Graphical User Interfaces
Programs With GUIs

• A Java program with a GUI, or *graphical user interface*, is pretty routine in most respects
  – It declares and manipulates the values of some variables of various types, albeit new ones intended for use in developing GUIs (e.g., buttons, scrollbars, drawing panels, etc.)

• There is just one (big) issue...
The User Interaction Problem

• Not just your program, but an end-user, can spontaneously change the “state” of any active user interface widget (e.g., click a button, check a box, move a slider, scroll a document, press a key, etc.)

• Problem: How does your program know when the user has attempted to provide input to the program via a widget, and determine which widget has been manipulated?
The User Interaction Problem

• Not just your program, but an end-user, can spontaneously change the “state” of any active user interface widget (e.g., click a button, check a box, move a slider, scroll a document, press a key, etc.)

• **Problem**: How does your program know *when* the user has attempted to provide input to the program via a widget, and determine *which* widget has been manipulated?

User interaction includes the keyboard—and any other input devices, e.g., a Kinect controller; so, it goes well beyond reading characters using a SimpleReader.
Terminology

• The act of a user manipulating a widget is called an \textit{event} for that widget
• The widget the user has manipulated is called the \textit{subject} of the interaction
• The objects in your program that need to do something in response to the events for a particular subject are called \textit{observers} (or \textit{listeners}) for that subject
Solution #1: Use Polling

- The main program (the only observer) continually polls each possible subject to ask whether any events have occurred
- This is considered cumbersome...
Polling Pseudo-code

while (true) {
    if (s₀ has experienced an event) {
        if (event is e₀) {
            respond to it
        } else if (event is e₁) {
            respond to it
        } else ...
    } else if (s₁ has experienced an event) {
        ...
    }
}
Solution #2: Use Callbacks

• Each observer (there may be many) registers its interest in a subject’s events, and then waits until the subject *calls it back* to tell it that there has been an event
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But how? What does this mean?
The Observer Pattern

• Each subject expects each observer (listener) to register itself with that subject if it is interested in the subject’s events

• Each subject keeps track of its own set of interested observers

• Whenever an event occurs, the subject invokes a specific callback method for each registered observer, passing an event argument that describes the event
The Observer Pattern

- Each subject expects each observer (listener) to **register** itself with that subject if it is interested in the subject’s events.
- Each subject keeps track of its own **set of interested observers**.
- Whenever an event occurs, the subject invokes a specific **callback method** for each registered observer, passing an **event** argument that describes the event.

Registering interest is done by calling a method of the subject; usually this is done once as part of set-up.
The Observer Pattern

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• Each subject keeps track of its own set of interested observers.

• Whenever an event occurs, the subject invokes a specific callback method for each registered observer, passing an event argument that describes the event.

The set of observers for a given subject can be kept in a `Set` variable, for example.
The Observer Pattern

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- Each subject keeps track of its own set of interested observers.
- Whenever an event occurs, the subject invokes a specific callback method for each registered observer, passing an event argument that describes the event. This method is described in an interface that any potential observer must implement.
The Observer Pattern

- Each subject expects each observer (listener) to register itself with that subject if it is interested.
- Each subject keeps track of its own set of interested observers.
- Whenever an event occurs, the subject invokes a specific callback method for each registered observer, passing an event argument that describes the event.

This is one of many object-oriented design patterns that address common OOP issues (often language deficiencies); most are considered best practices.
Example: Simple GUI Demo

![Diagram showing extending and implementing relationships between JFrame, DemoGUI, and ActionListener]
Example: Simple GUI Demo

Components from Java’s Swing Framework

JFrame

DemoGUI

extends

implements

ActionListener
Example: Simple GUI Demo

Components from Java’s Swing Framework

- JFrame
- ActionListener

This class is the type of the main window of a GUI application.

