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

Can handle an event of type $e_1$

Registered Event Handlers

Execution Environment
GUIs are Event-Driven Software

User events invoke event handlers

- User Events
  - $E_3$
  - $E_4$
  - $E_5$

- Event Handlers
  - $E_1$
  - $E_2$
  - $E_3$
  - $E_4$

- Events
  - newDocActionPerformed
    - (java.awt.event.ActionEvent evt)
  - fileSaveActionPerformed
    - (java.awt.event.ActionEvent evt)
  - changeFontSizeActionPerformed
    - (java.awt.event.ActionEvent evt)
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 \( \rightarrow \) 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
  • tables
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
• Swing tutorial
  http://java.sun.com/docs/books/tutorial/uiswing/components/
• Filthy Rich Clients
  http://filthyrichclients.org/