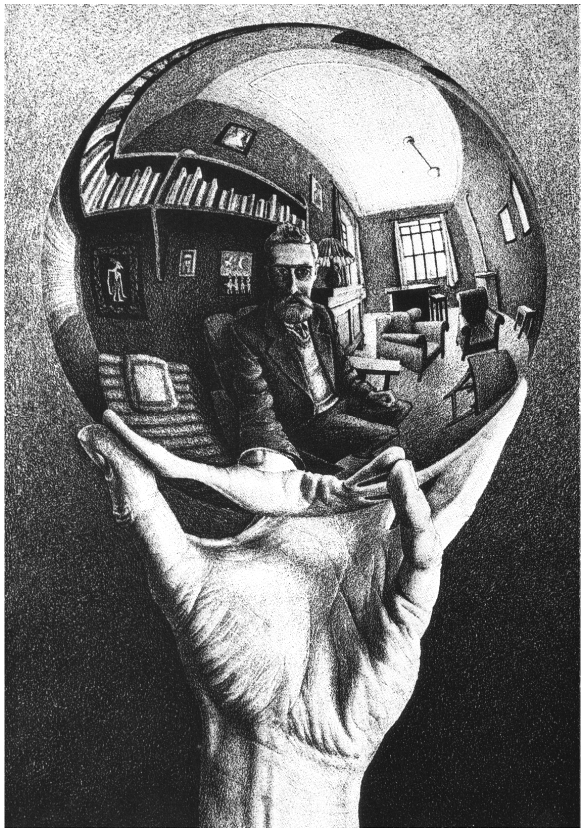
Reflexivita
(Java Reflection Model)



- možnosť čítať, vykonávať, resp. modifikovať program, ktorý sa práve vykonáva
- je to vlastnosť, ktorá sa vyskytuje v interpretovaných jazykoch, napr. exec a eval v Pythone, nie v kompilolvaných (v skutočných) jazykoch ako C, C++)

Prečo ??

- JAVA je niekde medzi, lebo sa kompiluje do byte kódu, ktorý je ale interpretovaný

JAVA poskytuje
- Introspection: triedy `Class` a `Field` pre čítanie vlastného programu
- Reflexívne volanie: triedy `Method, Constructor`

Nadtrieda a Podtrieda

(ilustračný príklad)

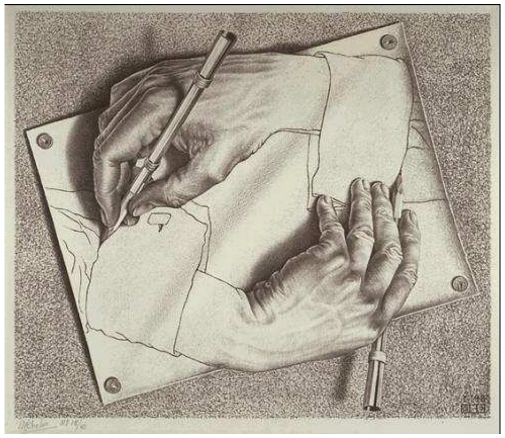
```
public class Nadtrieda implements Runnable {
           public int variabla;
           public int[] pole = {1,2,3};
           public String[] poleStr = {"janko", "marienka" };
           public Nadtrieda()  {   }
           public Nadtrieda(int a) {   }

           public void Too(double r) {   }
           public void run() {  … kvôli Runnable ... }
}
```

```
public class Podtrieda extends Nadtrieda {
      public Podtrieda(String s) { }

      public class Vnorena { }
      public interface Prazdny {}
}
```

Trieda Class<T>



Russellov paradox (antinómia)

$$S = \{X | X \notin X\}$$

Každý objekt pozná metódu getClass():

```
        Class nt = new Nadtrieda().getClass();
```

Class:

- **hodnotou sú reflexívne obrazy tried nášho programu,**
- **umožní nám čítať a spúšťať časti nášho programu,**
- **o.i. pozná metódu String getName()**

