Java inheritance notes

Prof Bill, Feb 2020

Our “textbook” links:

- ➢ Sedgewick Java 3.3 Designing data types, introcs.cs.princeton.edu/java/33design
- ➢ Oracle Java, Interfaces and Inheritance section, docs.oracle.com/javase/tutorial/java

Thank you - I bow down to Noctrl’s own **Dr. Godfrey Muganda** for his excellent Java textbook. I have liberally borrowed ideas from this book.
media.pearsoncmg.com/bc/abp/cs-resources/products/product.html#product,isbn=0134038177

Sections:

1) Definitions, 2) UML, 3) Inheritance and ctors, 4) Override methods,
5) Access to methods and variables, 6) Classes, abstract classes, and interfaces,
7) Polymorphism, 8) The Object class

Terms:

inheritance
concrete class
abstract class
interface
polymorphism
composition
	Keywords
	
	`extends, implements`
	`this, super`
	`public, private, protected`

Versus battles: is-a, has-a relationships super class, subclass override, overload inheritance, composition single inheritance, multiple inheritance	Object class inner classes uml diagram: class name, variables, methods; has-a arrow, is-a arrow

1. Definitions

Inheritance - allows a new class to extend an existing class; the new inherits the member methods and variables

In definition above, existing class is the **superclass**; the new class is the **subclass**.

Java snippet:

```
public class NewExample extends ExistingExample {
  // new inherits methods and variables from existing
  // NewExample is subclass; ExistingExample is superclass
}
```

Inheritance is often called the **is-a relationship**; example: Grasshopper is-a Insect; another example: every class is-a Object implicitly in Java

Java has two mechanisms for inheritance:

1. **Interface**, using **implements** keyword; methods only
2. **Class**, using **extends** keyword; methods and variables

Composition - allows a new class to specify other existing classes that are a part of it

In Java, composition simply means that one object is a member variable of another.

Composition is often call the **has-a relationship**; example: Grasshopper has-a Leg

More Grasshopper:

```
public class Grasshopper extends Insect {
  // Grasshopper is-a Insect; methods and vars inherited!

  // You can create Grasshopper-specific methods/vars
  Leg backLeft; // composition has-a Leg
  Leg backRight;

  int jump() {
    // code
  }
}
```

You can have levels of inheritance. Example: C is-a B, B is-a A.

```
public class A {
  // super class methods and variables
}

public class B extends A {
  // B is-a A; B is subclass, A superclass
}

public class C extends B {
  // C is-a B; C is subclass, B is superclass
}
```

Libraries like Java Collections Framework (JCF) have many, many levels of inheritance. It's fair to describe these libraries as "complex".

Some people call this an **inheritance chain**. Some call it the **inheritance hierarchy**.

Clash of the keywords: implements vs. extends

- ➢ A class may only extend only one other class
- ➢ However, Java allows you to implement as many interfaces as you like
- ➢ Why the difference? Interfaces don't have variables or ctors that can complicate inheritance

Clash of the relationships: inheritance vs. composition, is-a vs. has-a

- ❖ Select relationship that best models your design
- ❖ This is often a difficult design decision

/* Inheritance is the core of OOP in Java. Much of this stuff is very simple and makes sense; that's its power. */

2. UML

UML class diagrams are an easy, short-hand way to describe classes and the relationships between classes.

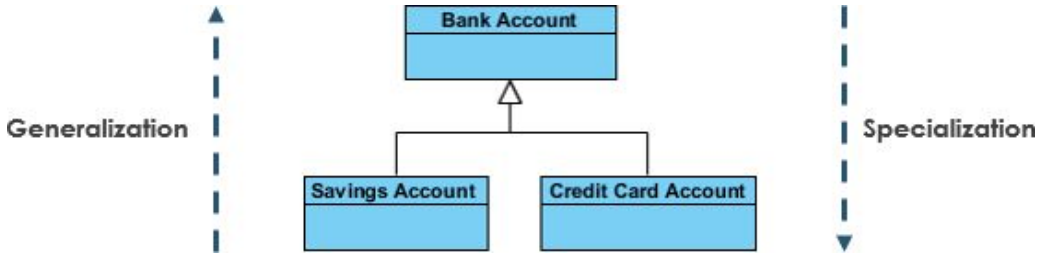
In UML, a class is defined as a rectangle with its name, variables, and methods

Professor
String name String collegeId int years
teach(Course c) grade(int hours)

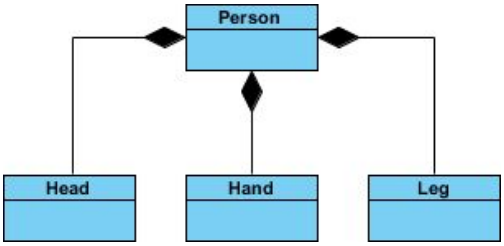
Your diagram can include +/- to indicate public/private members. If they're missing, we will assume that variables are private and methods are public. Data hiding!

This is a nice overview, and it's where I got my figures below:
www.visual-paradigm.com/guide/uml-unified-modeling-language/uml-aggregation-vs-composition/

Inheritance, the is-a relationship, is shown with an **open arrow** between classes
Example: SavingsAccount is-a BankAccount



Composition, the has-a relationship, is shown with a **diamond arrow** between classes
Example: Person has-a Hand



We won’t cover:

- ➔ Some people worry about the subtle difference between composition and aggregation...we will not
- ➔ The UML standard is HUGE and includes many different diagrams; we’ll only care about the class diagram

3. Inheritance and ctors

General ctor rules for all classes:

- ➔ The ctor method name is the same as the class name; example: for the Apple class, the default ctor is Apple().
- ➔ The **default ctor** has no parameters.
- ➔ If a class doesn't have any ctor specified, then Java implicitly calls a default ctor to create the variables for a new object.
- ➔ If you specify any ctors in a class, Java won't implicitly do anything...you must use the ctor(s) specified.

