Polymorphism

November 26, 2007

ComS 207: Programming I (in Java)
Iowa State University, FALL 2007
Instructor: Alexander Stoytchev

Final Exam

- **Time:**
  - **Thursday Dec 13 @ 4:30-6:30 p.m.**
- **Location:**
  - **Curtiss Hall, room 127 (classroom)**

Quick Review of Last Lecture

Method Overloading

- **The compiler determines which method is being invoked by analyzing the parameters**

```
float tryMe(int x)
{
   return x + .375;
}
```

[signature 1] tryMe: int

```
float tryMe(int x, float y)
{
   return x*y;
}
```

[signature 2] tryMe: int, float

Method Overriding

```
public class Parent
{
   public float tryMe(int x)
   {
      return x + .375;
   }
}


public class Child extends Parent
{
   public float tryMe(int x)
   {
      return x*x;
   }
}
```

Same Signatures

Different Method Bodies

Overriding Methods

- **A child class can *override* the definition of an inherited method in favor of its own**
- **The new method must have the same signature as the parent's method, but can have a different body**
- **The type of the object executing the method determines which version of the method is invoked**

Overriding

- A method in the parent class can be invoked explicitly using the `super` reference
- If a method is declared with the `final` modifier, it cannot be overridden
- The concept of overriding can be applied to data and is called *shadowing variables*
- Shadowing variables should be avoided because it tends to cause unnecessarily confusing code

Overloading vs. Overriding

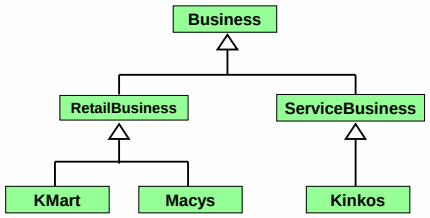
- Overloading deals with multiple methods with the same name in the same class, but with different signatures
- Overriding deals with two methods, one in a parent class and one in a child class, that have the same signature

Overloading vs. Overriding

- Overloading lets you define a similar operation in different ways for different parameters
- Overriding lets you define a similar operation in different ways for different object types

Class Hierarchies

- A child class of one parent can be the parent of another child, forming a *class hierarchy*



Class Hierarchies

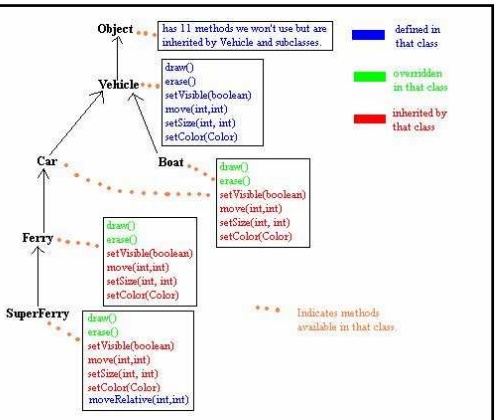
- Two children of the same parent are called *siblings*
- Common features should be put as high in the hierarchy as is reasonable
- An inherited member is passed continually down the line
- Therefore, a child class inherits from all its ancestor classes
- There is no single class hierarchy that is appropriate for all situations

Object – the mother of all objects in Java

```
boolean equals (Object obj)
    Returns true if this object is an alias of the specified object.
String toString ()
    Returns a string representation of this object.
Object clone ()
    Creates and returns a copy of this object.
```

The Object Class

- The `equals` method of the `Object` class returns true if two references are aliases
- We can override `equals` in any class to define equality in some more appropriate way
- As we've seen, the `String` class defines the `equals` method to return true if two `String` objects contain the same characters
- The designers of the `String` class have overridden the `equals` method inherited from `Object` in favor of a more useful version



[http://www.holtsoft.com/java/resources/inherit_tutorial/Inheritance/methods.jpg]

Abstract Classes

- An *abstract class* is a placeholder in a class hierarchy that represents a generic concept
- An abstract class cannot be instantiated
- We use the modifier `abstract` on the class header to declare a class as abstract:

```
public abstract class Product
{
   // contents
}
```



```
public abstract class Animal
{
   abstract void makeSound();
}
```

```
public class Cow extends Animal
{
   public void makeSound()
   {
      System.out.println("Moo-Moo");
   }
}
```

```
public class Dog extends Animal
{
   public void makeSound()
   {
      System.out.println("Wuf-Wuf");
   }
}
```

```
public class Duck extends Animal
{
   public void makeSound()
   {
      System.out.println("Quack-Quack");
   }
}
```


Abstract Classes

- An abstract class often contains abstract methods with no definitions (like an interface)
- Unlike an interface, the `abstract` modifier must be applied to each abstract method
- Also, an abstract class typically contains non-abstract methods with full definitions
- A class declared as abstract does not have to contain abstract methods -- simply declaring it as abstract makes it so

