

Object-Oriented Programming

Session: Week 3 Session 1

Instructor: Eric Pogue



Agenda:

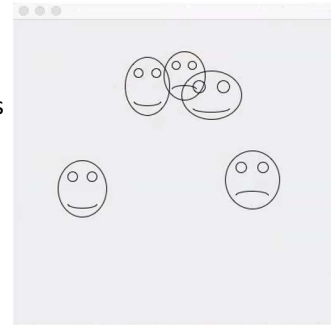
1. Discuss last week's Assignment
2. Review this week's Assignment
3. Introduce the week's Learning Objectives
4. Review Learning Objectives will be covered in this session
5. Present Topics
6. Closing Comments and Next Steps

Discuss FaceDraw Assignment

FaceDraw and Learning Objectives: FaceDraw will be a challenging assignment this week. Our Learning Objects, Discussion, Lecture, and Examples will all be focused on helping you complete the assignment and learn the key concepts through delivering a concrete example.

In FaceDraw we will:

1. Create an application in Java that draws random faces on a window
2. Generate a random number between 3 & 10 and draw that many faces
3. Randomly generate reasonable and visually appealing face
4. Position itself to a reasonable size and location
5. Draw all faces so they are entirely within the window.
6. Draw each face with two eyes and a mouth.
7. The mouth should be randomly smiling, frowning, or in-between



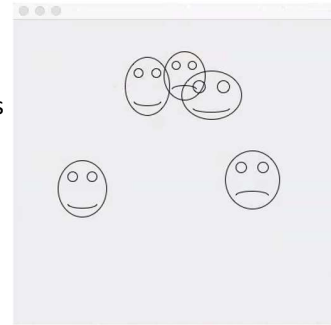
I'm looking for your feedback!

Review Week 4 Assignment

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In FaceDraw we will:

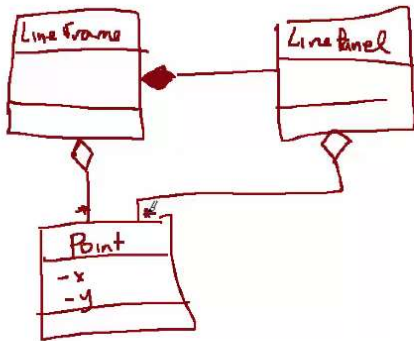
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Less theory and more practical development

Learning Objectives – Week 4

1. Implement a menu system that enables the user to trigger a variety of actions in a familiar way
2. Implement code that responds to a variety of events, including clicking the mouse on a frame or panel, moving or dragging the mouse, and typing a key on the keyboard
3. Design multiple intuitive ways for a user to perform a particular task
4. Implement animation using a timer and a corresponding event handler
5. Understand how Java achieves speedier input and output (IO) through a hierarchy file IO classes
6. Design and implement a controller class that outputs data to a text file
7. Design and implement a controller class that inputs data from a text file and builds a collection of objects from the data read data
8. Create interactive applications that adhere to the Model-View-Controller pattern



Learning Objectives – Week 3 / Session 1

1. Explain the difference between lightweight and heavyweight components
2. Identify lightweight and heavyweight components
3. Describe how lightweight and heavyweight components render themselves
4. Identify layout managers for heavyweight and lightweight components
5. Explain what a layout manager does and identify and describe three of them
6. Explain how to achieve true Model-View-Controller architecture by removing any reference from the view to the model and from the model to the view
7. Distinguish between extending a class and implementing an interface
8. Explain multiple ways to implement an event handler for a particular object and event (anonymous inner classes vs. named classes vs. having the frame itself serve as the handler)
9. Create an event handler that implements the `ActionListener` interface to respond to the user clicking on a button
10. Use `paint` and `paintComponent`'s `Graphics` object to draw a variety of shapes

Lightweight and Heavyweight User Interface Components

UI Components: There are two kinds of graphics components in the Java programming language: **heavyweight** and **lightweight**.

A **heavyweight component** is associated with its own native screen resource. **AWT** Components from the java.awt package, such as Button and Label, are heavyweight components.

