CMSC 132:
OBJECT-ORIENTED PROGRAMMING II

Graphical User Interfaces (GUIs)

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Model-View-Controller (MVC)

- Model for GUI programming (Xerox PARC '78)
- Separates GUI into 3 components
  - Model ⇒ application data
  - View ⇒ visual interface
  - Controller ⇒ user interaction
MVC Model of GUI Design

- Model
  - Should perform actual work
  - Should be independent of the GUI
    - But can provide access methods
- Controller
  - Lets user control what work the program is doing
  - Design of controller depends on model
- View
  - Lets user see what the program is doing
  - Should not display what controller thinks is happening (base display on model, not controller)
Programming Models

- Normal (control flow-based) Programming
  - Approach
    - Start at main()
    - Continue until end of program or exit()

- Event-driven Programming
  - Event → Action or condition occurring outside normal flow of control of program (e.g., mouse clicks, keyboard input, etc.)
  - Unable to predict time & occurrence of event
  - Approach
    - Start with main()
    - Define system elements and register event listeners
    - Await events (& perform associated computation)
Event Handling in Action

Events

Can handle an event of type $e_1$

Execution Environment
**GUIs are Event-Driven Software**

User events invoke event handlers

- User Events
- Event Handlers

- Event macros:
  - `newDocActionPerformed` (java.awt.event.ActionEvent evt)
  - `fileSaveActionPerformed` (java.awt.event.ActionEvent evt)
  - `changeFontSizeActionPerformed` (java.awt.event.ActionEvent evt)

- General process:
  - GUI  
  - User events
  - Event handlers
  - User actions
Desktop Java Graphics APIs: From “Filthy Rich Clients”
by Chet Haase and Romain Guy, Chap1, Page 12
ISBN-978-0-13-241393-0
Book Web Site: http://www.filthyrichclients.org/
GUIs in Java

- **AWT (Abstract Window Toolkit) (java.awt.*)**
  - First graphical user interface toolkit for Java
  - Old GUI framework for Java (Java 1.1)
  - Reliance on native system libraries
  - Platform independence problems
  - Responsible for input event mechanisms

- **Java 2D**
  - Graphics Library of Java
  - Introduced in JDK 1.2
  - Basics and advance drawing operation, image manipulation, and drawing
  - Handles Swing’s Rendering operations

- **Swing (javax.swing.*)**
  - GUI framework first introduced in JDK 1.2
  - Includes AWT features plus many enhancements
  - Pure Java components (no reliance on native code)
  - Pluggable look and feel architecture

Some of this material is from “Filthy Rich Clients” (see reference in previous slide).
Steps for Creating a GUI in Java

- **(Step 1)** Define a container to hold components (e.g., JFrame, JApplet)
- **(Step 2)** Add GUI components to the container (JButton, JTextField, …)
  - Use layout manager to determine positions
- **(Step 3)** Add actions to GUI
  - Add (register) event listeners to GUI components
  - Usually one event listener class per widget (item user sees)
  - Inner class usually utilized to implement listener
  - Example of Java listeners & Actions Causing Event
    - ActionListener → clicking button in GUI
  - At run time
    - Java generates event object when events occur
    - Java then passes event object to event listener
- **(Step 4)** Schedule the GUI processing in the EDT (Event-Dispatching Thread)
Java Layout Manager

- Definition
  - Arrangement of GUI components in container
- Layout manager
  - Entity translating layout specifications into actual coordinates at runtime, depending on conditions
- Examples
  - FlowLayout (lays out component from left to right)
  - BorderLayout (designates portions of the container as North, South, East, West, and Center)
Schedule GUI Processing in EDT

- What is a thread?
- Event Dispatching Thread (EDT) is a background thread to process GUI events
- These events are mainly updates that
  - Cause components to redraw themselves
  - Represent input events
- Swing uses a single-threaded painting model
  - Event Dispatching Thread is the only valid thread for updating GUI components
  - Avoid updating GUI components from other threads (a source of bugs)
- Java Code that allows current thread to execute GUI code in dispatching thread
  ```java
  public static void main(String[] args) {
      javax.swing.SwingUtilities.invokeLater(new Runnable() {
          public void run() {
              createAndDisplayGUI(); // actually creates GUI
          }
      });
  }
  ```
Examples

- Main Examples
  - eventHandlingIntro
  - singleClassBorderLayout
  - timer

- Additional Examples
  - textFileReaderMultipleClasses
  - textFileReaderSingleClass
  - textFileReaderFont
Additional Resources

• Javadoc from the JDK
• Swing tutorial - http://java.sun.com/docs/books/tutorials/uiswing/components/
• Filthy Rich Clients http://filthyrichclients.org/