Abstract Classes

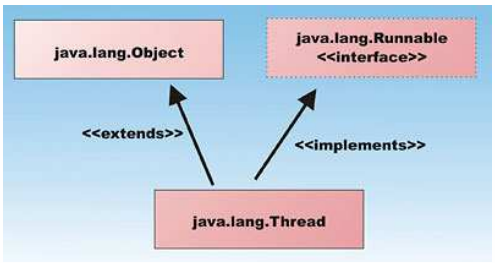
- The child of an abstract class must override the abstract methods of the parent, or it too will be considered abstract
- An abstract method cannot be defined as `final` or `static`
- The use of abstract classes is an important element of software design – it allows us to establish common elements in a hierarchy that are too generic to instantiate

Other Stuff From Chapter 8

Interface Hierarchies

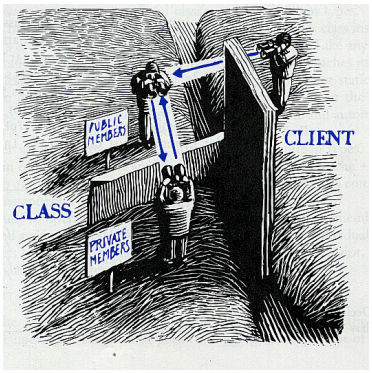
- Inheritance can be applied to interfaces as well as classes
- That is, one interface can be derived from another interface
- The child interface inherits all abstract methods of the parent
- A class implementing the child interface must define all methods from both the ancestor and child interfaces
- Note that class hierarchies and interface hierarchies are distinct (they do not overlap)

This example shows how multiple inheritance can be faked in java



[http://www.vsj.co.uk/pix/articleimages/may05/javathread3.jpg]

Visibility Cartoon



[http://faculty.juniata.edu/kruse/cs2/vis.gif]

Visibility Revisited

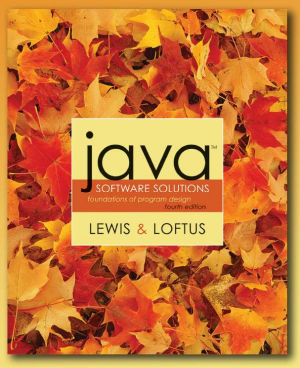
- It's important to understand one subtle issue related to inheritance and visibility
- All variables and methods of a parent class, even private members, are inherited by its children
- As we've mentioned, private members cannot be referenced by name in the child class
- However, private members inherited by child classes exist and can be referenced indirectly

Visibility Revisited

- Because the parent can refer to the private member, the child can reference it indirectly using its parent's methods
- The `super` reference can be used to refer to the parent class, even if no object of the parent exists

Chapter 9

Section 9.1 & 9.2

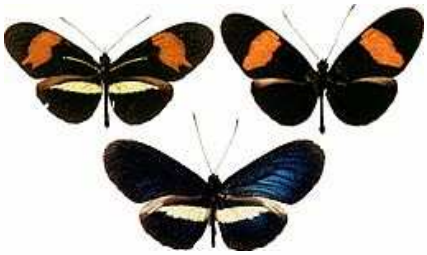


PEARSON Addison Wesley

Polymorphism

- Polymorphism is an object-oriented concept that allows us to create versatile software designs
- Chapter 9 focuses on:
  - defining polymorphism and its benefits
  - using inheritance to create polymorphic references
  - using interfaces to create polymorphic references
  - using polymorphism to implement sorting and searching algorithms
  - additional GUI components

Polymorphism in Nature



[http://www.blackwellpublishing.com/ridley/images/h_erato.jpg]

Binding

- Consider the following method invocation:

```
obj.doIt();
```

- At some point, this invocation is *bound* to the definition of the method that it invokes
- If this binding occurred at compile time, then that line of code would call the same method every time
- However, Java defers method binding until run time -- this is called *dynamic binding* or *late binding*
- Late binding provides flexibility in program design

Polymorphism

- The term *polymorphism* literally means "having many forms"
- A *polymorphic reference* is a variable that can refer to different types of objects at different points in time
- The method invoked through a polymorphic reference can change from one invocation to the next
- All object references in Java are potentially polymorphic

Polymorphism

- Suppose we create the following reference variable:

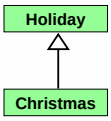
```
Occupation job;
```

- Java allows this reference to point to an `Occupation` object, or to any object of any compatible type
- This compatibility can be established using inheritance or using interfaces
- Careful use of polymorphic references can lead to elegant, robust software designs

Polymorphism via Inheritance

References and Inheritance

- An object reference can refer to an object of its class, or to an object of any class related to it by inheritance
- For example, if the `Holiday` class is used to derive a class called `Christmas`, then a `Holiday` reference could be used to point to a `Christmas` object




```
Holiday day;
day = new Christmas();
```


