

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**
- **“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)



References & Aliases – Issues

■ Copying

■ References

```
X = new Object();  
Y = X;           // Y refers to same object as X
```

■ Objects

```
X = new Object();  
Y = X.clone();   // Y refers to different object
```

■ Modifying objects

```
X = new Object();  
Y = X;  
X.change();      // modifies object for Y
```

“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

“this” Reference – Example

```
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 **w/o** return type
- 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

```
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

```
class foo {  
    foo() { ... }           // 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

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

Scope

■ Scope

- Part of program where a variable may be referenced
- Determined by location of variable declaration
 - Boundary usually demarcated by { }

■ Example

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

} myVar accessible in method between { }

Scope – Example

■ Example

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

Scopes

The diagram illustrates the scope of each element in the code. Brackets on the right side group the code into three levels: Method (for MyMethod1 and MyMethod2), Class (for MyClass1 and MyClass2), and Package (for the entire package declaration).

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

```
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
- Protected
- Package
 - Default if no modifier specified
- Private

Most visible



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 can not be changed
- Must be initialized in every constructor
- Attempts to modify final are caught at compile time

■ Final static variable

- Used for constants
- Example
`final static int Increment = 5;`

Modifier – Final

- **Final method**
 - Method **can not be overloaded** by subclass
 - Private methods are implicitly final

- **Final class**
 - Class can not 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

```
abstract class foo {           // abstract class
    abstract void bar() { ... } // abstract method
```

Interface

■ Description

- Collection of
 - Constants
 - Abstract methods
- Can not be instantiated

■ Classes can **implement** interface

- Must implement **all** methods in interface
- Example

```
class foo implements bar { ... } // interface bar
```

■ Similar to abstract class

- But class can “inherit” from multiple interfaces