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Example: Simple GUI Demo

Components from Java’s Swing Framework

- JFrame

This interface declares the callback method:

`actionPerformed`
Example: Simple GUI Demo

Components from Java’s Swing Framework

- JFrame
- ActionListener

This class (our code) contains the body of the `actionPerformed` method, based on the program’s intent, and other code to set up the GUI.
Important Interfaces/Methods

```java
interface ActionListener {
    void actionPerformed(ActionEvent e);
}

interface ActionEvent {
    Object getSource();
    ...
}
```
The class **Object** is special in Java: **every class** extends **Object**! We will return to this later...
Fundamentals: DemoGUI

JFrame

JPanel

JTextArea

in

JScrollPane

JButton
This is the underlying type of the main window of a GUI application using Swing.
Nested inside a JFrame’s *content pane*, you can put any number of things …
... such as a JPanel ...

JFrame

JPanel

JButton

JTextArea

in

JScrollPane
... and nested inside a JPanel, you can put any number of, e.g., JButton.
You can also put in a `JFrame` a `JScrollPane` with, e.g., a `JTextArea`. 
It’s Demo Time

• The DemoGUI1 project contains a very simple GUI application using Swing
• You can get it at:
  http://cse.osu.edu/software/common/DemoGUI1.zip
Set Up by **DemoGUI** Constructor

- `resetButton`
- `copyButton`
- `(and other widgets)`
- `this` (DemoGUI)
Before registration of \textit{this} as an observer of the buttons.
After registration of this as an observer of the buttons.
Instance Variables

• Variables can be declared:
  – in method bodies: *local variables*
  – in method headers: *formal parameters*
  – in classes: *fields* or *instance variables*

• Examples of instance variables:
  – resetButton, copyButton, inputText, outputText, input, output

• Instance variables are essentially *global* variables that are shared by and can be accessed from all instance methods in the class
Now, Who’s In Charge?

• Note: when DemoGUI is executed:
  – DemoGUI.main starts execution
    • Constructor for DemoGUI is called by main
    • Constructor for DemoGUI returns to main
  – DemoGUI.main finishes execution

• After that, what code is executing?
Threads

• A standard Java program executes in a thread, i.e., a single path of sequential code executing one step at a time

• A GUI program with Swing uses at least two threads rather than one:
  – The initial thread executes main (until it completes)
  – An event dispatch thread executes everything else, including actionPerformed
Timeline of Thread Execution

main

time
Timeline of Thread

This is the initial thread; main executes...
Timeline of Thread Execution

... until it calls the DemoGUI constructor, which executes...
Timeline of Thread Execution

DemoGUI

Swing code

... until it calls the JFrame constructor (super), which starts Swing code executing in the event dispatch thread...
... and the DemoGUI constructor continues until it returns to main...
Timeline of Thread Execution

... and `main` continues until it completes; end of initial thread.
Timeline of Thread Execution

The event dispatch thread is now the only executing thread.

Swing code
Timeline of Thread Execution

An event results in a call to `actionPerformed`...
... and when it returns, the Swing code resumes; and so on.
Layout Managers

• A *layout manager* allows you to arrange widgets without providing specific location coordinates
  
  – GridLayout (simplest?; used in DemoGUI)
  – FlowLayout (default for JPanel)
  – BorderLayout (default for JFrame)
  – ...

Java GUI Packages

• Some important packages in the Java libraries for GUI components:
  - `java.awt`
  - `java.awt.event`
  - `javax.swing`
  - ...
  - ...
Java Swing Widgets

• Some important classes in `javax.swing`:
  – JFrame
  – JPanel
  – JButton
  – JScrollPane
  – JTextArea
  – JCheckBox
  – JComboBox
  – ...
Resources

• Java Tutorials (and beyond...)
  – http://docs.oracle.com/javase/tutorial/uiswing/index.html

• A Visual Guide to Layout Managers
  – http://docs.oracle.com/javase/tutorial/uiswing/layout/visual.html