CMSC 132: Object-Oriented Programming II

Java Support for OOP

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Object Oriented Programming (OOP)

- OO Principles
  - Abstraction
  - Encapsulation

- Abstract Data Type (ADT)
  - Implementation independent interfaces
  - Data and operations on data

- Java
  - Many language features supporting OOP
Overview

- Objects & class
- References, alias, levels of copying
- “this” & “super” reference
- Constructor & initialization block
- Garbage collection & destructor
- Package & scope

Modifiers
- Public, Private, Protected
- Static, Final, Abstract
Object & Class

Object
- Abstracts away (data, algorithm) details
- Encapsulates data
- Instances exist at run time

Class
- Blueprint for objects (of same type)
- Exists at compile time
References & Aliases

- **Reference**
  - A way to get to an object, not the object itself
  - All variables in Java are **references** to objects

- **Alias**
  - Multiple references to same object
  - “x == y“ operator tests for alias
  - x.equals(y) tests contents of object (potentially)
Three Levels of Copying Objects

Assume y refers to object z

1. Reference copy
   - Makes copy of reference
   - x = y;

2. Shallow copy
   - Makes copy of object
   - x = y.clone();

3. Deep copy
   - Makes copy of object z and all objects (directly or indirectly) referred to by z
“this” Reference

Description

- Reserved keyword
- Refers to object through which method was invoked
- Allows object to refer to itself
- Use to refer to instance variables of object
class Node {
  value val1;
  value val2;

  void foo(value val2) {
    … = val1;  // same as this.val1 (implicit this)
    … = val2;  // parameter to method
    … = this.val2;  // instance variable for object
    bar( this );    // passes reference to object
  }
}
Inheritance

Definition
- Relationship between classes when state and behavior of one class is a subset of another class

Terminology
- Superclass / parent ⇒ More general class
- Subclass ⇒ More specialized class

- Forms a class hierarchy
- Helps promote code reuse
“super” Reference

Description

- Reserved keyword
- Refers to superclass
- Allows object to refer to methods / variables in superclass

Examples

- `super.x`  // accesses variable x in superclass
- `super()`  // invokes constructor in superclass
- `super.foo()`  // invokes method foo() in superclass
Constructor

**Description**

- Method invoked when object is instantiated
- Helps initialize object
- Method with same name as class \textit{w/o} return type
- Default parameterless constructor
  - If no other constructor specified
  - Initializes all fields to 0 or null
- Implicitly invokes constructor for superclass
  - If not explicitly included
Constructor – Example

class Foo {
    Foo( ) { ... }                       // constructor for Foo
}
class Bar extends Foo {
    Bar( ) {                             // constructor for Bar
        ...                               // implicitly invokes Foo( ) here
    }
}
class Bar2 extends Foo {
    Bar2( ) {                             // constructor for bar
        super();                            // explicitly invokes Foo( ) here
    }
}
Initialization Block

Definition
- Block of code used to initialize static & instance variables for class

Motivation
- Enable complex initializations for static variables
  - Control flow
  - Exceptions
- Share code between multiple constructors for same class
Initialization Block Types

- **Static initialization block**
  - Code executed when class loaded

- **Initialization block**
  - Code executed when each object created (at beginning of call to constructor)

**Example**

class Foo {
    static { A = 1; }  // static initialization block
    { A = 2; }         // initialization block
}
Variable Initialization

- Variables may be initialized
  - At time of declaration
  - In initialization block
  - In constructor

- Order of initialization
  1. Declaration, initialization block
     (in the same order as in the class definition)
  2. Constructor
Variable Initialization – Example

class Foo {
  static { A = 1; } // static initialization block
  static int A = 2; // static variable declaration
  static { A = 3; } // static initialization block
  { B = 4; } // initialization block
  private int B = 5; // instance variable declaration
  { B = 6; } // initialization block
  Foo() { // constructor
    A = 7;
    B = 8;
  }
  } // now A = 7, B = 8
} // initializations executed in order of number
Garbage Collection

Concepts
- All interactions with objects occur through reference variables
- If no reference to object exists, object becomes garbage (useless, no longer affects program)