References and Inheritance

- Assigning a child object to a parent reference is considered to be a widening conversion, and can be performed by simple assignment
- Assigning a parent object to a child reference can be done also, but it is considered a narrowing conversion and must be done with a cast
- The widening conversion is the most useful

Polymorphism via Inheritance

- It is the type of the object being referenced, not the reference type, that determines which method is invoked
- Suppose the `Holiday` class has a method called `celebrate`, and the `Christmas` class overrides it
- Now consider the following invocation:

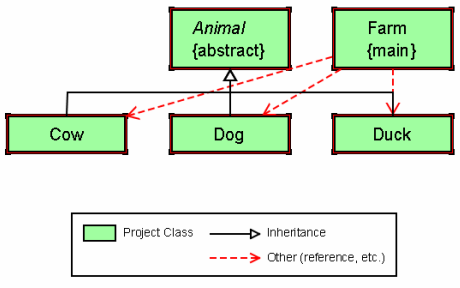
```
day.celebrate();
```

- If `day` refers to a `Holiday` object, it invokes the `Holiday` version of `celebrate`; if it refers to a `Christmas` object, it invokes the `Christmas` version

Example: Animals class hierarchy

- Animal.java
- Cow.java
- Duck.java
- Dog.java
- Farm.java

You can use jGrasp to draw diagram like this one



```
public abstract class Animal
{
   abstract void makeSound();
}
```

```
public class Cow extends Animal
{
   public void makeSound()
   {
      System.out.println("Moo-Moo");
   }
}
```

```
public class Dog extends Animal
{
   public void makeSound()
   {
      System.out.println("Wuf-Wuf");
   }
}
```

```
public class Duck extends Animal
{
   public void makeSound()
   {
      System.out.println("Quack-Quack");
   }
}
```



```
public class Farm
{
      public static void main(String[] args)
      {
            Cow c=new Cow();
            Dog d=new Dog();
            Duck k= new Duck();

            c.makeSound();
            d.makeSound();
            k.makeSound();
      }
}
```

Result:
Moo-Moo
Wuf-Wuf
Quack-Quack

```
public class Farm2
{
      public static void main(String[] args)
      {
            Animal[] a = new Animal[3];

            a[0] = new Cow();
            a[1] = new Dog();
            a[2] = new Duck();

            for(int i=0; i< a.length; i++)
                  a[i].makeSound();
      }
}
```

Result:
Moo-Moo
Wuf-Wuf
Quack-Quack

```
public abstract class Animal
{
   abstract void makeSound();
   public void move()
   {
     System.out.println("walk");
   }
}
```

Define a new method which is not abstract and is inherited by all children.

```
public class Cow extends Animal
{
   public void makeSound()
   {
      System.out.println("Moo-Moo");
   }
}
```

```
public class Dog extends Animal
{
   public void makeSound()
   {
      System.out.println("Wuf-Wuf");
   }
}
```

```
public class Duck extends Animal
{
   public void makeSound()
   {
      System.out.println("Quack-Quack");
   }
}
```



```
public abstract class Animal
{
   abstract void makeSound();
   public void move()
   {
     System.out.println("walk");
   }
}
```

```
public class Cow extends Animal
{
   public void makeSound()
   {
      System.out.println("Moo-Moo");
   }
}
```

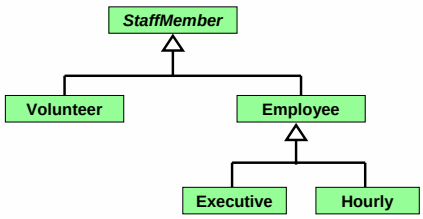
```
public class Dog extends Animal
{
   public void makeSound()
   {
      System.out.println("Wuf-Wuf");
   }
}
```

```
public class Duck extends Animal
{
   public void makeSound() {
      System.out.println("Quack-Quack");
   }
   public void move()  {
      System.out.println("fly");
   }
}
```

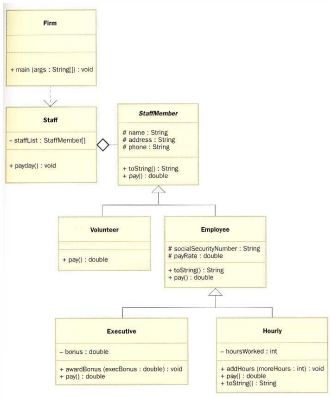
Override the move method defined in the Animal class.

Polymorphism via Inheritance

- **Consider the following class hierarchy:**



Employee Class Hierarchy



Polymorphism via Inheritance

- Now let's look at an example that pays a set of diverse employees using a polymorphic method
- See `Firm.java` (page 486)
- See `Staff.java` (page 487)
- See `StaffMember.java` (page 489)
- See `Volunteer.java` (page 491)
- See `Employee.java` (page 492)
- See `Executive.java` (page 493)
- See `Hourly.java` (page 494)

THE END