CS11 – Advanced Java

Winter 2011-2012

Lecture 3

Java Constants

- Frequently need to define constants in Java code

```
public class BoggleBoard {
    /** Default size for a Boggle board. */
    public static final int DEFAULT_SIZE = 4;
    ...
}
```

- Standard conventions for Java constants:
  - Name usually follows **`ALL_CAPS`** naming convention
  - Declare **`public static final`**
  - (or, use **`private`** / **`protected`** if appropriate)

The `static` Keyword

- Members of a class can be declared **`static`**
  - They are associated with the class, not a particular object
  - For static fields, there is only one copy of the value
- Example:

```
public class CommandPrompt {
    public static final String PROMPT =
        "Type command:  ";
    ...
}
```

  - **`PROMPT`** is an object, but it isn't associated with individual **`CommandPrompt`** instances
  - Only one value, and all code can share that single value
  - Much more efficient memory usage than an instance field, when other code can share a single value

Static Initialization

- When are static fields initialized?

```
public class CommandPrompt {
    public static final String PROMPT =
        "Type command:  ";
    ...
}
```

- The VM initializes a class the first time the type is actually used by other code.
  - Class definition is found via the classpath, and then verified
    - e.g. all instructions are valid; jump instructions go to valid addresses; etc.
  - Any references to other types may be verified and resolved
    - (may involve the loading of additional classes, of course)
  - Finally, static fields in the class are initialized

Static Initialization (2)

- Static fields are initialized at the end of the class-load process
- Sometimes, can't initialize a static field with a single line of code

```
public class NoiseGenerator {
    public static final Vector3f[] noiseVectors =
        new Vector3f[1024];
    ...
}
```

  - Also need to initialize the noise-vector elements to random unit-vectors
  - Clearly can't do it in a single line!
- How to implement this static initialization?

Static Initialization (3)

- Classes can specify static initializers:

```
public class NoiseGenerator {
    public static final Vector3f[] noiseVectors =
        new Vector3f[1024];

    static {
        for (int i = 0; i < noiseVectors.length; i++) {
            noiseVectors[i] = new Vector3f();
            ...  // Initialize the vector
        }
    }
    ...
}
```

  - Static initializers <u>cannot</u> throw checked exceptions!
  - Initialization of static fields, and execution of static initializers, occurs in order of appearance in the source file
  - Static initialization is also specified to be thread-safe in Java

The **`final`** Keyword

- Java variables can be declared as **`final`**
  - The variable can only be assigned to once.
- Frequently used for constant class and instance fields

```
public class CommandPrompt {
    public static final String PROMPT =
        "Type command:  ";
    ...
}
```

  - **`PROMPT`** can only be written to once, and then it is fixed
- **`final`** fields are usually assigned where they are declared, but this is not strictly required by Java!
  - **`final`** instance fields must be assigned to, by the end of every constructor
  - **`final`** class fields must be assigned to, by some static initializer

The **`final`** Keyword (2)

- **`final`** sometimes uses on local variables or method-arguments
  - Prevents reassignment to variables that shouldn't change
  - Used to reduce correctness issues
  - Technique does have some *limited* usefulness… ☺
- Example:

```
int findWord(String w, final ArrayList<String> words) {
    int i = 0;
    for (String s : words) {
        if (s.equals(w)) return i;
        i++;
    }
    return -1;
}
```

- What can't we do with **`words`**?
  - We can't set **`words`** to refer to something else
  - Increases the correctness of our own method (slightly)

The **`final`** Keyword (3)

- Example:

```
int findWord(String w, final ArrayList<String> words) {
    int i = 0;
    for (String s : words) {
        if (s.equals(w)) return i;
        i++;
    }
    return -1;
}
```

- What can we do with **`words`**?
  - We can call any of the methods on **`words`**…
  - We can call mutators on **`words`**!
    - **`words.add("yo' mama!");`**
    - **`words.clear();`**
- **`final`** only prohibits reassignment to the variable
- Declaring **`words`** as **`final`** doesn't really get us much…

`final` and `const`

- Java `final` keyword is nothing like C++ `const`
  - (and Java has no equivalent to C++ `const`)
- You will probably run into projects that use `final` for method-args and local variables…
  - Just be aware of the significant limitations of this technique
- If you *really* need immutable state:
  - Create a class without mutators!
    - (and if necessary, a subclass that provides mutators)
    - Java `String`, `Integer`, etc. classes are all immutable
  - Or, see `Collections.unmodifiableList(List)`, etc.
    - Provides an immutable view of another collection
    - Original collection is still mutable, but can pass the immutable view to other methods to work with

Back to Java Constants…

- Covered the standard modifiers used for constants

```
public class BoggleBoard {
    /** Default size for a Boggle board. **/
    public static final int DEFAULT_SIZE = 4;
    ...
}
```

- For simple constants, this is the recommended way
  - When constant is an object, improves memory efficiency
- Two other common ways constants are often used
  - Both are not so good. ☺

Interfaces and Constants

- Interfaces can contain two kinds of members
  - Public methods, and constants!
    - Constants are declared as **`static final`**, since all interface members are automatically **`public`**
- When a package uses a lot of constants, commonly put into a "constant interface"
  - The interface contains <u>only constants</u>, no methods
- Lots of examples of this in the Java API
  - **`javax.swing.SwingConstants`** interface
    - e.g. defines alignment constants **`LEFT`**, **`CENTER`**, **`RIGHT`**
  - Many Swing classes "implement" **`SwingConstants`**, so they can easily use the constants in their implementations
    - No methods need to be added; **`SwingConstants`** has none!

