Inheritance II

CMSC 202

`Protected` Access

- If a method or instance variable is modified by **`protected`** (rather than **`public`** or **`private`**), then it can be accessed *by name*
  - Inside its own class definition
  - Inside any class derived from it
  - In the definition of any class in the same package
- The **`protected`** modifier provides very weak protection compared to the **`private`** modifier
  - It allows direct access to any programmer who defines a suitable derived class
  - Therefore, instance variables should normally **not** be marked **`protected`**

Protected Members

- Derived classes can directly access inherited protected class members.

```
public class Vehicle {

    protected int speed;
}

public class Automobile extends Vehicle {
        // class definition

        public void applyEmergencyBrake(){
          speed = 0;
        }

        public static void main(String[] args){
                Automobile hummer = new Automobile("GMC","Hummer");

                hummer.speed = 100;
        }
}
```

Direct access to a base Class' instance variable

Problem: Public access to an instance variable of vehicle

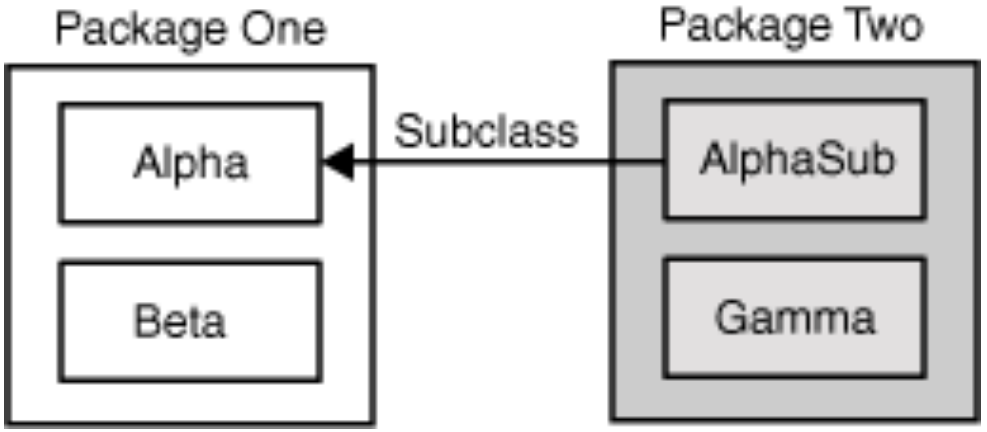
Package Access

- If you don’t explicitly specify an access control modifier, Java defaults to package access
  - Also known a “package-private” or “default”
- Package visibility modifiers imply access rights that are unique to package
  - All classes within the same package can access protected members as if they are public.
  - This may or may not be a problem...

Access Levels

Modifier	Same Class	Same Package	Subclass	World
public	✔	✔	✔	✔
protected	✔	✔	✔	✘
no modifier	✔	✔	✘	✘
private	✔	✘	✘	✘

Visibility of Alpha's Members



Modifier	From within Alpha	From within AlphaSub	From within Beta	From within Gamma
public	✔	✔	✔	✔
protected	✔	✔	✔	✘
no modifier	✔	✘	✔	✘
private	✔	✘	✘	✘

Inherited Constructors?

A Vehicle constructor cannot be used to create Automobile objects. Why not?

We must implement a specialized constructor for Automobile. But how can the Automobile constructor initialize the private instance variables in the Vehicle class since it doesn’t have direct access?

The `super` Constructor

- A derived class uses a constructor from the base class to initialize all the data inherited from the base class
  - In order to invoke a constructor from the base class, it uses a special syntax:

```
public DerivedClass(int p1, int p2, double p3)
{
  super(p1, p2);
  derivedClassInstanceVariable = p3;
}
```

  - In the above example, `super(p1, p2);` is a call to the base class constructor

The `super` Constructor

- Calling the base class' constructor uses the keyword `super()`
- A call to `super` must always be the first action taken in a constructor definition
- An instance variable cannot be used as an argument to `super.` **Why not?**

The `super` Constructor

- If a derived class constructor does not include an invocation of **`super`**, then the no-argument constructor of the base class will automatically be invoked
  - This can result in an error if the base class has not defined a no-argument constructor
- Since the inherited instance variables should be initialized, and the base class constructor is designed to do that, then an explicit call to **`super`** should always be used.

