Graphical User Interface (GUI)
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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

Diagram:
- Model
- View
- Controller

Connections:
- Model to View
- View to Controller
- Controller to View
- View to Display
- Controller to Keyboard
- Controller to Mouse
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

User Events

Event Handlers

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

newDocActionPerformed (java.awt.event.ActionEvent evt)

changeFontSizeActionPerformed (java.awt.event.ActionEvent evt)

fileSaveActionPerformed (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/
GUls 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/