Joshua Bloch and Constant Interfaces

- Interfaces define a type in Java
  - They specify a set of behaviors that implementing objects provide
- When a class implements an interface:
  - It should say something about what clients of the class can do with objects of that type!
  - Other code can refer to an object by its interface types
- Constant interfaces violate this principle
  - e.g. **`SwingConstants`** doesn't specify any behavior at all!
  - But, we can write strange code like this:

    ```
    SwingConstants c = new JButton("this is weird");
    ```
  - Can't call any methods on **`c`** because it declares none!

A Better Solution: Constant Utility Classes

- If you have a lot of constants to group together:
  - Put them into a utility class that can't be instantiated
    - Implement a private default constructor
  - Provide the set of public static final fields
- Moral:
  - Just because the Java API uses certain design patterns, doesn't mean that you should. ☺

Simple Enumerations

- Constants are also frequently used for enumerations

```
/** Represents the suits of cards in a card deck. */
public class Card {
    public static final int SPADES   = 1;
    public static final int HEARTS   = 2;
    public static final int CLUBS    = 3;
    public static final int DIAMONDS = 4;
    ...
}
```

- Problems?
  - No type-safety:

```
public class Card {
    ...
    void setSuit(int suit);
}
```

  - Could accidentally mix different enums, or specify invalid values!

Typesafe Enumerations

- Implementing enumerations this way is very error-prone
- A better approach: “typesafe enumerations”
  - Create a specific class for each enumeration
  - Create a unique object for each enum value

```
public class Suit {
    /** Only Suit can call its own constructor. */
    private Suit() { }

    public static final Suit SPADES   = new Suit();
    public static final Suit HEARTS   = new Suit();
    public static final Suit CLUBS    = new Suit();
    public static final Suit DIAMONDS = new Suit();
}
```

  - Can add other fields to represent details of each enum value, such as **`name`**, **`id`**, etc.

Typesafe Enumerations (2)

- The “typesafe enumerations” pattern is very useful, but also needs a lot of infrastructure code
  - Primarily to ensure that each enum-value is actually unique within the JVM
- Also, can’t write switch-statements that test objects:

```
Card c = ... ;
switch (c.getSuit()) {
    case Suit.SPADES:
        ...
}
```

  - This code won’t compile with the typesafe enum approach!
  - Will compile if suits are represented as integers, but that approach has bigger issues

Java 1.5 **`enum`** Types

- Java 1.5 introduced support for typesafe enums
  - The pattern is tremendously useful…
  - The implementation can be tricky to get right…
  - And we would also like language support (e.g. **`switch`**)
- Updating our **`Suit`** to be an enumeration:

```
public enum Suit {
    SPADES,
    HEARTS,
    CLUBS,
    DIAMONDS
}
```

  - Can put Javadoc comments on the enumeration, and on each value

Java 1.5 **enum** Types (2)

- Can write **switch** statements against **enum** values:

```
Card c = ... ;
switch (c.getSuit()) {
    case SPADES:
        ...
}
```

- Java enums also provide support for **toString()** and other **Object** methods automatically

```
System.out.println(c.getSuit());
→ SPADES
```

- Enums also have a **values** array-member, containing all specified enum-values

```
for (int val = 1; val <= 13; val++)
    for (Suit s : Suit.values)
        deck.add(new Card(val, s));
```

Extending Enumerations

- Java **enum** types are implemented as classes
  - Can add fields and methods to your enum types
- Example:

```
public enum ChessPiece {
    KING  (200),  // Arbitrary value for king
    QUEEN (9),
    ROOK  (5),
    BISHOP(3),
    KNIGHT(3),
    PAWN  (1);    // Note the semicolon!

    private final int value;  // Point-value of piece

    ChessPiece(int value) { this.value = value; }

    public int value() { return value; }
}
```

Nesting Enumerations

- Can also put **enum** declarations within other classes

```
public class Card {
    public enum Suit {
        SPADES, HEARTS, CLUBS, DIAMONDS
    }

    public Card(int value, Suit suit) {
        ...
    }
}
```

  - Card can refer to **enum** values as **Suit.SPADES**, etc.
  - External code must specify **Card.Suit.SPADES**, etc.