Lightweight components such as **Swing components** depend less on the target platform and use less native GUI resource. They also look less native.

```
// ShapesView
class ShapeFrame extends JFrame implements ActionListener {
    public ShapeFrame() {
        // Get the JFrame's container... JFrame is a
        // heavyweight component.
        Container myContainer = getContentPane();
        myContainer.setLayout(new BorderLayout());

        // Add an empty panel to the center.
        myContainer.add(new JPanel(), BorderLayout.CENTER);

        // Create a panel for Buttons
        JPanel myButtonPanel = new JPanel();
        myButtonPanel.setLayout(new FlowLayout());

        // Add two buttons and implement action listeners
        // with anonymous inner classes.
        JButton ClickMe = new JButton("ClickMe!!");
        ClickMe.addActionListener(new ActionListener() {
            public void actionPerformed(ActionEvent e) {
                System.out.println("Option 1: Inner class");
            }
        });
    }
}
```

These notes are from the Oracle site. There is also a nice article about on the Oracle site about mixing heavyweight and lightweight components at:

<http://www.oracle.com/technetwork/articles/java/mixing-components-433992.html>

Java platform graphics have been the Achilles heel of the Java platform since the mid-1990s. Programmers used to joke that AWT stood for Awful Windows Toolkit because the resulting applications were so slow to function and unpleasant to look at. AWT actually stands for Abstract Window Toolkit.

IBM's Standard Widget Toolkit (SWT) toolkit is an alternative to AWT and Swing that has taken root in the Eclipse Integrated Development Environment (IDE) world.

https://en.wikipedia.org/wiki/Standard_Widget_Toolkit

AWT and Swing are excellent learning tools; however, nearly all commercial user interface development has moved on to other tools and libraries. Native user interfaces or Web type interfaces using Java Script is seem to be the direction. Note: Java and Java Script have **NOTHING** to do with each other! It was completely a marketing ploy to give Java Script the Java name.

Java Applets are Java applications that run in a browser. They never really did work... The "write once and run everywhere" philosophy never did play out very well in the industry when it comes to leading edge client applications. Browser based applications seem to have filled that gap while native applications have filled the "rich client" areas. I suspect that trend will continue.

java.awt.*: Graphics, Color, Font

Java.swing: JFrame, JPanel, JButton

Heavyweight Components

- Paint themselves using their “`paint(Graphics g)`” method.
- Provide methods associate with “Graphic g” such as: `drawOval()`, `fillOval()`, `drawRect()`, `fillRect()`, and `drawstring()`
- Own a Content Pane, which is a type of Container
- Implement “`getContentPane()`” method to access their Content Pane
- Can implement a **Layout Manager** via their Container

The Graphics class is defined in package `java.awt`.

A window in Java is called a `JFrame`. `JFrames` are heavyweight components: graphical components that communicate directly with the operating system and show up directly on the desktop. Heavyweight components contain what are called lightweight components. Lightweight components include panels and buttons. In Java, panels are implemented as `JPanels`, and buttons are implemented as `JButtons`.

Lightweight Components

- Paint themselves using their “paintComponent(Graphics g)” method
- Provide methods associate with “Graphic g” such as: drawOval(), fillOval(), drawRect(), fillRect(), and drawstring()
- Are a Container... so no need to call a method to get a Container
- Can implement a **Layout Manager** via their Container

Specifically, a JFrame, a heavyweight component ...

1. Can setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE) to make the program vanish from memory (i.e. free resources) when closed.
2. Can set size and location using setBounds(x,y,width,height)
3. Can show itself using setVisible(true) and hide itself using setVisible(false)
4. Can give you a reference to its Container through its getContentPane() function. Once you have access to its Container object, you can set the layout of that container so that you can arrange lightweight components in it.

