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)
GUI Topics

- Model-View-Controller model
- Java support for GUIs
  - Containers
  - Components
  - Events
- Event-driven programming
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)
Java GUI Classes

- AWT (Abstract Window Toolkit) (java.awt.*)
  - Old GUI framework for Java (Java 1.1)
  - Some reliance on native code counterparts
  - Platform independence problems

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

- SWT (Standard Widget Toolkit; from Eclipse)
Creating a GUI in Java

1. Define a **container** to hold components
   - Examples: JFrame, JPanel, 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
GUI Elements 1 – Container

Definition
- Abstractions occupying space in GUI

Properties
- Usually contain one or more widgets
- Can be nested in other containers

Examples
- JFrame, JDialog, JPanel, JScrollPane
GUI Elements 2 – Component

Definition

Actual items (widgets) user sees in GUI

Examples

Labels (fixed text)
Text areas (for entering text)
Buttons
Checkboxes
Tables
Menus
Toolbars
Etc…
GUI Elements 3 – Events

Definition

Action or condition occurring outside normal flow of control of program

Examples

- Mouse clicks
- Keyboard input
- Menu selections
- Window actions
Programming Models

Normal (control flow-based) programming

- **Approach**
  - Start at `main()`
  - Continue until end of program or `exit()`

Event-driven programming

- **Unable to predict time & occurrence of event**
- **Approach**
  - Start with `main()`
  - Build GUI
  - Await events (& perform associated computation)
Event-driven Programming in Java

During implementation
- Implement event listeners for each event
- Usually one event listener class per widget

At run time
- Register listener object with widget object
- Java generates event object when events occur
- Java then passes event object to event listener
Event Handling in Action

Registered Event Handlers

Can handle an event of type $e_1$

Dispatcher

Events

Event $e_2$

Event Handlers

State = $S_0$

Execution Environment

Registered Event Handlers

Can handle an event of type $e_1$

Dispatcher
GUls are Event-Driven Software

User events invoke event handlers

newDocActionPerformed (java.awt.event.ActionEvent evt)

changeFontSizeActionPerformed (java.awt.event.ActionEvent evt)

fileSaveActionPerformed (java.awt.event.ActionEvent evt)
Event-driven Programming in Java

Example listeners & actions causing event

- **ActionEvent** ⇒ clicking button in GUI
- **CaretEvent** ⇒ selecting portion of text in GUI
- **FocusEvent** ⇒ component gains / loses focus
- **KeyEvent** ⇒ pressing key
- **ItemEvent** ⇒ selecting item from pull-down menu
- **MouseEvent** ⇒ dragging mouse over widget
- **TextEvent** ⇒ changing text within a field
- **WindowEvent** ⇒ closing a window

In Java

- GUI events handled in event dispatching thread
Event Dispatching Thread

- Background thread to process events
  - From AWT graphical interface event queue
- 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

Example code

- Allows current thread to execute GUI code in dispatching thread
- `createAndDisplayGUI`
  - Method that actually defines the GUI

```java
javax.swing.SwingUtilities.invokeLater(new Runnable() {
    public void run() {
        createAndDisplayGUI();
    }
});
```
Java Support For GUIs

Additional Resources

- Appendix C of textbook
- Javadoc for the JDK
- Swing tutorial
- Course slides and code handouts
- Java Ranch