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, this, super
- References, alias, levels of copying
- Constructor, initialization block
- Garbage collection, destructor
- Package, scope, inner classes
- Modifiers
  - Public, Private, Protected
  - Static, Final, Abstract
- Generic programming

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

“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**

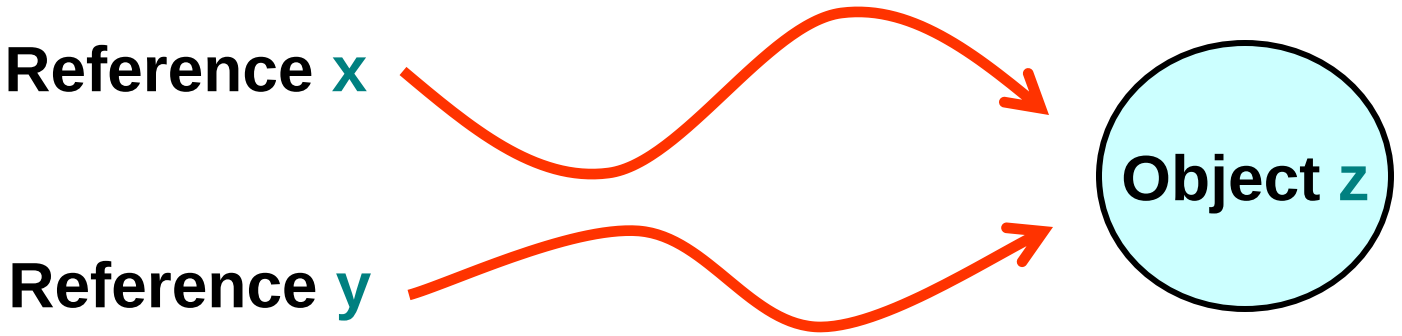
“super” Reference

- **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

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)



Implementing Equals

- **Approach we want to use (assuming class A)**

```
public boolean equals(Object obj) {
    if (obj == this)
        return true;
    if (!(obj instanceof A))
        return false;
    A a = (A)obj;
    /* Specific comparison based on A fields appears here */
}
```

- **What happens if we use comparisons of Class objects rather than instanceof?**
- **Example: See equalsMethod package**

