No image loaded.");
    }
}
```

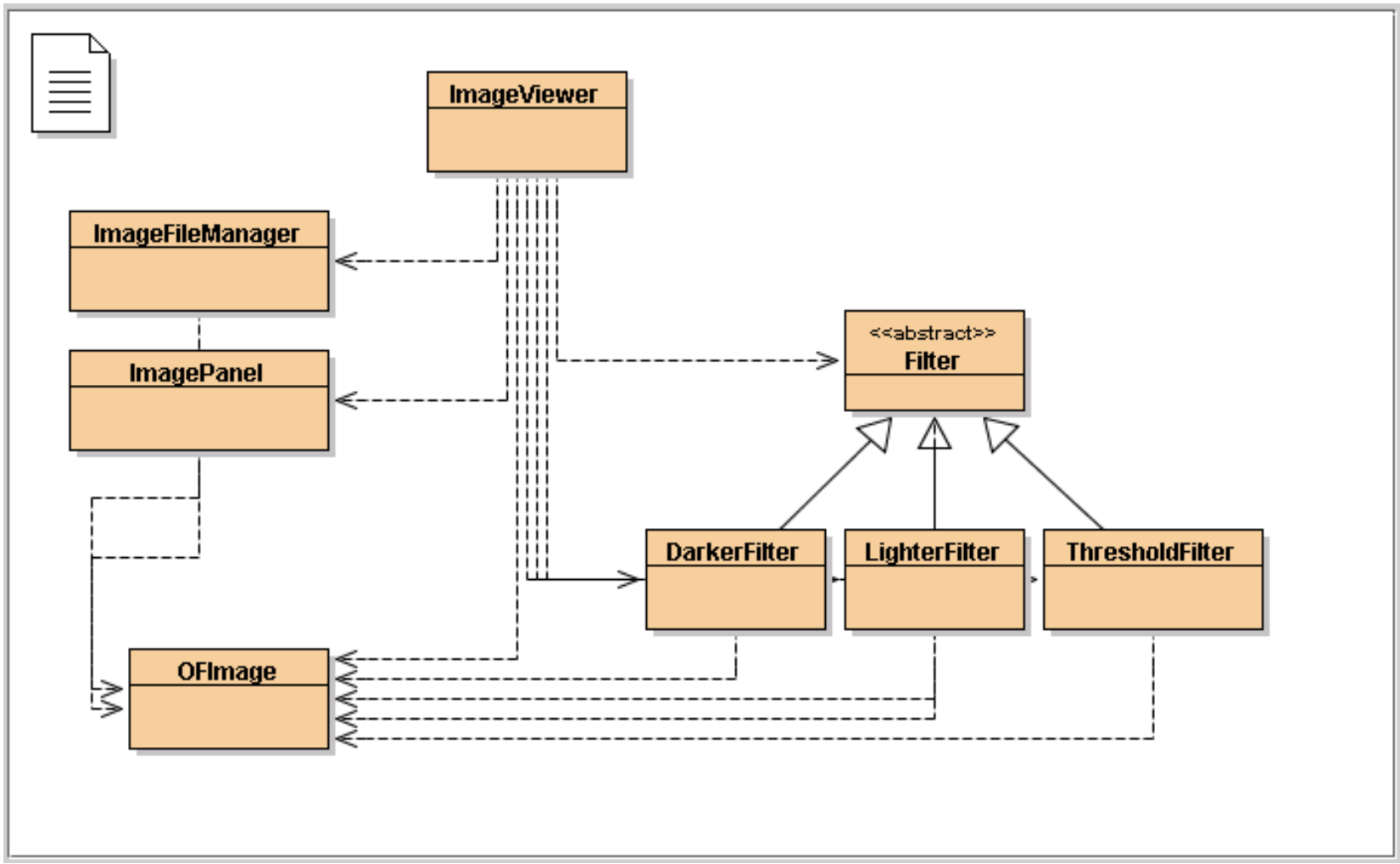
```
private void threshold()
{
    if(currentImage != null) {
        currentImage.threshold();
        frame.repaint();
        showStatus("Applied: threshold");
    }
    else {
        showStatus("No image loaded.");
    }
}
```



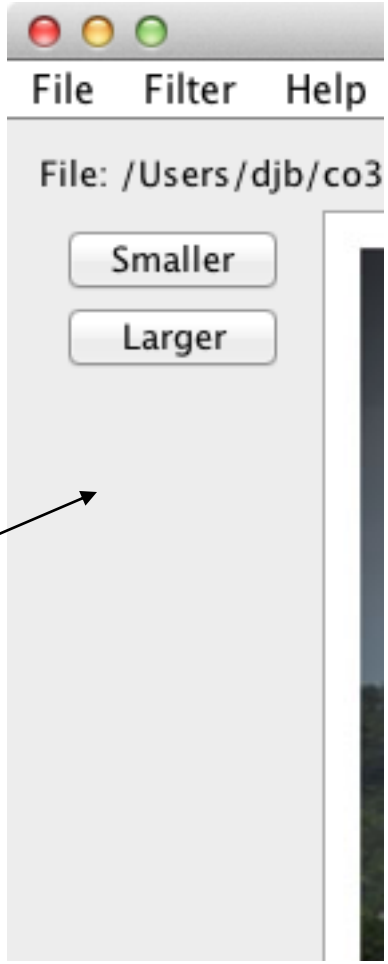
Adding further filters

- Define a **`Filter`** superclass (abstract).
- Create function-specific subclasses.
- Create a collection of subclass instances in **`ImageViewer`**.
- Define a generic **`applyFilter`** method.
- See *imageviewer2-0*.

imageviewer2-0



Buttons and nested layouts



A GridLayout inside a FlowLayout inside a BorderLayout.

Borders

- Used to add decoration around components.
- Defined in **`javax.swing.border`**
  - **`BevelBorder`**, **`CompoundBorder`**, **`EmptyBorder`**, **`EtchedBorder`**, **`TitledBorder`**.

Adding spacing

```
JPanel contentPane = (JPanel)frame.getContentPane();
contentPane.setBorder(new EmptyBorder(6, 6, 6, 6));

// Specify the layout manager with nice spacing
contentPane.setLayout(new BorderLayout(6, 6));

imagePanel = new ImagePanel();
imagePanel.setBorder(new EtchedBorder());
contentPane.add(imagePanel, BorderLayout.CENTER);
```

Other components

- Slider
- Spinner
- Tabbed pane
- Scroll pane

Review

- Aim for cohesive application structures.
  - Endeavor to keep GUI elements separate from application functionality.
- Pre-defined components simplify creation of sophisticated GUIs.
- Layout managers handle component juxtaposition.
  - Nest containers for further control.

Review

- Many components recognize user interactions with them.
- Reactive components deliver events to listeners.
- Anonymous inner classes are commonly used to implement listeners.