Garbage collection
- Reclaiming memory used by unreferenced objects
- Periodically performed by Java
- Not guaranteed to occur
- Only needed if running low on memory
Destructor

Description
- Method with name `finalize()`
- Returns `void`
- Contains action performed when object is freed
- Invoked automatically by garbage collector
  - Not invoked if garbage collection does not occur
- Usually needed only for non-Java methods

Example
```java
class Foo {
    void finalize() { ... } // destructor for foo
}
```
Method Overloading

- **Description**
  - Same name refers to multiple methods

- **Sources of overloading**
  - Multiple methods with different parameters
    - Constructors frequently overloaded
  - Redefine method in subclass

- **Example**

```java
class Foo {
    Foo() { ... } // 1st constructor for Foo
    Foo(int n) { ... } // 2nd constructor for Foo
}
```
Package

Definition
- Group related classes under one name

Helps manage software complexity
- Separate namespace for each package
  - Package name added in front of actual name
  - Put generic / utility classes in packages
  - Avoid code duplication

Example
package edu.umd.cs; // name of package
**Package – Import**

- **Import**
  - Make classes from package available for use
  - Java API
    - java.* (core)
    - javax.* (optional)

- Example

```java
import java.util.Random;  // import single class
import java.util.*;      // all classes in package
...                      // class definitions
```
Scope

Part of program where a variable may be referenced

Determined by location of variable declaration

Boundary usually demarcated by \{ \}

Example

```java
public MyMethod1() {
    int myVar;
    ...
}
```

myVar accessible in method between \{ \}

Scope – Example

Example

```java
package edu.umd.cs;
public class MyClass1 {
    public void MyMethod1() {
        ...
    }
    public void MyMethod2() {
        ...
    }
}
public class MyClass2 {
}
```
Modifier

**Description**
- Java keyword (added to definition)
- Specifies characteristics of a language construct

**(Partial) list of modifiers**
- Public / private / protected
- Static
- Final
- Abstract
Modifier

Examples

```java
public class Foo {
    private static int count;
    private final int increment = 5;
    protected void finalize { … }
}

public abstract class Bar {
    abstract int go( ) { … }
}
```
Visibility Modifier

Properties
- Controls access to class members
- Applied to instance variables & methods

Four types of access in Java
- Public
  - Most visible
- Protected
- Package
  - Default if no modifier specified
- Private
  - Least visible
Visibility Modifier – Where Visible

• “public”
  - Referenced anywhere (i.e., outside package)

• “protected”
  - Referenced within package, or by subclasses outside package

• None specified (package)
  - Referenced only within package

• “private”
  - Referenced only within class definition
  - Applicable to class fields & methods
Visibility Modifier

For instance variables
- Should usually be private to enforce encapsulation
- Sometimes may be protected for subclass access

For methods
- Public methods – provide services to clients
- Private methods – provide support other methods
- Protected methods – provide support for subclass
Modifier – Static

Static variable
- Single copy for class
- Shared among all objects of class

Static method
- Can be invoked through class name
- Does not need to be invoked through object
- Can be used even if no objects of class exist
- Can not reference instance variables
Modifier – Final

Final variable
- Value cannot be changed
- Must be initialized in every constructor
- Attempts to modify final are caught at compile time

Final static variable
- Used for constants
- Example
  ```java
  final static int Increment = 5;
  ```
Modifier – Final

Final method
- Method cannot be overridden by subclass
- Private methods are implicitly final

Final class
- Class cannot be a superclass (extended)
- Methods in final class are implicitly final
Modifier – Final

- Using final classes
  - Prevents inheritance / polymorphism
  - May be useful for
    - Security
    - Object oriented design

- Example – class String is final
  - Programs can depend on properties specified in Java library API
  - Prevents subclass that may bypass security restrictions
Modifier – Abstract

Description
- Represents generic concept
- Can not be instantiated

Abstract class
- Placeholder in class hierarchy
- Can be partial description of class
- Can contain non-abstract methods
- Required if any method in class is abstract

Example
```java
abstract class Foo { // abstract class
    abstract void bar( ) { ... } // abstract method
```