# Java Reflection

UA.DETI.PDS

José Luis Oliveira

## What is reflection?

- When you look in a mirror:
  - You can see your reflection
  - You can act on what you see, for example, straighten your tie
- In computer programming:
  - Reflection is infrastructure enabling a program can see and manipulate itself
  - It consists of metadata plus operations to manipulate the metadata
- Meta means self-referential
  - So metadata is data (information) about oneself

## What is reflection?

Reflection

- "Reflection is the ability of a program to manipulate as data something representing the state of the program during its own execution." [Demers and Malenfant]

Java Tutorials

- "Reflection is commonly used by programs which require the ability to examine or modify the runtime behavior of applications running in the Java virtual machine."

- "… advanced feature … a powerful technique … can enable applications to perform operations which would otherwise be impossible."

## Java looking at Java

- Reflection permite que um programa se examine a si mesmo, e.g.:
  - Determinar a classe de um objecto
  - Descobrir a informação associada a determinada classe:
    - access modifiers, superclass, fields, constructors, and methods
  - Obter informação relativa ao conteúdo de uma interface.
  - Criar e manipular vectores de objectos
- Sem saber o nome (classes, métodos,...) podemos:
  - Criar uma instância de uma classe
  - ler/modificar variáveis
  - Invocar métodos

# Utilização de Java Reflection

- Microkernel architectures
- Database applications
- Serialization
- Scripting applications
- Runtime Debugging/Inspection Tools
- …

# Acesso a metadados

- Java armazena metadados de **classes**
  - for a class: `java.lang.`**`Class`**
  - for a constructor: `java.lang.reflect.Constructor`
  - for a field: `java.lang.reflect.Field`
  - for a method: `java.lang.reflect.Method`

- Podemos aceder à Class de um objeto de duas formas:

```
Class<?> cl1 = Class.forName("java.util.Properties");
ou
Object obj = ... // e.g. new StringBuffer("Teste");
Class<?> cl2 = obj.getClass();
```

- As classes do package Reflection são inter-dependentes
  - Exemplos a seguir…

## Metadata de tipos primitivos e vectores

- Java associa uma instância de Class a cada **tipo primitivo**:

```
Class<?> c1 = int.class;
Class<?> c2 = boolean.class;
Class<?> c3 = void.class;
```

- Podemos usar Class.forName() para aceder à classe de um vector

```
Class<?> c4 = byte.class;              // byte
Class<?> c5 = Class.forName("[B");   // byte[]
Class<?> c6 = Class.forName("[[B"); // byte[][]
```

- Encoding scheme utilizado por Class.forName()

  B → byte; C → char; D → double; F → float; I → int; J → long; Lclass-name → class-name[]; S → short; Z → boolean

  Use as many "["s as there are dimensions in the array

# Reflection API - Class

```
public final class Class<T>
extends Object
implements Serializable, GenericDeclaration,
   Type, AnnotatedElement
```

```
      static Class<?> forName(String className);
      T newInstance();
      Field[] getFields();
      Method[] getMethods();
      boolean isInstance(Object obj);
      String getName();

      getInterfaces(), getSuperclass(),
      getModifiers(), getField(), getMethod(),...
```

```
void printClassName(Object obj) {
    System.out.println("The class of " + obj +
                      " is " + obj.getClass().getName());
}
```

UNIVERSIDADE DE AVEIRO

# Reflection API - Field

```
public final class Field
extends AccessibleObject
implements Member

   Object get(Object obj);
   void   set(Object obj, Object val);

   getType(), getDeclaringClass(),

   setDouble(…), setInt(…), .....
```

```
Field[] flds = someObject.getClass().getFields();
for (Field f: flds)
        System.out.println(f.getName());
```

