CMSC 132:
Object-Oriented Programming II

Graphical User Interface (GUI)

Department of Computer Science
University of Maryland, College Park
Graphical User Interface (GUI)

User interface
- Interface between user and computer
- Both input and output
- Affects usability of computer

Interface improving with better hardware
- Switches & light bulbs
- Punch cards & teletype (typewriter)
- Keyboard & black/white monitor (text)
- Mouse & color monitor (graphics)
Model-View-Controller (MVC)

Model for GUI programming (Xerox PARC ’78)
Separates GUI into 3 components

1. Model ⇒ application data
2. View ⇒ visual interface
3. 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

Registered Event Handlers

Can handle an event of type $e_1$

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

User events invoke event handlers:

- `E_1`: changeFontSizeActionPerformed
- `E_2`: fileSaveActionPerformed
- `E_3`: newDocActionPerformed
- `E_4`: newDocActionPerformed
- `E_5`: newDocActionPerformed

**Example Code**

```java
public void newDocActionPerformed(ActionEvent evt) {
    // Implementation
}
```
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

1. Define a container to hold components
   - Examples: JFrame, JApplet...

2. Add GUI components to the container
   - Examples: JButton, JTextField, JScrollBar...
   - Use layout manager to determine positions

3. Add actions to GUI
   - Add event listeners to GUI components

4. Schedule the GUI processing in the EDT (Event-Dispatching Thread)
Step 1 (Define Container)

- Container Definition
  - Abstractions occupying space in GUI

- Properties
  - Usually contain one or more widgets
    - widget - actual item user can see
  - Can be nested in other containers

- Container Examples
  - JFrame, JDialog, JPanel, JScrollPane
Step 2 (Define Components)

Component Definition

- Actual items *(widgets)* user sees in GUI

Examples

- Labels *(fixed text)*
- Text areas *(for entering text)*
- Buttons
- Checkboxes
- Tables
- Menus
- Toolbars
- Etc…
Step 3 (Set Event Listeners)

Implementation
- Implement event listeners for each event
- Usually one event listener class per widget
- Inner class usually utilized to implement listener
- Register (add) listener object with widget object

At run time
- Java generates event object when events occur
- Java then passes event object to event listener

Example of Java listeners & Actions Causing Event
- ActionListener → clicking button in GUI
- CaretListener → selecting portion of text in GUI
- FocusListener → component gains / loses focus
- KeyListener → pressing key
- MouseListener → mouse clicked
- WindowListener → closing a window
Step 4 (Schedule GUI Processing in EDT)

- What is a thread?
- Event Dispatching Thread (EDT)
  - EDT is a background thread to process 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 common bugs
Event Dispatching Thread

- 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
        }
    });
}
```
Additional Resources

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