Popular Lightweight Swing UI components include:

Jbutton

JTextArea

JPanel

Layout Managers

Layout Managers arrange controls on the screen so they are visually appealing. They allow developers to be able to focus less on layout details. Both AWT and Swing provide general purpose Layout Managers including:

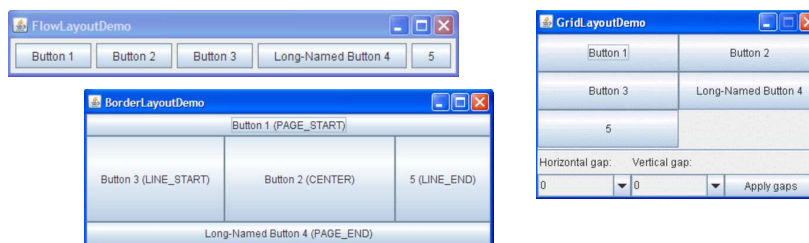
- BorderLayout
- BoxLayout
- CardLayout
- FlowLayout
- GridBagLayout
- GridLayout
- GroupLayout
- SpringLayout

This is different from environments where developers (or designers) layout screens pixel by pixel (like Visual Basic for example). With modern UIs that need to fit in all types of sizes and orientations, layout managers are a necessity.

Layout Managers (continued)

Layout Managers arrange controls on the screen so they are visually appealing. We will be focusing on three very common Layout Managers:

- **FlowLayout:** Arranges components left to right, top to bottom. When a FlowLayout runs out of room horizontally on a row, it places the next component as far left as it can go on the row below.
- **BorderLayout:** Arranges components in NORTH, SOUTH, EAST, WEST, and CENTER sections.
- **GridLayout:** Arranges components in an Excel-like table of rows and columns.



This is different from environments where developers (or designers) layout screens pixel by pixel (like Visual Basic for example). With modern UIs that need to fit in all types of sizes and orientations, layout managers are a necessity.

Several AWT and Swing classes provide layout managers for general use:

- BorderLayout
- BoxLayout
- CardLayout
- FlowLayout
- GridBagLayout
- GridLayout
- GroupLayout
- SpringLayout

Model-View-Controller

Model-View-Controller (MVC): This week are focus will be in creating our first Graphical view. Specifically we will:

1. Implement our first graphical view using Java AWT and Swing graphics
2. Demonstrate a view that you will be able to build off of for our assignment
3. Implement a more sophisticated view to draw smiling and frowning faces as our assignment for the week
4. Discuss why our command line interface is also a view
5. Discuss how we “render” our data to the command line using the toString() method
6. Discuss pros and cons of “rendering” our data to our graphical view via a “toGraphic()” method

We will be focuses on the View this week, and will keep our references to Models and Controllers to a minimum.

MVC is an important pattern, will be a primary focus of this course, and will be an important pattern for you to master in your career.

Segregation of our Model (data) from our View (user interface) is necessary to effectively develop, enhance, and maintain modern software.

An example would be a system that manages student data. We would want to segregate the Model (data) from the View (UI) for several reasons including that there will likely be many different Views that access the same data including:

student view
faculty view
administrator view,
Web student view,
mobile student view, etc.

Evolution of UI and Data segregation

- Document-View (View was responsible for View-Controller functionality)
- Model-View-Controller
- Model–View–Viewmodel

Interface Implementation vs. Class Extension

Differences include:

1. Interfaces are implicitly abstract and cannot have implementations
2. An interface specifies one or more abstract methods that a class that implements the interface must implement
3. Abstract classes can have both abstract methods and concrete methods
4. A class can descend (extends) only one Class but can implement many interfaces

Note: Interfaces are Java's way of avoiding the significant complexities of multiple inheritance while providing most of the benefits.

A little history:

Some languages including C++ implemented multiple inheritance in order to allow Classes to inherit from multiple parent classes. That solution has pros and cons beyond the scope of this course.

Other languages including Java only support single inheritance, but also implemented Interfaces in order to allow class to act like multiple things. An example that we will be discussing this week is our OvalFrame that we would like to be a JFrame but may also want it to act like an ActionListener to respond to buttons being pushed.

Interface Implementation

Interface implementation is basically agreeing to a contract to implement a given set of methods.

The **ActionListener** Interface is a good example of an interface that a class must implement in order to receive notification that a button has been pushed by the user.

```
// ShapesView
import java.awt.event.ActionEvent;
import java.awt.event.ActionListener;

class SeparateClassListener implements ActionListener {
    public void actionPerformed(ActionEvent e) {
        System.out.println("Option 2: Separate class listener...");
    }
}
```

Class Extension

Class Extension is **Inheritance**. Enough said?

In Java a class can extend from only one parent class, but can implement multiple interfaces.