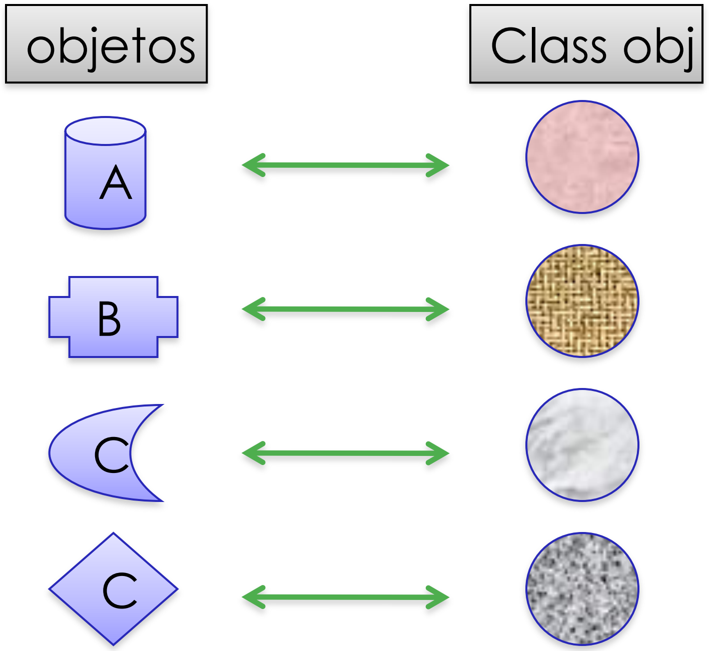
## Reflection API - Method

```
public final class Method
extends AccessibleObject
implements GenericDeclaration, Member

   Object invoke(Object obj, Object... args);

   Class<?> getReturnType();

   Class<?>[] getParameterTypes(),


   getExceptionTypes(), getDeclaringClass(),..
```

```
Method methods[] = someClass.getMethods();
for (Method m: methods)
        System.out.println(m);
```

# A Classe Class

- Para cada objeto carregado pela JVM, existe um objeto do tipo Class associado.
  - Os tipos primitivos também são representados por objetos Class.
- As instâncias do tipo Class armazenam informações sobre a classe:
  - Nome da classe
  - Herança
  - Interfaces Implementadas
  - Métodos
  - Atributos
- Permite invocar métodos e referenciar atributos



# Métodos de java.lang.Class - 1

- public static Class<?> forName(String className)
  - returns a Class object that represents the class with the given name
- public String getName()
  - returns the full name of the Class object, such as “java.lang.String”.
- public int getModifiers()
  - returns an integer that describes the class modifier: public, final or abstract
- public T newInstance()
  - creates an instance of this class at runtime

# Exemplo - newInstance

```java
public class ReflectionNew {
   public static void main(String[] args) throws Exception {
      Class<?> sc = Class.forName("aula5_1.Circulo");

      System.out.println("Name = " + sc.getName());
      System.out.println("SimpleName = " + sc.getSimpleName());

      Class<?>[] paramTypes = { Double.TYPE, Double.TYPE, Double.TYPE };
      Constructor<?> cons = sc.getConstructor(paramTypes);
      Object ar[] = { 2, 4, 10 };
      Object theObject = cons.newInstance(ar);
      System.out.println("New object: " + theObject);

      Constructor<?> cs = sc.getConstructor(new Class<?>[]{Double.TYPE});
      System.out.println("New object: " + cs.newInstance(new Object[]{20}));
   }
}
```

```
Name = aula5_1.Circulo
SimpleName = Circulo
New object: Circulo de Centro (2.0,4.0) e de raio 10.0
New object: Circulo de Centro (0.0,0.0) e de raio 20.0
```

# Exemplo - Modifiers

```java
public class SampleModifier {
    public static void main(String[] args) {
        printModifiers(new String());
        printModifiers(new SampleModifier());
    }
    public static void printModifiers(Object o) {
        Class<?> c = o.getClass(); // returns the Class object of o
        System.out.print("***** Class " + c.getName()+" : ");
                int m = c.getModifiers(); // return the class modifiers
        if (Modifier.isPublic(m)) // checks if is public
                System.out.print("public ");
        if (Modifier.isAbstract(m)) // checks if it is abstract
                System.out.print("abstract ");
        if (Modifier.isFinal(m)) // checks if it is final
                System.out.print("final ");
        System.out.println();
    }
}
```

```
***** Class java.lang.String : public final

***** Class reflection.SampleModifier : public
```

# Métodos de java.lang.Class - 2

- public Class[] getClasses()
  - returns an array of all inner classes of this class
- public Constructor getConstructor(Class[] params)
  - returns all public constructors of this class whose formal parameter types match those specified by params
- public Constructor[] getConstructors()
  - returns all public constructors of this class

