Java – Inheritance, Interfaces

Kurt Schmidt

Dept. of Computer Science, Drexel University

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These notes are intended for students familiar with C++

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Intro

Java is Object-Oriented

Inheritance in Java is rather like inheritance in C++. Some differences to note:

- No multiple inheritance
    - We use Java *Interfaces*
- All methods are virtual
    - All variables of type Object are references, so...
- There is no destructor
    - `finalize()` is called when object is released back to the heap
    - So, not reliably called
- Java allows static attributes of any type to be initialised at the declaration
- Java allows classes to be defined inside a class
- Java allows unnamed classes

Java Classes

Classes as Namespaces

The `Math` class, e.g., is simply a container for methods and constants.

- Can't be instantiated
  - The default constructor is made `private`
- The class is `final` – can't be subclassed
- All methods are `public static`
  - `Math.sin( a ) ;`
  - `Math.exp( x ) ;`
- Constants are `public static` attributes

Inheritance

Inheritance vs. Aggregation

- Inheritance is the *is-a* relationship
  - A square is a shape
  - An employee is a person
  - A professor is an employee
  - So, a professor is a person
  - It's not perfect
- Aggregation is the *has-a* relationship
  - A square has a color
  - An employee has an address
  - A car has an engine
    - And 4 tires

Inheritance

Given a simple class:

```
public class Person {
   protected String _name ;
   public Person( String n ) { _name = n ; }
   public String getName() { return _name ; }
}
```

We can define a subclass:

```
public class Professor extends Person {
   protected String _id ;
   public Professor( String n, string i )
   {  super(n) ; _id = i ; }
   public String getName()
   { return "Prof. " + _name ; }
}
```

Abstract Superclass

- An abstract class can not be instantiated
- It typically contains method declarations, w/out definitions
  - These are behaviors that subclasses must provide to be meaningfull objects
  - Use the `@Override` annotation
- E.g., a closed shape might well know its color, and declare a method to compute its area
  - All closed shapes have an area
  - Computed differenty for each shape
  - Area of an abstract shape is meaningless

Abstract Superclass – example

```java
public abstract class ClosedShape {
   protected Color _color ;
   public ClosedShape( Color c ) { _fill = c ; }
   public Color color() { return _fill ; }
   public abstract double getArea() ;
}
```

We create an actual shape

```java
public class Circle extends ClosedShape {
   protected double _radius ;

   public Circle( Color c, double r )
   {  super(c) ; _radius = r ; }

   @Override
   public double getArea()
   { return Math.Pi * _radius * _radius ; }

   public double getRadius() { return _radius ; }
}
```

Casting

- Objects can be cast up the tree
  - Always safe
  - Explicit cast not needed
  - Only methods from ancestor may be called
  - Remember, all methods are virtual

```
ClosedShape s = new Circle( Color.BLUE, 3 ) ;
```

- Objects can be cast down the tree
  - Might throw `ClassCastException`
  - Only methods from ancestor may be called
  - Remember, all methods are virtual

```
Circle c = (Circle) s ; // This works fine
Square q = (Square) s ; // This throws exception
```

instanceof Operator

- We can test objects
- An object of a subclass is always an instance of an ancestor
- An object of a class is not, generally, an instance of a descendant

```
Circle c = new Circle( Color.PURPLE, 8 ) ;
...
if( c instanceof Square ) System.out.prinln( "c is a Square" ) ;
if( c instanceof Circle ) System.out.prinln( "c is a Circle" ) ;
if( c instanceof ClosedShape )
   System.out.prinln( "c is a ClosedShape" ) ;
```

```
c is a Circle
c is a ClosedShape
```

Containers of Shapes

We can create containers of shapes:

```
public static void main( String [] args )
{
   GridLoc l = new GridLoc( 1, 2 ) ;
   ArrayList<Shape> zoo = new ArrayList<Shape>() ;
   zoo.add( new Circle( 3, l )) ;
   zoo.add( new Square( 5, l )) ;

   for( Shape s : zoo )
   {
      System.out.printf( "Area: %.2f\n", s.getArea() ) ;
   }
}
```

```
Area: 28.27
Area: 25.00
```

Interfaces

Interfaces

- Java does not support mulitple inheritance
  - This is not a bad thing
  - Multiple inheritance is messy, both in design and implementation
- An interface describes behaviors which must be supplied by any implementing class
  - It *declares* methods
  - It does not *define* any
  - Attributes, however, *can* be defined

Interfaces

- An interface can “inherit” from one or more other interfaces:

```
public interface Stealthy
{
   public void stalk() ;
}

public interface Predator extends Stealthy
{
   public void pounce() ;
}
```

- A class might implement multiple interfaces:

```
public class Cat extends Animal implements Predator, Yowler
{ ... }
```