The code to the right demonstrates ShapeFrame:

- Extending from JFrame so that it can “be a” JFrame and hold lightweight UI components
- Implementing ActionListener so that it can “act like” a ActionListener and receive notification that a button has been pressed.

```
// ShapesView
// ShapeFrame extends JFrame implements ActionListener {
public ShapeFrame() {
    // Get the JFrame's container... JFrame is a
    // heavyweight component.
    Container myContainer = getContentPane();
    myContainer.setLayout(new BorderLayout());

    // Add an empty panel to the center.
    myContainer.add(new JPanel(), BorderLayout.CENTER);

    // Create a panel for Buttons
    JPanel myButtonPanel = new JPanel();
    myButtonPanel.setLayout(new FlowLayout());

    // Add two buttons and implement action listeners
    // with anonymous inner classes.
    JButton ClickMe = new JButton("ClickMe?!");
    ClickMe.addActionListener(new ActionListener() {
        public void actionPerformed(ActionEvent e) {
            System.out.println("Option 1: Inner class");
        }
    });

    JButton Cancel = new JButton("Cancel");
    Cancel.addActionListener(new ActionListener() {
        public void actionPerformed(ActionEvent e) {
            System.exit(0);
        }
    });
}
```

Event Handling

Clicking Event Handling is the way that all graphic user interface environment allow an application to respond to user (or system) events. Possible events include:

- Keyboard strokes
- Clicking buttons
- Dragging a mouse
- Low power warning or automatic system hibernation
- Attaching to an overhead projector
- And many, many others

Event Handling – ActionListener

We will specifically need to implement Java ActionListeners to respond to button clicks. To do that we will need to:

- Understand that **ActionListener**, like other listeners, are an **interface**... not a class
- Implement a Java ActionListeners Interface
- Utilize our ActionListener to receive notifications of an event and respond appropriately
- Understand the three ways we could implement an ActionListener to respond to a user pressing a button contained in a our JFrame:
 1. Implement an ActionListener interface in our JFrame
 2. Utilize an external class that implements ActionListener
 3. Implement an ActionListener utilizing an Anonymous Inner Class

Learning Objectives – Closing Comments

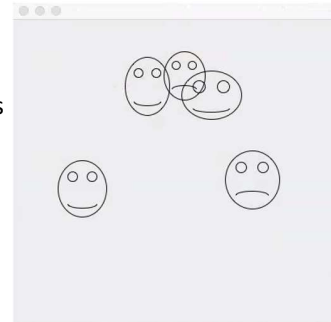
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FaceDraw Assignment - Closing Comments

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Read the details in the assignment. Keep these in mind as you watch the examples. Start working on this early. It is unlikely to go well if you try to do this at the last minute.

End of Session

Course Number: CPSC-24500

Week: 3

Session: 1

Instructor: Eric Pogue

Object-Oriented Programming

Session: Week 3 Session 2

Instructor: Eric Pogue



Agenda:

1. Review where we left off in session 1
2. Identify the goal of session 2
3. Implement ShapesLibrary.class
4. Get ready for Graphics drawing session

While everyone is getting logged in and set up for our virtual discussion, I wanted to thank those of you who have posted their background and/or responded to other people's discussion board posting. I have enjoyed reading through your comments.

I am going to start recording so that others can watch later; however, if I think that is impacting our ability to have a good discussion, I will stop the recording and just send out notes later.

Learning Objectives – Session 1

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Learning Objectives – Session 2

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Graphics Objects

Graphics Objects [\[link\]](#): We will generally see the Graphics object as part of overriding paintComponent(Graphics g). The “g” object has many useful methods including:

- drawOval(x,y,width,height)
- fillOval(x,y,width,height)
- setColor(Color.BLUE)
- drawRect()
- drawArc() [\[link\]](#)... You will want to use this draw your smiling faces in the assignment this week.
- drawString()
- setFont()

```
*****
// CircleDraw
import java.util.ArrayList;
import javax.swing.*;
import java.awt.*;

class ShapePanel extends JPanel {
    private ArrayList<Shape> panelShapesList;

    ShapePanel() {
        panelShapesList = null;
    }

    ShapePanel(ArrayList<Shape> ShapesList) {
        panelShapesList = ShapesList;
    }

    public void paintComponent(Graphics g) {
        // Graphics objects have lots of drawing functions
        super.paintComponent(g); // Draws other components.
        if (panelShapesList != null) {
            for (Shape s : panelShapesList) {

            }
        }
    }
}
```