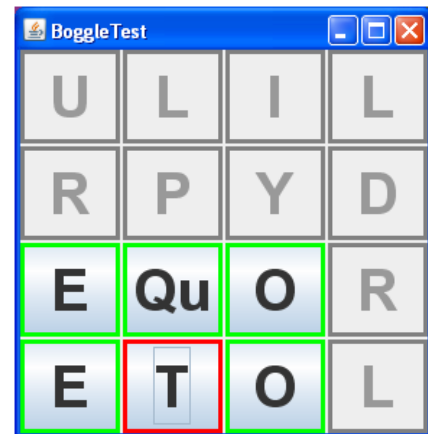
This Week's Lab

- Begin building the UI for Boggle game
  - Start with classes to display a Boggle board, and to let users enter words they find
- Give the user some visual cues
  - Use a font that is large enough to read easily
  - Update button "enabled" status and border-color to indicate what letters are available to select next
- UI code also needs to provide a method to return the currently selected word

Example User Interface

- A grid of buttons displays the current Boggle board
- Button borders indicate what letters can be chosen

- When user selects a letter, it shows a red border
- Only the letters adjacent to last selection are available



Example User Interface (2)

- As letters are selected, word is shown in red
  - The word itself is the concatenation of each button's text-value
- "Available letters" are always based on last selected letter
  - Exclude already-selected letters!

General Approach

- Don't reinvent the wheel!
- Swing already provides buttons and panels
  - Let's just customize their behavior!
- Create a subclass of **`JButton`** that handles Boggle-specific details of displaying a cell
  - Manage button-state, appearance, cell value, etc.
- Create a subclass of **`JPanel`** that displays an entire **`BoggleBoard`**
  - Methods to set the board to use, and to get current word
  - Handles action-events from buttons and updates their appearance

Swing Component Appearance

- All Swing components derive from **`javax.swing.JComponent`**
  - Provides common functionality across all components
  - Custom components that paint their own contents are also derived from **`JComponent`**
- Many ways to change a **`JComponent`**'s appearance
  - Set a tooltip, add one or more borders, change foreground / background colors, change the cursor, change the font, etc.
- Can also enable/disable components
  - Disabled components do not receive user input
  - Indicated in UI by graying out the component
  - Use **`setEnabled(boolean)`** and **`isEnabled()`**

Swing Component Naming

- Another naming convention for Swing components
- All Swing components derive from **`JComponent`**
  - The Swing analogue to Java AWT's **`Component`** type

- All Swing component names start with a "J"
- Unless it *really* doesn't make sense for your code, you should also follow this convention
  - e.g. **`JBoggleButton`**, **`JBoggleBoard`**

Swing Components and Fonts

- Can change the font on Swing components
  - **`setFont(Font)`** and **`getFont()`** methods
- The **`java.awt.Font`** class represents fonts in Java
- Java fonts fall into two categories:
  - Physical fonts correspond to actual fonts installed on your computer (e.g. Arial or Helvetica)
  - Logical fonts are "generic" fonts that all Java VMs <u>must</u> provide
    - Typically provided by mapping each logical font-name to a physical font, based on what OS provides by default
    - Serif, SansSerif, **`Monospaced`**, Dialog, and DialogInput

Swing Components and Fonts (2)

- Easiest way to get fonts is via **`Font`** constructor
  - **`Font(String name, int style, int size)`**
  - **`Font`** has constants for all logical font names, and all styles

```
// Get a bold, 20-point font without serifs
Font f = new Font(Font.SANS_SERIF, Font.BOLD, 20);
```

  - Can also specify other font names, but no guarantee they will be available!

```
// Get an italicized, 12-point Times New Roman font
f = new Font("Times New Roman", Font.ITALIC, 12);
```

  - If a font name is unrecognized then Java will switch to the "Dialog" logical font
  - Suggestion: only use <u>logical</u> font names with constructor

Swing Components and Fonts (3)

- To get all fonts on a particular system, use:

  Font[] java.awt.GraphicsEnvironment.getAllFonts()

  - Returns an array of Font objects that includes all available fonts
  - Returned fonts are only 1-point in size
  - Looks like this: (the dot is "this text is 1-point")
  - Application must <u>derive</u> fonts from these "base fonts"
- To make your application most portable, use this mechanism to find system fonts
  - Or, just stick with the logical fonts

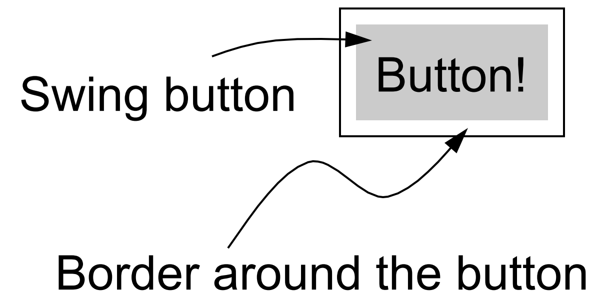
Swing Components and Borders

- Swing components can be given a border
  - Effectively shrinks the Swing component itself
- Set and get a component's border via **`setBorder(Border)`** and **`getBorder()`** methods
- **`Border`** is an interface defined in **`javax.swing.border`** package
  - See Java APIs for implementations!
- Two ways to get simple borders:
  - Create it yourself:

```
Border b = new LineBorder(Color.RED, 3);
```

  - Use the **`javax.swing.BorderFactory`** class

```
Border b = BorderFactory.createLineBorder(Color.RED, 3);
```



References

- Effective Java by Joshua Bloch
  - Item 17: Use interfaces only to define types
  - Item 21: Replace `enum` constructs with classes