Java 101 - Magistère BFA

Lesson 2: Object Oriented Programming in Java

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Goal : Thou Shalt not re-code the same lines

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1  public class Character {
2     public String name;
3
4     // default constructor
5     public Character(){
6       nom = "Unknown";
7     }
8
9     public Character(String name){
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11    }
12 }
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How should we do this ?

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`Java` one solution : inheritance.

Inheritance

Inheritance : a class can be a subclass of another class.

- The **parent**/**super** class is more general
- ⇨ the **super** class has all the properties of all the subclasses.
- subclasses have more specific properties.
- ⇨ We obtain a class hierarchy.

To express that a class is a subclass, we use the `extends` keyword in the class declaration.

```
1 class <subclass name> extends <superclass name>
```

In `Java`, a sublass may extends **only one** superclass.

Example

```
1  public class Character {
2     private String name;
3     // Constructor
4     public Character(String name){
5       this.name = name;
6     }
7
8     public String introduction(){
0       return "My name is " + name;
10    }
11 }
```

```
1  public class Gaul extends Character {
2
2
3     public String intoduction(){
4       What should I write?
5     }
6
7
8     public Gaul(String name){
9       What should I write?
10    }
11 }
```

Consequences

- What happens to variables ?
- What happens to methods ?
- How to work with constructors

Protected members– `protected`

Methods or variable could be `private` or `public`

- `public` variables or methods are accessible to subclasses
  (of course !)
- `private` variables or methods remain inaccessible, even for subclasses !

  Careful however !
  Even though we do not have a direct access to those variables or methods, they do exist, but are simply hidden.

➥ `protected` : a class and its subclasses can access a `protected` method or variable.

Method overriding

For `public` or `protected` method :

- either the behaviour is the same : we do not need to rewrite the method in the subclass
- or the behaviour is different : we need to re-write the method
  We can use an annotation `@Override` to note that we are redefining a method of a superclass.
  ⇨`Java` will check whether we *actually* override a method from the superclass.

How to refer to the superclass ?

- **this** : is a reference to the current class.
- **super** : is a reference to the superclass.

Of course, we can add method in a superclass that do not exist in the superclass !

Example

```java
public class Character {
   private String name;
   // Constructor
   public Character(String name){
     this.name = name;
   }

   public String introduction(){
     return "My name is " + name;
   }
}
```

```java
public class Gaul extends Character {

   @Override
   public String introduction(){
     return super.introduction() + " I am a Gaul";
   }



  public static void main(String[] args){
     Gaul asterix = new Gaul("Astérix");
   System.out.println( asterix.introduction());
   }
}
```

Writing the constructor of a subclass

The constructors name and signature follows the usual rules.
For the body, there are two steps :

1. call the constructor of the superclass name : its name ?
   super(<arguments list>)
2. write the code that is specific to the subclass.

if you do not explicitly call the constructor of the superclass, `Java` will try to call the default constructor

- if it exists, everything goes fine
- if it does not exist ⇨ compilation error ! Solutions :
  - either you add a call to a constructor of the superclass
  - or you write a default constructor of the superclass.

Example

```
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3     // Constructor
4     public Character(String name){
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8     public String introduction(){
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```
1  public class Gaul extends Character {
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3     public Gaul(String name){
4       super(name);
5     }
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7     public String introduction(){
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9     }
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11    public static void main(String[] args){
12      Gaul asterix = new Gaul("Astérix");
13      System.out.println( asterix.introduction());
14    }
15 }
```

Operator `instanceof`

We can check whether an instance is a member of a class.
(sometimes, we may not know the precise type of a variable)

```
1 public class Character { ... }
```

```
1 public class Gaul extends Character { ... }
```

```
1 public class IndomitableGaul extends Gaul { ... }
```

```
1 public class Roman extends Character { ... }
2 ...
5   public static void main(String[] args){
6     IndomitableGaul asterix = new IndomitableGaul();
7     System.out.println( asterix instanceof Character);
8     System.out.println( asterix instanceof Gaul);
9     System.out.println( asterix instanceof Roman);
```

Astérix is a character, a Gaul, and even an indomitable Gaul. Of course, he is not a Roman !

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```

```
1 | public class Roman extends Character { ... }
2 | ...
5 |   public static void main(String[] args){
6 |     IndomitableGaul asterix = new IndomitableGaul();
7 |     System.out.println( asterix instanceof Character); ✔
8 |     System.out.println( asterix instanceof Gaul);
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1 | public class IndomitableGaul extends Gaul { ... }
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```

Astérix is a character, a Gaul, and even an indomitable Gaul. Of course, he is not a Roman !

Polymorphism

From the previous example, it seems Astérix has many types : this is what is called **polymorphism** : the fact that a variable may have several types.

This allows the manipulation of objects that all share the same superclass !