# Exemplo - Construtores

```java
public class Reflection2 {
   public static void main(String[] args) throws InstantiationException,
                                   IllegalAccessException {
        String s="Mar";

        Class<?> sc = s.getClass();
        System.out.println("******** Construtores ***********");
        Constructor<?> contrs[] = sc.getConstructors();
        for (Constructor<?> c: contrs)
                System.out.println(c);
   }
}
```

```
******** Construtores **********
public java.lang.String()
public java.lang.String(java.lang.String)
public java.lang.String(char[])
public java.lang.String(char[],int,int)
public java.lang.String(int[],int,int)
public java.lang.String(byte[],int,int,int)
public java.lang.String(byte[],int)
...
```

# Métodos de java.lang.Class - 3

- public Field getField(String name)
  - returns an object of the class Field that corresponds to the instance variable of the class that is called name

- public Field[] getFields()
  - returns all accessible public instance variables of the class

- public Field[] getDeclaredFields()
  - returns all declared fields (instance variables) of the class

## Exemplo - Fields

```java
public class Reflection2 {
   public static void main(String[] args) throws InstantiationException,
                                IllegalAccessException {
        String s="Mar";
        Class<?> sc = s.getClass();
        System.out.println("******** Fields **********");
        Field fields[] = sc.getFields();
        for (Field f: fields)
                System.out.println(f);
   }
```

```
******** Fields **********
public static final java.util.Comparator java.lang.String.CASE_INSENSITIVE_ORDER
```

# Exemplo - Fields

```java
public static void main(String[] args) throws Exception {
   Class<?> sc = Class.forName("aula5_1.Circulo");
   System.out.println("\n******** Fields *****************\n");
   Field fields[] = sc.getFields();
   for (Field f: fields)
        System.out.println(f);
   System.out.println("\n******** Declared Fields *************\n");
   Field dfields[] = sc.getDeclaredFields();
   for (Field f: dfields)
        System.out.println(f);
   System.out.println("\n******** raio Field  ******************\n");
   Field field = sc.getField("raio");  // deve usar-se getDeclaredField
   System.out.println(field);
}
```

```
******** Fields *****************

******** Declared Fields *************
private double aula5_1.Circulo.raio
******** raio Field  ******************
    Exception in thread "main" java.lang.NoSuchFieldException:
    aula5_1.Circulo.raio
    at java.lang.Class.getField(Class.java:1520)
    at reflection.Reflection2.main(Reflection2.java:39)
```

## Ler atributos

```
class SampleGet {
   public static void main(String[] args) {
      Rectangle r = new Rectangle(100, 325);
      printHeight(r);
   }
   static void printHeight(Object r) {
      Field heightField; // declares a field
      Integer heightValue;
      Class<?> c = r.getClass(); // get the Class object
      try {
         heightField = c.getField("height"); // get the field object
         heightValue = (Integer) heightField.get(r); // get the value
         System.out.println("Height: " + heightValue.toString());
      } catch (Exception e) {
         e.printStackTrace();
      }
   }
}
```

```
Height: 325
```

## Modificar atributos

```
class SampleSet {
   public static void main(String[] args) {
      Rectangle r = new Rectangle(100, 20);
      System.out.println("original: " + r.toString());
      modifyWidth(r, 300);
      System.out.println("modified: " + r.toString());
   }
   public static void modifyWidth(Object r, Integer widthParam ) {
      Field widthField; // declare a field
      Integer widthValue;
      Class<?> c = r.getClass(); // get the Class object
      try {
          widthField = c.getField("width"); //get the field object
          widthField.set(r, widthParam); //set the field to widthParam =300
      } catch (Exception e ) {
          // . . .
      }
   }
}
```

```
original: java.awt.Rectangle[x=0,y=0,width=100,height=20]
modified: java.awt.Rectangle[x=0,y=0,width=300,height=20]
```

## Métodos de java.lang.Class - 4

- public Method getMethod(String name, Class[] params)
  - returns an object Method that corresponds to the method called name with a set of parameters params
- public Method[] getMethods()
  - returns all accessible public methods of the class
- public Method[] getDeclaredMethods()
  - returns all declared methods of the class.
- public Package getPackage()
  - returns the package that contains the class
- public Class getSuperClass()
  - returns the superclass of the class