Containers and Interfaces

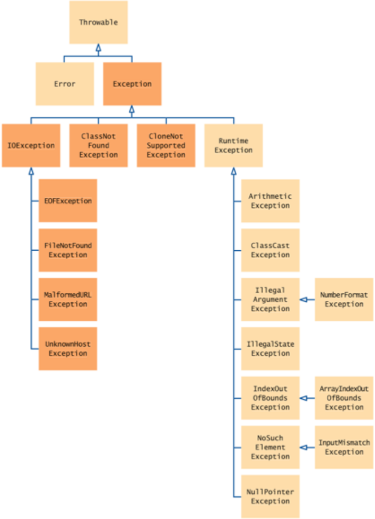
- Instances of an class implementing an interface can be viewed as objects of that type
  - A `KeyListener` object, whatever else it is, has methods `keyTyped`, `keyPressed`, and `keyReleased`
  - All `Animals` that implement the `Yowler` interface can be contained together:

```
public static void main( String [] args )
{
   ArrayList<Yowler> zoo = new ArrayList<Yowler>() ;
   zoo.add( new Cat( "Sylvester" )) ;
   zoo.add( new Wolf( "Nighteyes" )) ;
   ...
   for( Yowler y : zoo )
   {
      y.singAncientSongOfYourPeople() ;
   }
}
```

Exceptions

Library Exceptions

- These are the exceptions in the Java standard library
- Exceptions in darker boxes are *checked* exceptions
  - Must be caught, or listed in a `throws` statement
  - All *should* be so listed
- Inherit off of any of these to make your own exceptions
  - No behavior need be defined
  - Its value is its type



Taken from Cay Horstmann's Big Java, 4th ed.

User-Defined Exceptions

```java
public class ThatsOdd extends IllegalArgumentException
{
   public ThatsOdd( String s ) { super( s ); }
}
```

Can be used as any other exception:

```java
public static void foo( int i ) throws ThatsOdd {
  if( i%2==1 )
    throw new ThatsOdd( "We're partial to evens, in this method." ) ;
  ...
}
public static void bar( int n ) {
  try {
    foo( n/2 ) ;
    ...
  } // try
  catch( ThatsOdd e ) {
    System.err.printf( "bar> caught ThatsOdd: %s\n", e.toString() ) ;
    e.printStackTrace() ;
  }
}
```

Nested Classes

Nested Classes in Java

- Java allows classes to be defined inside other classes
  - Even inside methods
  - Even unnamed
- We'll briefly look at these, describe common uses
  - We will not discuss nuances of design in this course

Types of Nested Classes

- The possibilities are:
  - Static nested class
  - Non-static inner class
    - Need an instance of outer class to instantiate
  - Defined inside a method (*method-local*)
    - Can only be instantiated in that method
    - Object can be returned from method
- Do not confuse visibility (scope) with access
  - A private member is not accessible, outside of that class

Public Static Nested Classes

- Just a container for similar classes

```
public class Public
{
   public static class Inner1
   {
      public void talk()
      { System.out.println( "In Public.Inner1.talk" ) ; }

   } // class Inner1

   public static class Inner2
   {
      public void talk()
      { System.out.println( "In Public.Inner2.talk" ) ; }

   } // class Inner1
} // class Public
```

Public Static Nested Classes (cont.)

- Used like any other class
- Note the scope

```
public static void main( String [] args )
{
   Public.Inner1 i1 = new Public.Inner1() ;
   Public.Inner2 i2 = new Public.Inner2() ;

   i1.talk() ;
   i2.talk() ;

} // class Inner1
```

Non-Static Nested Classes

- Also called *inner* classes
- About all Java offers in the way of a *closure*
  - Needs an instance of outer class
  - These objects capture their surrounding scope, even if the containing object is no longer accessible
- Can be an alternative to exposing outer class' attributes to entire package (or world)
- An inner class may be *unnamed*
  - Commonly used to install event handlers

Non-Static Nested Classes (cont.)

E.g., inside a Dialog we might have event handlers for some controls

```
buttonYes = new JButton() ;
buttonNo = new JButton() ;
...
buttonYes.addActionListener(
  new java.awk.ActionListener() // class definition here
  {
    public void actionPerformed( java.awt.event.ActionEvent e )
    {
      doSomething() ;
    }
  }
)
```

Factory Methods

- Object creation is abstracted
- Class will choose which subclass to create
- Subclasses are hidden (can't be instantiated directly)
  - Private static nested class, OR
  - Method local (defined inside the factory method)
- Consider the Sorting Hat, from Hogwarts
  - It decides which House a student belongs to
  - All houses have same i/f:

```
public abstract class House {
   ...
   public abstract represent() ;
}
```

Factory Methods – Hogwarts

- Inside we could define our subclasses:

```
private static class Gryffyndor extends House {
  @Override
  public void represent()
  { System.out.println( "Gryffyndor!" ) ; }
}

private static class Slytherin extends House {
  @Override
  public void represent()
  { System.out.println( "Slytherin!" ) ; }
}

private static class RavenClaw extends House {
  @Override
  public void represent()
  { System.out.println( "RavenClaw!" ) ; }
}
```

Hogwarts (cont.)

- Here's our factory method, with exclusive access to the subclasses:

```
public static House SortingHat( int i )
{
  House rv = null ;
  switch( i%3 ) {
    case 0 : rv = new Gryffyndor() ; break ;
    case 1 : rv = new Slytherin() ; break ;
    case 2 : rv = new RavenClaw() ; break ;
  }
  return rv ;
}
```

- We let the factory decide the proper subclass to use:

```
public static void main( String [] args )
{
  House h = House.SortingHat( 27 ) ;
  h.represent() ;
}
```