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 $\rightarrow$ 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

- \( e_1 \)
- \( e_2 \)
- \( e_3 \)

Registered Event Handlers

- \( E_1 \)
- \( E_2 \)
- \( E_3 \)
- \( E_4 \)
- \( E_5 \)
- \( E_6 \)
- \( E_7 \)
- \( E_8 \)

Can handle an event of type \( e_1 \)

Execution Environment
GUIs are Event-Driven Software

User events invoke event handlers

- $E_1$, $E_2$, $E_3$, $E_4$, $E_5$

ChangeFontSizeActionPerformed
(newDocActionPerformed
(fileSaveActionPerformed
(changeFontSizeActionPerformed)
(newDocActionPerformed
(fileSaveActionPerformed

User Events

Event Handlers

GUI
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)
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
        }
    });
}
```
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)
Examples

• Main Examples
  • eventHandlingIntro
  • singleClassBorderLayout
  • timer

• Additional Examples
  • textFileReaderSingleClass
  • textFileReaderFont
  • textFilerReaderFontSlider
  • textFileReaderFont
Beware of Long Computations in Swing

• Swing uses a single-threaded model
• Long computations in the EDT freezes the GUI
• Usually you place the computation is a separate thread
• We will talk about this matter once we have covered threads
Additional Resources

• Javadoc from the JDK
  http://java.sun.com/docs/books/tutorial/uiswing/components/

• Swing tutorial
  http://java.sun.com/docs/books/tutorial/uiswing/components/

• Filthy Rich Clients
  http://filthyrichclients.org/