# Exemplo - Métodos

```java
public class Reflection2 {
    public static void main(String[] args) throws InstantiationException,
                                               IllegalAccessException {
        String s="Mar";
        Class<?> sc = s.getClass();
        System.out.println("******** Métodos  ***************\n");
        Method methods[] = sc.getMethods();
        for (Method m: methods)
                System.out.println(m);
    }
}
```

```
********  Métodos    ****************

public boolean java.lang.String.equals(java.lang.Object)
public java.lang.String java.lang.String.toString()
public int java.lang.String.hashCode()

…..
public final native void java.lang.Object.notify()
public final native void java.lang.Object.notifyAll()
```

## Manipulação de vectores

```
public static void main(final String[] args) {
   try {
      String[] z = new String[] { "Jim", "John", "Joe" };
      final Class<?> type = z.getClass();
      if (!type.isArray()) {
         throw new IllegalArgumentException();
      } else {
         System.out.println("Name = "+ type.getName() +
              "\nType = "+type.getComponentType());
      }
   } catch (final Exception ex) {
      ex.printStackTrace();
   }
}
```

```
Name = [Ljava.lang.String;
Type = class java.lang.String
```

UNIVERSIDADE DE AVEIRO

## Manipulação de vectores

```
public class ArrayNew {
    public static void main(String[] args) throws ClassNotFoundException {
        System.out.println(createNativeArray("int", 12).getClass());
        System.out.println(createNativeArray("boolean", 10, 10).getClass());
        System.out.println(createNativeArray("double", 5, 5, 5).getClass());
    }
    public static Object createNativeArray(String typeName, int... dim)
    throws ClassNotFoundException {
        Class<?> clazz = null;
        if ("int".equals(typeName)) {
            clazz = Integer.TYPE;
        } else if ("boolean".equals(typeName)) {
            clazz = Boolean.TYPE;
        } else if ("double".equals(typeName)) {
            clazz = Double.class;
            // All other native types: short, long, float ......
        } else {
            throw new ClassNotFoundException(typeName);
        }
        return Array.newInstance(clazz, dim);
    }
}
```

```
class [I
class [[Z
class [[[Ljava.lang.Double;
```

## Utilização de Plugins

```
public interface IPlugin {
    public void metodo();
}
```

IPlugin.java

```
public class Plugin1 implements IPlugin {
    public void metodo() {
          System.out.println("Plugin1: metodo invocado");
    }
}
```

Plugin1.java

```
public class Plugin2 implements IPlugin {
    public void metodo() {
          System.out.println("Plugin2: metodo invocado");
    }
}
```

Plugin2.java

```
public class Plugin3 implements IPlugin {
    public void metodo() {
          System.out.println("Plugin3: metodo invocado");
    }
}
```

Plugin3.java

## Utilização de Plugins

Plugin.java

```java
package reflection;
import java.io.File;

abstract class PluginManager {
    public static IPlugin load(String name) throws Exception {
      Class<?> c = Class.forName(name);
      return (IPlugin) c.newInstance();
    }
}

public class Plugin {
    public static void main(String[] args) throws Exception {
      File proxyList = new File("reflection/plugins");
      for (String f: proxyList.list()) {
         try {
            IPlugin obj =
                 PluginManager.load("reflection."+f.substring(0,f.lastIndexOf('.')));
            obj.metodo();
         }
         catch (Exception e) {
            e.printStackTrace();
         }
      }
    }
}
```

```
Plugin1: metodo invocado
Plugin2: metodo invocado
Plugin3: metodo invocado
```

## Padrões: Fábrica sem reflection

```
class Viveiro {
   public static Arvore factory(String pedido) {
     if (pedido.equalsIgnoreCase("Figueira"))
      { return new Figueira(); }
     if (pedido.equalsIgnoreCase("Pessegueiro"))
      { return new Pessegueiro(); }
     if (pedido.equalsIgnoreCase("Nespereira"))
      { return new Nespereira(); }
     else
      throw new IllegalArgumentException(”Árvore não
     existente!");
}
```

# Padrões: Fábrica com reflection

```
class Viveiro {
public static Arvore factory(String pedido){
   Arvore arv = null;
   try {
       arv = (Arvore)
Class.forName("patterns."+pedido).newInstance();
   }
   catch(Exception e) {
       throw new IllegalArgumentException(“Arvore nao
existente!");
   }
   return arv;
}
}
```