Static Members, Enumerations and Packages

Lecture 5
Example Class Declaration

class Pencil {
  private int defaultLength = 10;
  private String color;
  private int length;

  public Pencil (int length) {
    if (length > 0) {
      this.length = length;
    } else {
      this.length = defaultLength;
    }
  }

  public int sharpen (int amount) { . . . }

  public String toString () { . . . }
}
One Pencil Instance

defaultLength: 10

color: "red"

length: 6

Pencil()

sharpen()

toString()
Multiple Pencil Instances

```
import Pencil

redPencil = Pencil()
redPencil.defaultLength = 10
redPencil.color = "red"
redPencil.length = 6
redPencil.sharpen()
redPencil.toString()

bluePencil = Pencil()
bluePencil.defaultLength = 10
bluePencil.color = "blue"
bluePencil.length = 3
bluePencil.sharpen()
bluePencil.toString()

blackPencil = Pencil()
blackPencil.defaultLength = 10
blackPencil.color = "black"
blackPencil.length = 3
blackPencil.sharpen()
blackPencil.toString()
```
Object vs Class Members

- Class member: only one copy, which is *shared* by all instances
  - Keyword: `static`
  ```java
  static int defaultLength;
  static void reset() { . . . }
  ```

```java
class Pencil {
  private static int defaultLength = 10;
  private String color;
  private int length;
  . . .
}
```
Multiple Pencil Instances

- Pencil
  - defaultLength: 10

- Pencil
  - color: "blue"
  - length: 3
  - sharpen()
  - toString()

- Pencil
  - color: "red"
  - length: 6
  - Pencil()
  - sharpen()
  - toString()

- Pencil
  - color: "black"
  - length: 3
  - Pencil()
  - sharpen()
  - toString()
aka Instance vs Static Members

- Static members available even before instances (objects) are created!
  - From outside of class: `classname.member`
    ```java
    Pencil.defaultLength++; //must be public
    ```
  - From inside class: `classname` is optional

- Conversely, static members can not access instance members
  - ie `this` reference can not be used
    ```java
    public static void reset () {
        length = defaultLength;
    }
    ```
    Compile-time Error
Good Practice: Static Members

- Do not access static members through object references
- Use class names instead
  - Do this: `int t = Pencil.defaultLength;`
  - Not this: `int t = p1.defaultLength;`
- This applies within a class too
  ```java
class Pencil {
    private static int defaultLength = 10;
    private int length;
    public void reset() {
      length = defaultLength;      //correct
      length = Pencil.defaultLength; //better
    }
  }
```
Example: println

- System.out.println(“Hello”);

- What is System?
  - A class from the Java standard library
  - See API documentation: java.lang.System

- What is out?
  - A static field of System (available from class)
  - Type: reference to an instance of PrintStream

- What is println?
  - An overloaded method in PrintStream
  - Different versions for printing string, int, boolean...
Example: main()

```
class HelloWorldApp {
    public static void main(String[] args) {
        // ...
    }
}
```

- **public**: so that the JVM can run this method
- **static**: no instances of class created (yet)
- **void main(String[]):** required signature
  - JVM looks to invoke the method with this name
- **args**: array of command-line arguments
  - Any name can be used for formal parameter
  - “args” is just Java convention
Example

- See Artifact.java
  - Static members
    - Fields for: class creation time, first instantiation, most recent instantiation, total number of instantiations
    - Method for getting number of instantiations
  - Instance members
    - Field holding a float
    - Method for getting information (toString)
  - Constructor
  - Static initialization block (more on that later)

- See ArtifactTester.java
  - Note output showing different times
Constant Fields: final

- Modifier `final` on field means it cannot change
  - For primitive type, effectively a constant
    ```java
    final int i1 = 53;
    final int i2 = (int) (Math.random() * 20);
    final int i3;  //constructor must initialize
    . . .
    i2++;
    Compile-time Error
    ```
  - For objects, only the `reference` is constant
    ```java
    final Pencil p = new Pencil("blue");
    . . .
    p = new Pencil();
    p.sharpen(3);
    Compile-time Error
    ```

- Often used in conjunction with static
  - Class-wide constant value
    ```java
    static final int DEFAULT_LENGTH = 10;
    ```
Good Practice: No Magic Numbers

- “Magic Number”: a numeric constant in code
  ```java
  for (int i=0; i < 365; i++) { ... }
  ```

- Some literals are acceptable
  - Booleans and references (`true`, `false`, `null`)
  - Integers: `-1, 0, 1, 2`

- The rest should *all* be avoided
  ```java
  final int DAYS_PER_YEAR = 365;
  for (int i=0; i < DAYS_PER_YEAR; i++) { ... }
  ```

- See Java libraries (API, `constant-values`):
  ```java
  Integer.MAX_VALUE, Math.PI,
  Float.POSITIVE_INFINITY, Thread.MAX_PRIORITY
  ```

- Important benefits:
  - Single point of control over change
  - Legibility
Outdated (bad) Idiom: int enums