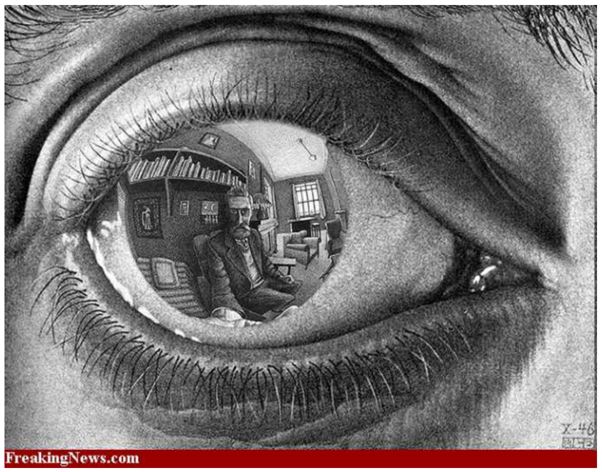
```
        System.out.println(nt.getName());        // Nadtrieda

Class nt1 = Nadtrieda.class;                      // Trieda.class
        System.out.println(nt1.getName());       // Nadtrieda
```

- **meta-trieda:**

```
        Class klas = Class.class;
        Class klas1 = nt.getClass();
```

Trieda Class<T>



```
try {
        Class pt = Class.forName("Podtrieda");      // forName("…")
        System.out.println(pt.getName());           // Podtrieda
        Class nt2 = pt.getSuperclass();             // getSuperClass()
        System.out.println(nt2.getName());                  // Nadtrieda
        for(Class cl:pt.getClasses())               // getClasses()
                                                    // public classes & interf
          System.out.print(cl.getName());           // Podtrieda$Prazdny
                                                    // Podtrieda$Vnorena

} catch (ClassNotFoundException e) {
        e.printStackTrace();
}
```

Metódy Class<T>

- T cast(Object obj) pretypuje obj do triedy T
- static Class<?> forName(String name)
  vráti Class objekt zodpovedajúci triede s menom name
- Class[] getClasses() public triedy a interface implementované touto triedou

- Constructor[] getConstructors()
  všetky konštruktory triedy
- Constructor<T> getConstructor(Class... parameterTypes)
  konštruktor triedy pre parameterTypes
- Field[] getFields() všetky položky (premenné) triedy
- Field getField(String name) položka s menom name

- Method[] getMethods() všetky metódy triedy
- Method getMethod(String name, Class... parameterTypes)

- int getModifiers() atribúty triedy (public, abstract, …)
- String getName() meno triedy
- boolean isInstance(Object obj) je inštanciou triedy ?
- boolean isArray() je pole ?
- boolean isPrimitive() je primitívny typ ? (int, double, boolean…)

Class<T>

Trieda Class umožňuje prístup k atribútom triedy

```
int m = nt.getModifiers();
if (Modifier.isPublic(m))
        System.out.println("public");
```

podobne:
isPrivate(), isProtected(), isStatic, isFinal(), isAbstract(), isFinal(), isSynchronized(),

Trieda Class umožňuje prístup k interface triedy

```
Class[] theInterfaces = nt.getInterfaces();
for (int i = 0; i < theInterfaces.length; i++) {
        String interfaceName = theInterfaces[i].getName();
        System.out.println(interfaceName);
}
```

java.lang.Runnable

Premenné, konštruktory

```
Field[] publicFields = nt.getFields();
for (int i = 0; i < publicFields.length; i++) {
      String fieldName = publicFields[i].getName();
      Class typeClass = publicFields[i].getType();
      String fieldType = typeClass.getName();
      System.out.println("Name: " + fieldName + ", Type: " + fieldType);
 }
```

```
Name: variabla,  Type: int
Name: pole,      Type: [I
Name: poleStr,
Type: [Ljava.lang.String;
```

```
Class intArray = Class.forName("[I");
Class stringArray =
Class.forName("[Ljava.lang.String;");
```

```
Constructor[] theConstructors = nt.getConstructors();
 for (int i = 0; i < theConstructors.length; i++) {
   System.out.print("( ");
   Class[] parameterTypes = theConstructors[i].getParameterTypes();
   for (int k = 0; k < parameterTypes.length; k ++) {
        String parameterString = parameterTypes[k].getName();
        System.out.print(parameterString + " ");
    }
   System.out.println(")");
 }
```

```
( )
( int )
```