JavaDoc:

<https://docs.oracle.com/javase/7/docs/api/java/awt/Graphics.html>

Java Graphics Tutorial:

<https://docs.oracle.com/javase/tutorial/2d/basic2d/>

drawArc:

<http://www.java2s.com/Code/JavaAPI/java.awt/GraphicsdrawArcintxintyintwidthintheightintstartAngleintarcAngle.htm>

drawArc Example:

<http://www.java-examples.com/draw-arc-applet-window-example>

Repaint Sequence:

OS -> Frame -> Frame's paint function -> each LW component paintComponent function

Code Sharing, Package Visibility, and ShapesLibrary.class

Sharing or reusing source code is a fundamental practice in object-oriented programming. In this session we are going to demonstrate creating ShapesLibrary.java by:

1. Creating a new ShapesLibrary from our ShapesStep2 project from last week
2. Separating the reusable Shapes code into a separate ShapesLibrary.java file
3. Making a few enhancements to make the code more reusable including:
 - Demonstrate static “helper functions”
 - Creating a separate test Test application
 - Demonstrate assert
4. Compiling ShapesLibrary.java to ShapesLibrary.class

```
// *****  
// ShapesStep2  
import java.util.ArrayList;  
  
abstract class Shape {  
    public final void setPositionX(int positionXIn) { positionX = positionXIn; }  
    public final int getPositionX() { return positionX; }  
    private int positionX;  
  
    public final int getPositionY() { return positionY; }  
    public final void setPositionY(int positionYIn) { positionY = positionYIn; }  
    private int positionY;  
  
    public Shape() {  
        this(0,0);  
    }  
  
    public Shape(int positionXIn, int positionYIn) {  
        setPositionX(positionXIn);  
        setPositionY(positionYIn);  
    }  
  
    public String toString() {  
        return String.format("positionX=%d, positionY=%d", positionX, positionY);  
    }  
  
    abstract public double CalcArea();  
    abstract public double CalcPerimeter();  
}
```

There is a fundamental issue with most teams and organizations related to code sharing. Developing and maintaining shared code is more difficult than developing and maintaining non-shared code. I think that it is at least 50% more difficult and more likely twice as difficult. Therefore, in order for making the creation and maintenance of code sharing economically beneficial the ratio of creating shared code versus using other people's code needs to be 2 or 3 to one. In other words, for every hour you spend writing shared code, you should be spending 2 or 3 hours working to effectively utilize other people's code. The reality is most developers spend most of their time working diligently to develop reusable code, but they very rarely reuse code from other people on their team.

Using asserts is an important defensive coding tactic. The idea is that you “assert” things to be true in the code which serves as both a forceful comment and a developer notification mechanism. Then when developers are testing their code, the environment will automatically warn them when their assumptions are not valid.

<http://docs.oracle.com/javase/7/docs/technotes/guides/language/assert.html>

Static methods are methods that we can associate with a class, but do not require a class instance to execute. They can be very helpful with writing small helper functions.

The command line flag for enabling asserts is:

`java -enableassertions ShapesStep2`

End of Session

Course Number: CPSC-24500

Week: 3

Session: 2

Instructor: Eric Pogue

Object-Oriented Programming

Session: Discussion & Lecture (Week 3 Session 3)

Instructor: Eric Pogue



Agenda:

1. Review where we left off after sessions 1 and 2... and what to expect in session 4
2. Graphics Object and drawing and Layout Manager review
3. Update ShapesLibrary
4. Implement ShapeDraw application
5. Possible next steps for implementing FaceDraw
6. Questions & Answers
7. Closing Comments

While everyone is getting logged in and set up for our virtual discussion, I wanted to thank those of you who have posted their background and/or responded to other people's discussion board posting. I have enjoyed reading through your comments.