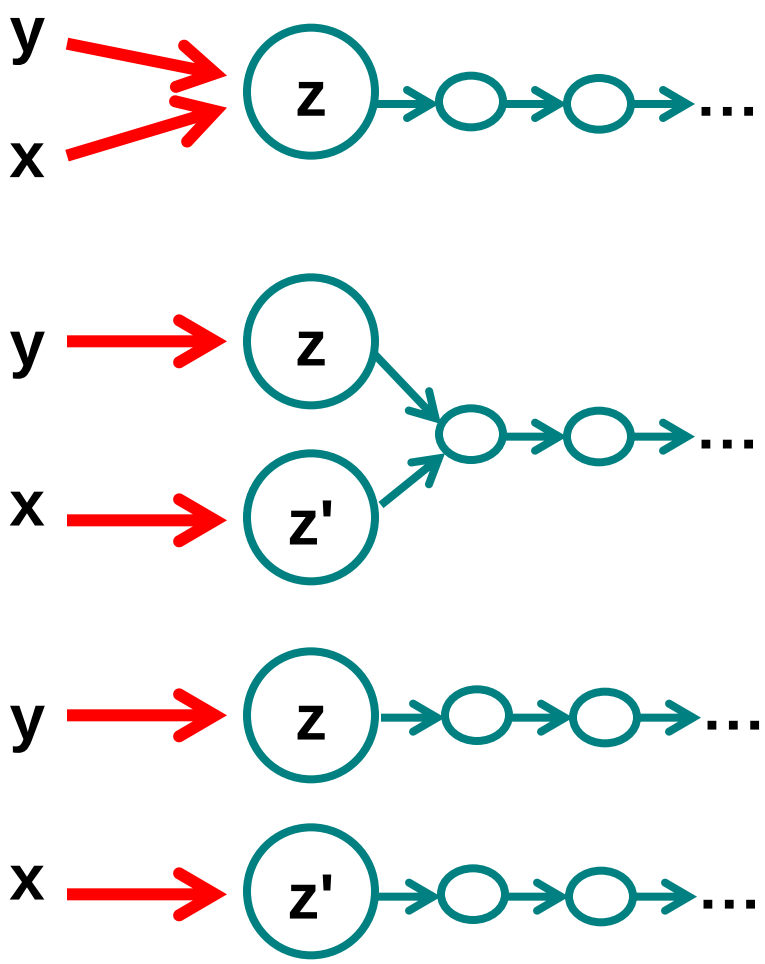
Cloning

- Cloning
  - Creates identical copy of object using clone( )
- Cloneable interface
  - Supports clone( ) method
  - Returns copy of object
    - Copies all of its fields
    - Does not clone its fields
    - Makes a shallow copy
- Example: See cloning package

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



Constructor

- **Description**
  - Method invoked when object is instantiated
  - Helps initialize object
  - Method with same name as class 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**

```
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( ) { … }          // 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**

```
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;
    ...
}
```

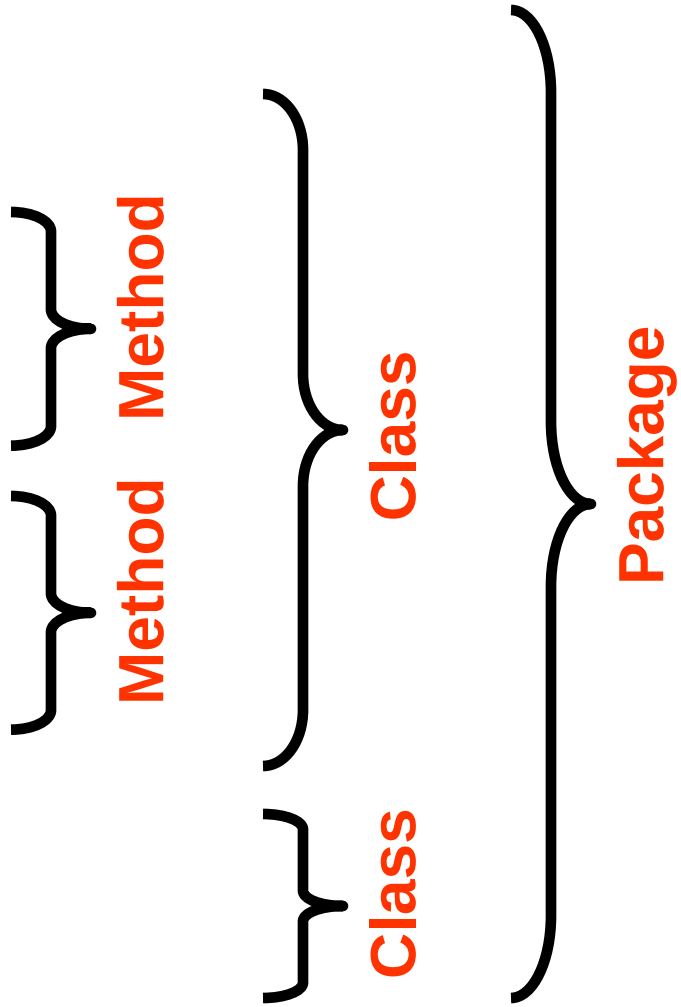
myVar accessible in method between { }

Scope – Example

- **Example**

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

Scopes



Inner Classes

- **Description**
  - Class defined in scope of another class
- **Property**
  - Can directly access all variables & methods of enclosing class (including private fields & methods)
- **Example**