Premenné, konštruktory

```
for (Field f : nt.getFields() ) {
      String fieldName = f.getName();
      Class typeClass = f.getType();
      String fieldType = typeClass.getName();
      System.out.println("Name: " + fieldName + ", Type: " + fieldType);
}
```

```
Name: variabla,  Type: int
Name: pole,      Type: [I
Name: poleStr,
Type: [Ljava.lang.String;
```

```
Class intArray = Class.forName("[I");
Class stringArray =
Class.forName("[Ljava.lang.String;");
```

```
for (Constructor c : nt.getConstructors()) {
  System.out.print("( ");

  for (Class parameterType : c.getParameterTypes() ) {
       String parameterString = parameterType.getName();
       System.out.print(parameterString + " ");
   }
  System.out.println(")");
}
```

```
( )
( int )
```

Metódy

```
Method[] theMethods = nt.getMethods();
 for (int i = 0; i < theMethods.length; i++) {
        String methodString = theMethods[i].getName();
        System.out.println("Name: " + methodString);

        String returnString =  theMethods[i].getReturnType().getName();
        System.out.println("   Return Type: " + returnString);

        Class[] parameterTypes = theMethods[i].getParameterTypes();
        System.out.print("   Parameter Types:");
        for (int k = 0; k < parameterTypes.length; k ++) {
                String parameterString = parameterTypes[k].getName();
                System.out.print(" " + parameterString);
        }
        System.out.println();
 }
```

```
Name: Too
   Return Type: void
   Parameter Types: double
Name: run
   Return Type: void
   Parameter Types:
... Metódy Object-u
```

Je inštanciou

cl.isInstance(obj) je true, ak obj je inštanciou triedy reprezentovanie v cl.

Class nt = new Nadtrieda().getClass();

nt.isInstance(new Nadtrieda()) == true

class1.isAssignableFrom(class2) je true ak trieda reprezentovaná class1 je nadtriedou/nadinterface triedy reprezentovanej class2, teda do premennej typu reprezentovaneho class1 môžeme priradiť objekt typu reprezentovaného class2.

Ergo:

cl.isAssignableFrom(obj.getClass()) == cl.isInstance(obj)

Prístup k premennej

```
if (Integer.class.isAssignableFrom(Integer.class)) {   // true
    Nadtrieda o = new Nadtrieda();
    Field f = o.getClass().getField("boxedInt");
    f.setAccessible(true);
    f.set(o, new Integer(88));                    // o.boxedInt = 88;
    System.out.println(f.get(o));                 // o.boxedInt;
}
if (int.class.isAssignableFrom(int.class)) {   // true
    Nadtrieda o = new Nadtrieda();
    Field f = o.getClass().getField("variabla");
    f.setAccessible(true);
    f.set(o, new Integer(66));                    // o.variabla = 66;
    alebo
    f.setInt(o, 77);                              // o.variabla = 77;
    System.out.println(f.get(o));                 // o.variabla;
    System.out.println(f.getInt(o));              // o.variabla;
}
```

```
public class Nadtrieda implements Runnable {
    public int variabla;
    public Integer boxedInt;
    public Nadtrieda()   {            }
    public Nadtrieda(int a) {   }
    public void Too(double r) {   }
    public void run() {  … kvôli Runnable ... }
}
```

Volanie konštruktora

```
try {
    Nadtrieda nt2 = (Nadtrieda)(nt.getConstructor(int.class).newInstance(3));
                                                          // new Nadtrieda(3)
} catch (InstantiationException e) {
    e.printStackTrace();
} catch (IllegalAccessException e) {
    e.printStackTrace();
} catch (IllegalArgumentException e) {
    e.printStackTrace();
} catch (InvocationTargetException e) {
    e.printStackTrace();
} catch (NoSuchMethodException e) {
    e.printStackTrace();
} catch (SecurityException e) {
    e.printStackTrace();
}
```

```
public class Nadtrieda implements Runnable {
    public int variabla;
    public Integer boxedInt;
    public Nadtrieda()  {           }
    public Nadtrieda(int a) {   }
    public void Too(double r) {   }
    public void run() {  … kvôli Runnable ... }
}
```