****Start Recording**

Comments:

I will post our week 1 assignment review via a separate video. I think it will take away from our current discussion if we try to intermix the topics today. I want to have laser focus on our programming assignment today.

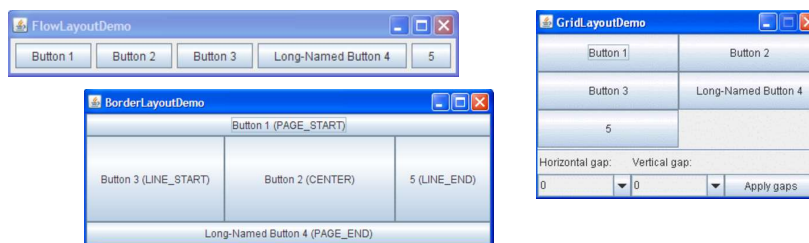
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Layout Managers (continued)

Layout Managers arrange controls on the screen so they are visually appealing. We will be focusing on three very common Layout Managers:

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- **BorderLayout**: Arranges components in NORTH, SOUTH, EAST, WEST, and CENTER sections.
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This is different from environments where developers (or designers) layout screens pixel by pixel (like Visual Basic for example). With modern UIs that need to fit in all types of sizes and orientations, layout managers are a necessity.

Several AWT and Swing classes provide layout managers for general use:

- BorderLayout
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- drawRect()
- drawArc() [\[link\]](#)... You will want to use this draw your smiling faces in the assignment this week.
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        // Graphics objects have lots of drawing functions
        super.paintComponent(g); // Draws other components.
        if (panelShapesList != null) {
            for (Shape s : panelShapesList) {