```
1 Character asterix = new Gaul("Astérix");
```

```
1 Gaul obelix = new Gaul("Obélix");
2 Gaul asterix = new Gaul("Astérix");
3 Character cleopatre = new Character("Cléopâtre");
3 Character[] distribution= new Character[3];
4 distribution[0]= asterix;
5 distribution[1]= obelix;
6 distribution[2]= cleopatre;
```

Polymorphism

```
1 | Character asterix = new Gaul("Astérix");
```

In this example `asterix` is declared as a `Character`, even though the real object stored in memory is a `Gaul`.

As the variable is declared as a `Character`, we can only call methods from the class `Character` and **not** specific method of a subclass such as `Gaul`.

For example :
`asterix.isAffraidOfTheSkyFallingOnHisHead();` is **not** allowed !

Late binding

The three classes have an `introduction()` method
`Java` chooses the appropriate method at **execution** time.
➪ dynamic binding.

At compilation time, `Java` checks whether the method is from the `Character` class or one of its superclass

➪ If an object `o` est declared of type `T`, we call only call methods from class `T` or its superclasses on object `o` !

But the executed method is the one of the class `o` was constructed from

```
1 public class Character {
2     ...
3   public String introduction(){
4     return "my name is "+name;
5   }
6 }
```

```
1 public class Gaul extends Character {
2   public Gaul(String name){ super(name);}
3   @Override
4   public String introduction(){
5     return super.introduction() + "I am a Gaul";
6   }
7 }
```

```
1 public class Roman extends Character {
2   public Roman(String name){ super(name);}
3   @Override
4   public String introduction(){
5     return super.introduction() + " romanus sum.";
6   }
7 }
```

```
1   public static void main(String[] args){
2     Random generator = new Random();
3     Character mystere;
4     if (generator.nextBoolean())
5       mystere = new Gaul("Astérix");
6     else
7       mystere = new Roman("Jules");
8     System.out.println(mystere.introduction());
9   } }
```

`final` keyword

- used for a class : this class cannot have a subclass
  - ⇨ security
    - example : class `String`
- for a method : this method cannot be overriden in a subclass
  ⇨ we force that the method of the superclass is the only possible behaviour
- for a variable : it will not be modified once the execution of the constructor is over

`Object` is the superclass of all objects

Modifier and Type	Method Description
`protected Object`	`clone()` Creates and returns a copy of this object.
`boolean`	`equals(Object obj)` Indicates whether some other object is "equal to" this one.
`protected void`	`finalize()` Called by the garbage collector on an object when garbage collection determines that there are no more references to the object.
`Class<?>`	`getClass()` Returns the runtime class of this Object.
`int`	`hashCode()` Returns a hash code value for the object.
`String`	`toString()` Returns a string reintroduction of the object.

Object is the superclass of all objects : consequence

if you do not redefine a method of Object, it is the implementation of the method in the Object class that is executed.

- toString() : The toString method for class Object returns a string consisting of the name of the class of which the object is an instance, the at-sign character '@', and the unsigned hexadecimal representation of the hash code of the object. In other words, this method returns a string equal to the value of:
  getClass().getName() + '@' +
  Integer.toHexString(hashCode())
- clone() : this method creates a new instance of the class of this object and initializes all its fields with exactly the contents of the corresponding fields of this object, as if by assignment; the contents of the fields are not themselves cloned. Thus, this method performs a "shallow copy" of this object, not a "deep copy" operation.

`Object` is the superclass of all objects : **consequence**

`equals()` The equals method for class Object implements the most discriminating possible equivalence relation on objects; that is, for any non-null reference values x and y, this method returns true if and only if x and y refer to the same object (x == y has the value true).

⇨ it is your job to write the appropriate code for equality ! How do you consider two instances of a class are equal.

warning : `boolean equals(Object obj)`
Note that the argument `obj` is of type `Object`.

If you want to redefine correctly the method `equals`, you must use this signature.

- you can first check if `obj` has the right type
- if so, the cast is safe and you can check whether the properties of `obj` match the ones of the current object.

Let's apply

Do exercise 1.

Abstract methods and abstract classes

Context : If we give some thoughts, the `Character` will never be instantiated as we will always use a subclass (e.g. `Roman`, `Gaul`, `Animals`, etc).

For some methods, we will always use the method of the subclass : there is no need to have an implementation!
But having the declaration may be **very** useful!

Declaring without implementing the method will force the implementation in a subclass (maybe not the direct subclass)

Abstract methods and abstract classes

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But having the declaration may be **very** useful!

Declaring without implementing the method will force the implementation in a subclass (maybe not the direct subclass)

Solution : We use the keyword `abstract`

- An **abstract** method
  - never has a body
  - must be implemented in a subclass
- an abstract class
  - has at least an abstact method
  - can not be instantiated !

Example

```
1  public abstract class Character {
2
3     String name;
4
5     public Character(String name);
6
7     // to be defined in subclasses
8     public abstract void introduction();
9
10    // shared by all subclasses
11    public void myNameIs(){
12       System.out.println(" my name is " + name);
13    }
14 }
```

N.B. even though `Character` is abstact, it can have a constructor

- this is useful if one wants to initialise some variables before using the object

Interfaces

In Java, a class can inherit from a single class
It woud be useful to inherit from multiple entities. In Java, **interfaces** are the way to go !
We can view an interface as a norm : to follow a norm

- a class must implement the method declared in the interface
- ⇨ we say a class implements an interface.
- a class may implement **multiple** interfaces.

```
1 [public] interface <interface name>
2     [extends <interface name 1> <interface name 2> ... ] {
3   // declaration of methods
4   // we can have static methods or variables }
4 }
```

Interfaces

- a method without body in an interface is implicitly abstract (i.e.no need to add the keywor `abstract`)
- Any variable is `static` and `final`.

```
1 public interface Fighter {
2   public void attack(Character p);
3   public void defend(Fighter c);
4 }
```

```
1  public class IndomitableGaul implements Fighter {
2      ...
3    public void attack(Character p){
4      magicPotion.drink();
5      while(p.isStanding())
6        punch(p);
7    }
8
9    public void defend(Fighter c){
10     dodge();
11     attack(c);
12   }
13 }
```