One of the downsides of inheritance...it complicates the creation of objects. Here are some ctor guidelines:

- The superclass ctor always executes before the subclass ctor. This makes sense: a subclass may need superclass data in its own ctor. Java makes this happen automatically.
- In rare cases, you may want to call the super ctor yourself.
    - To do this, use the keyword **super**.
    - When calling the super ctor, it must be the first line in your subclass ctor.
    - One reason to do this: send super ctor arguments; example: super(17)
- When interfaces are used for inheritance, these rules don't apply. Interfaces don't have ctors.
- If no ctor is specified, then Java

Note the important class vs. interface tradeoff here:

+ Interfaces are simpler and more elegant than classes for inheritance; they don't have ctor complexity/issues
- But interfaces don't have variables
- Interfaces are abstract and therefore can't be created as objects

/* The impact of inheritance on ctors and creating objects is sometimes difficult and hard to follow. This is a weakness of inheritance. */

4. Override methods

It's common for a subclass to **override** the methods of a superclass. This is done by matching the method name and parameters exactly in your subclass.

Some guidelines:

- ❏ A subclass must override any abstract methods in the superclass
- ❏ All interface methods are abstract (they have no code)
- ❏ Why override a superclass method that is **not** abstract (and therefore has code)? Because the subclass needs to accomplish something different in the method.

Java snippet:

```
public class A {
  public void exitMaze( int level) {
    // code here
  }
}

public class B extends A {
  public void exitMaze( int level) {
    // override code here!
  }
}
```

You can't override superclass variables. You can change their value, but not their type or anything like that.

/* I can **override** a method. I can **overload** a method. What's the difference? */

5. Access to methods and variables

Access to class methods and variables is controlled by these three keywords:

- **public** - can be called (method) or changed (variable) by anyone
- **private** - can only be called or changed within the class
- **protected** - can only be called or changed within the class or any subclass

For data hiding, we typically have private variables and public methods.

Java example:

```
public class A {
  private int powerUps;
  protected String levelName;

  public void moveMario() {
    // code here
  }
}

public class B extends A {
  public void example() {
    // powerUps var - no access because it's private
    // levelName var - can change in subclass because it's protected
    levelName = "Rainbow road";
  }
}
```

6. Classes, abstract classes, and interfaces

A **class** has code for all its methods. This is sometimes called a **concrete class**.

An **interface** has no code, only method signatures. All methods are implicitly abstract.

An **abstract class** is a mixture, some abstract and some code. It must be specified explicitly using the keyword **abstract**.

These three options are tools to you as a Java coder. They are there for you to best model the design you are trying to implement.

Java abstract class example:

```
public abstract class GhostWorld {
  private String[] actors;

  public double averageReview() {
    // code here
  }

  public abstract favoriteActor( int appearances);

}
```

Interfaces and abstract classes **can not** be created as objects. They are missing code!

They can only be used as a superclass.

One common paradigm for abstract classes: add code to an interface.

Java snippet:

```
public interface WordCounter {
  public void countWord( String w);
}

public abstract class WordCounterAbs implements WordCounter {

  public void countWordsInString( String sentence) {
    // code here, calls countWord() defined in interface
  }

  public void countWordsInFile( String fileName) {
    // code here, calls countWord() defined in interface
  }

  // NOTE: no countWord() method; so class is still abstract
}

public class MyWordCounter extends WordCounterAbs {
  public countWord( String w) {
    // code here; method is no longer abstract!
  }
}
```

So, motivation for abstract class is often code sharing. JCF example: the abstract class AbstractMap has code that is shared by HashMap and TreeHashMap classes.

/* Yes, abstract classes are more complex, a deeper dive. */

7. Polymorphism

Polymorphism literally means: many forms or shapes.

In Java, it means that a subclass method is given priority over the superclass. Example!

```
public interface Shape {
  public void draw();
}

public Rectangle implements Shape {
  public void draw() {
    // code to draw a rectangle
  }
}

// define Circle is-a Shape, Square is-a Shape, etc
// snippet: ArrayList of Shapes draws correctly with polymorphism
ArrayList<Shape> shapes = new ArrayList<>();
Rectangle r = new Rectangle();
shapes.add( r);
Circle c = new Circle();
shapes.add( c);
Square sq = new Square();
shares.add( sq);

for( Shape sh: shapes) {
  sh.draw(); // correct subclass method called, polymorphism!
}
```

Nice polymorphism example: Animal class with Cat, Horse subclasses.
beginnersbook.com/2013/03/polymorphism-in-java/

/* Once you “get it”, polymorphism is easy to use and powerful. */

8. The Object class

Java snippet.

```
public class Example {
  // methods and variables here
}
```

Implicit for every class: Example is-a Object, or public class Example extends Object

Here's the Javadoc: docs.oracle.com/javase/8/docs/api/java/util/Objects.html

Three important methods in Object:

- equals() - compare two objects; default use **pointer**
- hashCode() - get hash code for object; default use **pointer**
- toString() - return string for object; default create string for **pointer**

The method defaults are to use Object pointers, but that's often not very helpful.

The answer: Override in your class.

```
public class Example {

  // override Object method for nicer printing
  public String toString() {
    return "Last example!";
  }
}
```