Vehicle Constructor

```
public class Vehicle {

    protected int speed;

    private int vin;
    private Color color;
    private int numOperators;
    private int numPassangers;


    private static int serialNumber = 111111;

    public Vehicle(){
       this(Color.blue, 1);
    }

    public Vehicle(Color cc, int numOperators) {
       vin = serialNumber++;
       color = cc;
       this.numOperators = numOperators;
       numPassengers = 0;
    }
}
```

Automobile Constructor

```
public class Automobile extends Vehicle {
        // instance variables local to the derived class extends
        private String make;
        private String model;
        private boolean locked;

        // note we have not taken care to implement any class
        // invariant checking however, each class should validate
        // its own state
        public Automobile(String make, String model, Color color,
                          int numOperators) {
                // calling which constructor of vehicle?
                super(color, numOperators);

                this.make = make;
                this.model = model;
                this.locked = false;
        }

        public Automobile() {
          this("Mazda","CX-9", Color.RED, 1);
        }
}
```

Access to a Redefined Base Method

- Within the definition of a method of a derived class, the base class version of an overridden method of the base class can still be invoked
  - Simply preface the method name with super and a dot

```
// Automobile's toString( ) might be
public String toString( )
{
  return (super.toString() + "$" + getRate( ));
}
```

- However, using an object of the derived class outside of its class definition, there is no way to invoke the base class version of an overridden method

You Cannot Use Multiple `supers`

- It is only valid to use `super` to invoke a method from a direct parent
  - Repeating `super` will not invoke a method from some other ancestor class
- For example, if the `Helicopter` class were derived from the class `Aircraft`, and the `Aircraft` class were derived form the class `Vehicle` , it would not be possible to invoke the `toString` method of the `Vehicle` class within a method of the `Helicopter` class
  - You must use composition to accomplish that task.

```
super.super.toString() // ILLEGAL!
```

An Object of a Derived Class Has More than One Type

- An object of a derived class has the type of the derived class, and it also has the type of the base class

- More generally, an object of a derived class has the type of every one of its ancestor classes
  - Therefore, an object of a derived class can be assigned to a variable of any ancestor type

An Object of a Derived Class Has More than One Type

- An object of a derived class can be plugged in as a parameter in place of any of its ancestor classes
- In fact, a derived class object can be used anyplace that an object of any of its ancestor types can be used
- Note, however, that this relationship does not go the other way
  - An ancestor type can never be used in place of one of its derived types

Base/Derived Class Summary

Assume that class D (Derived) is derived from class B (Base).

1. Every object of type D **is a** B, but not vice versa.

2. D is a more specialized version of B.

3. **Anywhere an object of type B can be used, an object of type D can be used just as well**, but not vice versa.

(Adapted from: ***Effective C++***, 2nd edition, pg. 155)

Tip: Static Variables Are Inherited

- Static variables in a base class are inherited by any of its derived classes
- The modifiers **`public`**, **`private`**, and **`protected`** have the same meaning for static variables as they do for instance variables

The Class `Object`

- In Java, every class is a descendent of the class ***`Object`***
  - Every class has **`Object`** as its ancestor
  - Every object of every class is of type **`Object`**, as well as being of the type of its own class
- If a class is defined that is not explicitly a derived class of another class, it is still automatically a derived class of the class **`Object`**

The Class `Object`

- The class `Object` is in the package `java.lang` which is always imported automatically
- Having an `Object` class enables methods to be written with a parameter of type `Object`
  - A parameter of type `Object` can be replaced by an object of any class whatsoever
  - For example, some library methods accept an argument of type `Object` so they can be used with an argument that is an object of any class

The Class `Object`

The class `Object` has some methods that every Java class inherits

- For example, the `equals` and `toString` methods

Every object inherits these methods from some ancestor class

- Either the class `Object` itself, or a class that itself inherited these methods (ultimately) from the class `Object`

However, these inherited methods should be overridden with definitions more appropriate to a given class

- Some Java library classes assume that every class has its own version of such methods

The Right Way to Define `equals`

- Since the **`equals`** method is always inherited from the class **`Object`**, methods like the following simply overload it:

```
public boolean equals(Vehicle otherVehicle)
 { . . . }
```

- However, this method should be **overridden**, not just overloaded:

```
public boolean equals(Object otherObject)
 { . . . }
```

The Right Way to Define `equals`

- The overridden version of `equals` must meet the following conditions
  - The parameter `otherObject` of type `Object` must be type cast to the given class (e.g., `Vehicle)`
  - However, the new method should only do this if `otherObject` really is an object of that class, and if `otherObject` is not equal to `null`
  - Finally, it should compare each of the instance variables of both objects

A Better Vehicle Class Equals()

```
public boolean equals(Object otherObject){
    if(otherObject == null){
        return false;
    }
    if(otherObject.getClass() != this.getClass()){
        return false;
    }
    // Downcast so that we can access the instance variables
    // and methods of the Vehicle Class
    Vehicle v = (Vehicle) otherObject;
    if(v.vin == this.vin){
        return true;
    }
    else{
        return false;
    }
}
```

Prevent null pointer exception

Prevent class mismatch exception

Finally check to see if the two vehicles are the Same vehicle based on the state of each instance.

The `getClass()` Method

- Every object inherits the same `getClass()` method from the `Object` class
  - This method is marked `final`, so it cannot be overridden
- An invocation of `getClass()` on an object returns a representation *only* of the class that was used with `new` to create the object
  - The results of any two such invocations can be compared with `==` or `!=` to determine whether or not they represent the exact same class

```
(object1.getClass() == object2.getClass())
```