```
public class OuterClass {
    private Object value;
    public class InnerClass {
        ...Object x = value;
    }
}
```

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

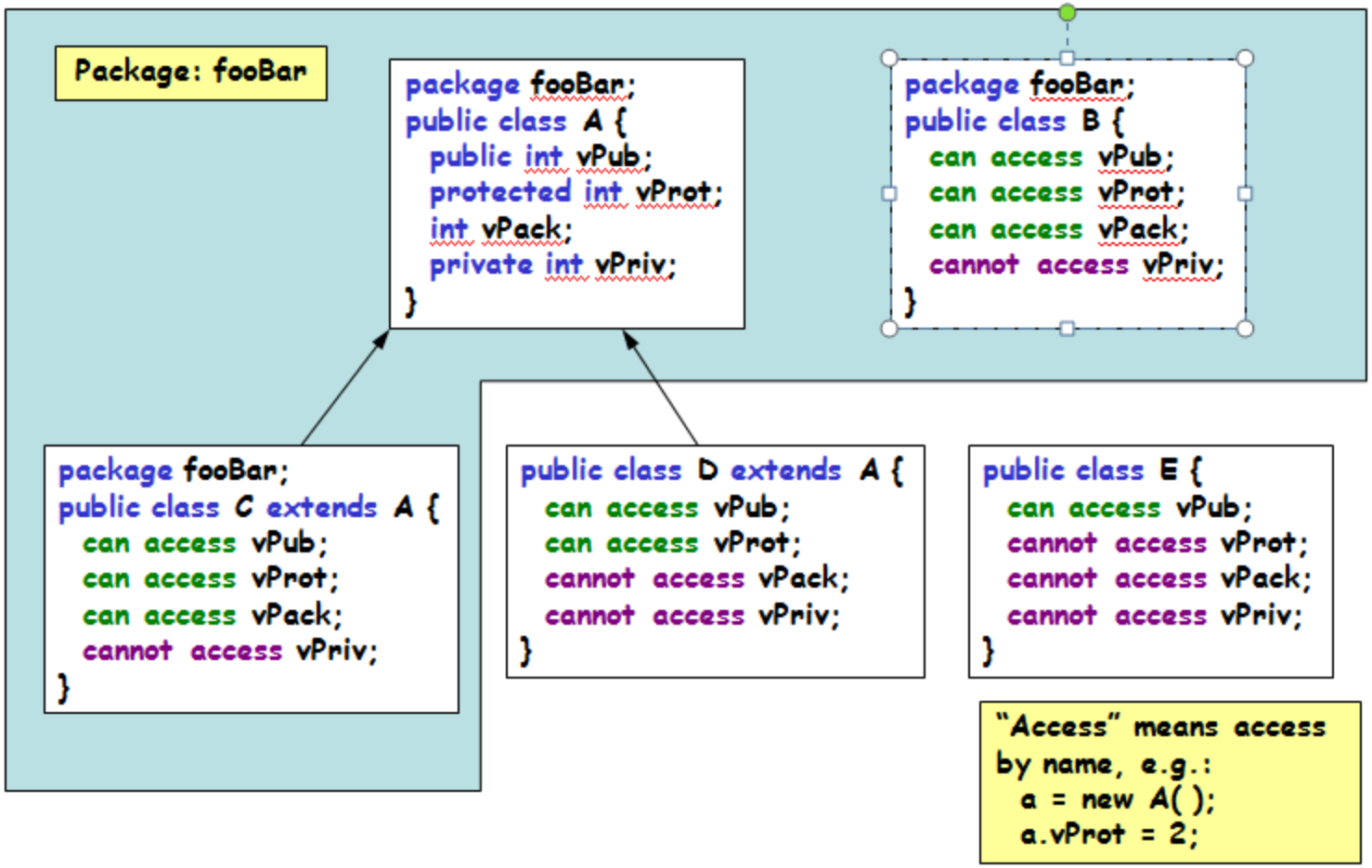
Visibility Modifier – Where Visible

- “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

Visibility Modifier



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 overridden 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**