- Enumeration type: legal values a finite set of constants
  - Card suits (clubs, diamonds, hearts, spades)
  - Days of the week (D, M, T, W, R, F, S)
- This could be done with static final fields
  ```java
  class PlayingCard {
    public static final int CLUBS = 0;
    public static final int DIAMONDS = 1;
    public static final int HEARTS = 2;
    public static final int SPADES = 3;
    ...
  }
  ```
- Later, use these named constants
  ```java
  int trump = . . . ;
  if (trump == PlayingCard.CLUBS) { . . . }
  ```
- Problem: no type safety! `trump` is just an int
  ```java
  if (trump == 23) { . . . }
  ```
Enum Types

- Declared like a class, keyword `enum`
  - Contains a list of `enum constants`
    ```java
    enum Suit {
        CLUBS, DIAMONDS, HEARTS, SPADES
    }
    ``
  - These constants are (implicitly) static fields
    ```java
    Suit trump = Suit.SPADES; //do not use new()!
    if (trump == Suit.CLUBS) { . . . }
    ``
- Can also contain fields & methods (and nested types)
- Automatically provided (static) methods include:
  - `values()` - returns array of constants
    ```java
    Suit.values()[0] == Suit.CLUBS;
    ``
  - `valueOf(String)` - returns constant with that name
    ```java
    Suit.valueOf("CLUBS") == Suit.CLUBS;
    ``
  - `ordinal()` - returns constant’s position in declaration list
    ```java
    Suit.CLUBS.ordinal() == 0;
    ```
A package is a grouping of classes
- Hierarchical: subpackages within packages
- Sun standard libraries organized in packages
  - java.lang, java.util, java.util.logging
  - see http://java.sun.com/javase/6/docs/api

A package provides
- Logical structuring: related classes are bundled
- Encapsulation: another level of access control
- Distinct namespace: classes in different packages can have the same name without conflict
  - Convention to guarantee uniqueness of package name: reverse of company’s domain name
  - org.w3c.dom, edu.ohio-state.cse
Declaration

☐ Use package statement at top of source file
  ■ Must appear first, before any class declarations
  ```
  package edu.ohio-state.cse;
  class Pencil { . . . }
  ```

☐ This file must be in a directory matching package name
  ■ Pencil.java in ???/edu/ohio-state/cse
  ■ Eclipse handles this correspondence for you

☐ At most one package declaration in a file

☐ If there is no package declaration, class is in unnamed default package
  ■ This is fine only for very small programs (like the ones you will write for this class)
Access Control

- Another level of visibility: package
  - Default for members (public/private omitted)
  - Package-visible members are accessible by all classes in the same package
    ```java
    package edu.ohio-state.edu;
    class Pencil {
        private String color;
        int length;
        ...}
    ```

- Classes are public or package (default)
  - Public classes available outside package
    ```java
    public class Math { . . . }
    ```
  - Package classes available only within same package
    ```java
    class Pencil { . . . }
    ```
Type Imports

- Fully-qualified type name is `package.class`
  ```java
  java.util.Date d = new java.util.Date();
  ```
  - Do not confuse this `.` with member access

- Shorthand: import statement at top of file
  - To import a single `public` type
    ```java
    import java.util.Date;
    Date d = new Date();
    ```
  - To import all `public` types, use wildcard `*`
    ```java
    import java.util.*;
    Date d = new Date();
    ```
    - `*` does not import subpackages

- All classes implicitly import `java.lang.*`

- Static members can be explicitly imported
  ```java
  import static java.lang.Math.exp;
  exp(x); //instead of Math.exp(x)
  ```
  - Can use wildcard `*` as well
Good Practice: Naming Conventions

- Avoid name conflicts with packages and reserved keywords
- Package names: lowercase letters
  - java.util, java.net, java.io, . . .
- Class names: start with uppercase letter
  - Math, Pencil, PriorityQueue, . . .
- Variable, field and method names: start with lowercase letters
  - x, out, myColor, abs(), getName(), isEven() . . .
- Constant names: all uppercase letters
  - PI, DEFAULT_LENGTH, DAY_OF_WEEK . . .
- Type parameters: single letter upper case
  - E (element) T (type) V (value type)
Initialization Block

- Statement block outside methods/constructors
- Executed *before* the body of any constructor

**Without initialization block**

```java
class Body {
    private long idNum;
    private String name = "";
    private Star orbits;
    private static long nextID = 0;

    Body() {
        idNum = nextID++;
    }

    Body(String name, Star orbits) {
        this();
        this.name = name;
        this.orbits = orbits;
    }
}
```

**With initialization block**

```java
class Body {
    private long idNum;
    private String name = "";
    private Star orbits;
    private static long nextID = 0;

    { idNum = nextID++; }

    Body(String name, Star orbits) {
        this();
        this.name = name;
        this.orbits = orbits;
    }
}
```
Static Initialization Block

- Similar to initialization block, but:
  - Can only reference static members
  - Executed only once, when class is first loaded

```java
class Primes {
    static int[] primes = new int[4];

    static {
        primes[0] = 2;
        for (int i = 1; i < primes.length; i++) {
            primes[i] = nextPrime(i);
        }
    }

    // declaration of static nextPrime(int) ...
}
```
Summary

- Static members (ie class members)
  - Instance member belongs to one objects
  - Static member is shared amongst instances
- Enumerated types
- Packages (ie component catalogs)
  - Declaration
  - Another level of visibility
  - Import statements
    - Syntactic shorthand for frequent use
    - Static imports
- Initialization blocks, including static initialization