Volanie konštruktora

V prípade konštruktora bez argumentov:

```
Class classDefinition = Class.forName(className);
Object object = classDefinition.newInstance();
```

```
Class rectangleDefinition = Class.forName("java.awt.Rectangle");

// pole typov argumentov konštruktora, t.j. Class[]
Class[] intArgsClass = new Class[] {int.class, int.class};

// daj mi konštruktor s daným typom argumentov
Constructor intArgsConstructor =
      rectangleDefinition.getConstructor(intArgsClass);

// pole hodnôt argumentov konštruktora, t.j. Object[]
Object[] intArgs = new Object[] {new Integer(12), new Integer(34)};
Rectangle  rectangle =
      (Rectangle) createObject(intArgsConstructor, intArgs);
```

Volanie metódy

```
try {

    (o.getClass()).getMethod("run").invoke(o);            // o.run();

    Method met = (o.getClass()).getMethod("Too",new Class[]{double.class});
    met.invoke(o,new Object[]{new Double(Math.PI)});// o.Too(Math.PI);

    (o.getClass()).getMethod("Too",double.class).invoke(o,Math.PI);
                                                          //  o.Too(Math.PI);

} catch (SecurityException | NoSuchFieldException | IllegalAccessException |
    IllegalArgumentException | InvocationTargetException |
    NoSuchMethodException e) {
    e.printStackTrace();
}
```

```
public class Nadtrieda implements Runnable {
    public int variabla;
    public Integer boxedInt;
    public Nadtrieda()   {           }
    public Nadtrieda(int a) {    }
    public void Too(double r)  {    }
    public void run() {  … kvôli Runnable ... }
}
```

Volanie metódy

```
public static String append(String firstWord, String secondWord) {
    String result = null;

    try {

        // pole typov argumentov metódy, t.j. Class[]
        Class[] parameterTypes = new Class[] {String.class};
        Class c = String.class;

        // daj mi metódu s daným typom argumentov
        Method concatMethod = c.getMethod("concat", parameterTypes);

        // pole hodnôt argumentov metódy, t.j. Object[]
        Object[] arguments = new Object[] {secondWord};
        result = (String) concatMethod.invoke(firstWord, arguments);

    } catch (Exception e) {
     . . . .
    }
    return result;
  }
```

Polia

(java.lang.reflect.Array)

```
int[] pole = (int[]) Array.newInstance(int.class, 5);      // int[] pole = new int[5];

for(int i = 0; i < Array.getLength(pole); i++) {
    Array.set(pole, i, i);                                  // pole[i] = i;
    Array.setInt(pole, i, i);                               // pole[i] = i;
}
for(int i = 0; i < Array.getLength(pole); i++ ) {
    System.out.println("pole["+i+"] = " + Array.get(pole, i));      // pole[i] = i;
    System.out.println("pole["+i+"] = " + Array.getInt(pole, i));   // pole[i] = i;
}
```

```
pole[0] = 0
pole[1] = 1
pole[2] = 2
pole[3] = 3
pole[4] = 4
```

Polia

(**java.lang.reflect.Array**)

```
Nadtrieda o = new Nadtrieda();
Field f = o.getClass().getField("pole");
Object oo = f.get(o);
 if (oo.getClass().isArray()) {
   System.out.println(Array.getLength(oo));
   for(int i=0; i<Array.getLength(oo); i++)
        System.out.println(Array.getInt(oo,i));
 }

 Object ooo = o.getClass().getField("poleStr").get(o);
 if (ooo.getClass().isArray()) {
   System.out.println(Array.getLength(ooo));
   for(int i=0; i<Array.getLength(ooo); i++)
        System.out.println(Array.get(ooo,i));
 }
```

```
3
1
2
3
```

```
2
janko
marienka
```

Efektivita

```
Nadtrieda nt=new Nadtrieda();

start=System.nanoTime();
for(int i=0;i<MAX;i++)
     nt.Too(Math.PI);
end=System.nanoTime();

Method m=nt.getClass().getMethod("Too",double.class);
startReflex=System.nanoTime();
for(int i=0;i<MAX;i++)
     m.invoke(nt, Math.PI);
endReflex=System.nanoTime();
```

Regular method call: 0.05669715
reflexive method call:1.47600883
Slowdown factor:26x

regular new (constructor): 0.56120261
reflexive new (constructor):2.3079218200000002
Slowdown factor:4x