            }
        }
    }
}
```

This is your second or third time seeing this. After today, you should mostly “get it”.

JavaDoc:

<https://docs.oracle.com/javase/7/docs/api/java/awt/Graphics.html>

Java Graphics Tutorial:

<https://docs.oracle.com/javase/tutorial/2d/basic2d/>

drawArc:

<http://www.java2s.com/Code/JavaAPI/java.awt/GraphicsdrawArcintxintyintwidthintheightintstartAngleintarcAngle.htm>

drawArc Example:

<http://www.java-examples.com/draw-arc-applet-window-example>

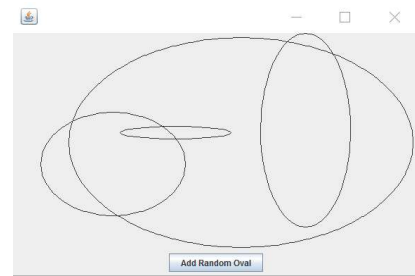
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Graphical Views & Drawing Shapes

Our Discussion & Lecture Session will be focuses on giving you some insights in methods you may want to use in implementing FaceDraw including:

1. Update ShapesLibrary to:
 - Include width & height in the base Shapes class so that we can use them Polymorphically
 - Define the specifics for position x & y... lower left corner of shape
 - Updating Circle so that it utilizes width & height instead of radius
 - Create Oval which can now more easily be descended from Circle
2. Create a new ShapeDraw application that will leverage the new Oval class from ShapesLibrary
3. Create OvalDraw application
4. Implement JFrames, JPanels, and ArrayLists
5. Add new code to GitHub
6. Discuss how you might enhance OvalDraw to FaceDraw



You can imagine that we are going to need JFrames, Jpanels (x2), Border Layouts, Flow Layouts, JButton, Action Listeners, Action Events, Containers, Random, Graphics, ArrayLists, and more...

Object-Oriented Programming

Session: Discussion & Lecture (Week 3 Session 3)

Instructor: Eric Pogue



Closing Comments:

1. Build something that you can take pride in delivering!
2. If you do something special in this assignment, let me know

End of Session

Course Number: CPSC-24500

Week: 3

Session: Discussion & Lecture (Session 3)

Instructor: Eric Pogue

Object-Oriented Programming

Week 3 Session 4

Eric Pogue



Agenda:

1. Explain multiple ways to implement an event handler for a particular object and event (anonymous inner classes vs. named classes vs. having the frame itself serve as the handler)
2. Create an event handler that implements the ActionListener interface to respond to the user clicking on a button
3. Wrap-up Session 4 with our original week 3 Learning Objectives and our original overview of our FaceDraw programming assignment

While everyone is getting logged in and set up for our virtual discussion, I wanted to thank those of you who have posted their background and/or responded to other people's discussion board posting. I have enjoyed reading through your comments.

I am going to start recording so that others can watch later; however, if I think that is impacting our ability to have a good discussion, I will stop the recording and just send out notes later.

Learning Objectives – Week 3

1. Explain the difference between lightweight and heavyweight components
2. Identify lightweight and heavyweight components
3. Describe how lightweight and heavyweight components render themselves
4. Identify layout managers for heavyweight and lightweight components
5. Explain what a layout manager does and identify and describe three of them
6. Explain how to achieve true Model-View-Controller architecture by removing any reference from the view to the model and from the model to the view
7. Distinguish between extending a class and implementing an interface
8. Explain multiple ways to implement an event handler for a particular object and event (anonymous inner classes vs. named classes vs. having the frame itself serve as the handler)
9. Create an event handler that implements the ActionListener interface to respond to the user clicking on a button
10. Use paint and paintComponent's Graphics object to draw a variety of shapes

Quick Review: Event Handling

Clicking Event Handling is the way that all graphic user interface environment allow an application to respond to user (or system) events. Possible events include:

- Keyboard strokes
- Clicking buttons
- Dragging a mouse
- Low power warning or automatic system hibernation
- Attaching to an overhead projector
- And many, many others

Quick Review: Event Handling – ActionListener

We will specifically need to implement Java ActionListeners to respond to button clicks. To do that we will need to:

- Understand that **ActionListener**, like other listeners, are an **interface**... not a class
- Implement a Java ActionListeners Interface
- Utilize our ActionListener to receive notifications of an event and respond appropriately
- Understand the three ways we could implement an ActionListener to respond to a user pressing a button contained in a our JFrame:
 1. Implement an ActionListener interface in our JFrame
 2. Utilize an external class that implements ActionListener
 3. Implement an ActionListener utilizing an Anonymous Inner Class

Live Demo: Event Handlers & Action Listener

Let's implement a new Java application to demonstrate a graphic application that responds to clicking a button. To demonstrate this we will:

- Create a Java graphic application
- Create a JFrame and JPanel
- Implement a Layout Manager (BorderLayout) on our JFrame
- Create and insert JButtons in our JPanel
- Insert our JPanel into the SOUTH section of our BorderLayout Layout Manager
- Create Action Listeners that can respond to our Buttons being clicked
- Each of our three buttons will utilize one of the ActionListener implementation practices:
 1. Implement an ActionListener interface in our JFrame
 2. Utilize an external class that implements ActionListener
 3. Implement an ActionListener utilizing an Anonymous Inner Class

Learning Objectives – Week 3

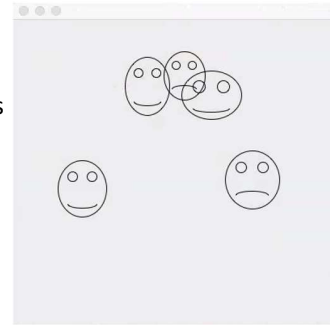
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FaceDraw Assignment & Learning Objectives

FaceDraw and Learning Objectives: FaceDraw will be a challenging assignment this week. Our Learning Objects, Discussion, Lecture, and Examples will all be focused on helping you complete the assignment and learn the key concepts through delivering a concrete example.

In FaceDraw we will:

1. Create an application in Java that draws random faces on a window
2. Generate a random number between 3 & 10 and draw that many faces
3. Randomly generate reasonable and visually appealing face
4. Position itself to a reasonable size and location
5. Draw all faces so they are entirely within the window.
6. Draw each face with two eyes and a mouth.
7. The mouth should be randomly smiling, frowning, or in-between



I intentionally list our assignment first and our learning objectives second. This week our intent is to support our assignment through our learning objectives, discussion, lecture, and examples... and not the other way around.

It is important to understand the concepts, practices, and principles; however, it is essential that we can utilize them to deliver solutions.

The details of FaceDraw are provided in this week's assignment.

End of Session

Course Number: CPSC-24500

Week: 3

Session: 4

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