

Reflection and Annotations



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#java-advanced

1. **Reflection** - What? Why? Where?

2. Reflection **API**

- **Reflecting** Classes
- Reflecting **Constructors**
- Reflecting **Fields**
- Reflecting **Methods**
- **Access** Modifiers
- Reflecting **Annotations**

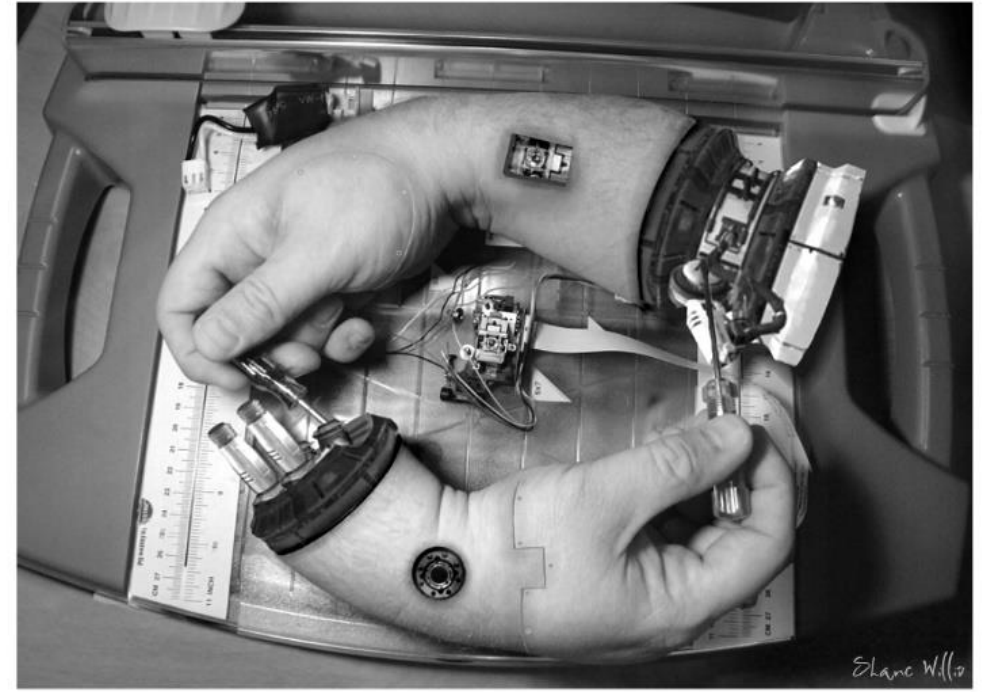




Reflection

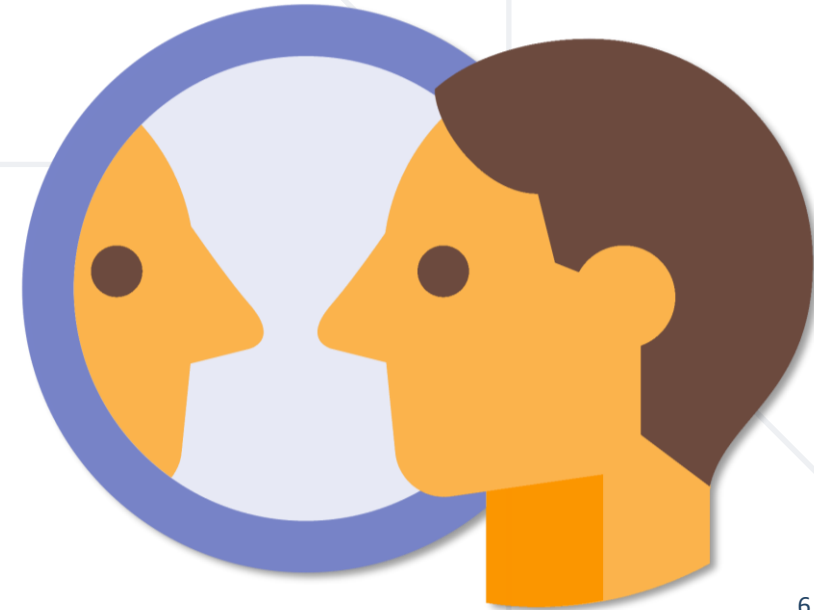
What is Metaprogramming?

- **Programming technique** in which computer programs have the ability to treat **programs as their data**
- The program can be designed to:
 - **Read**
 - **Generate**
 - **Analyze**
 - **Transform**
- **Modify itself** while **running**



What is Reflection?

- The ability of a programming language to be its **own metalanguage**
- Programs can examine information about **themselves**



When to Use Reflection?

- Whenever we want:
 - Code to become more **extendible**
 - To **reduce code** length significantly
 - Easier **maintenance**
 - Easier **testing**



When Not to Use Reflection?

- If it is **possible** to **perform** an operation **without** using **reflection**, then it is preferable to **avoid using it**
- Cons from using Reflection
 - **Performance** overhead
 - **Security** restrictions
 - Exposure of **internal logic**





Reflection API

- Obtain it' **java.lang.Class** object

- If you **know** the **name**

```
Class myObjectClass = MyObject.class;
```

- If you **don't** know the name at **compile time**

```
Class myClass = Class.forName(className);
```

You need fully qualified
class name as String

- Obtain **Class** name
 - Fully qualified class name

```
String className = aClass.getName();
```

- Class name without the package name

```
String simpleClassName = aClass.getSimpleName();
```

- Obtain **parent class**

```
Class className = aClass.getSuperclass();
```

- Obtain **interfaces**

```
Class[] interfaces = aClass.getInterfaces();
```

- **Interfaces** are also **represented** by **Class** objects in Java Reflection
- Only the interfaces **specifically declared** implemented by a given class are **returned**

- Import ReflectionClass to your **src** folder in your project
- Using **reflection** you should print:
 - This class type
 - Super class type
 - All Interfaces
 - Instantiate object using reflection and print it
- Don't change anything in class

Solution: Reflection

```
Class<Reflection> aClass = Reflection.class;
System.out.println(aClass);
System.out.println(aClass.getSuperclass());
Class[] interfaces = aClass.getInterfaces();
for (Class anInterface : interfaces)
    System.out.println(anInterface);
//Reflection ref = aClass.newInstance();//Deprecated since Java 9
Reflection ref = aClass.getDeclaredConstructor().newInstance();
System.out.println(ref);
```

Create new object



Constructors, Fields and Methods

- Obtain **only public constructors**

```
Constructor[] ctors = aClass.getConstructors();
```

- Obtain **all constructors**

```
Constructor[] ctors =  
    aClass.getDeclaredConstructors();
```

- Get constructor by **parameters**

```
Constructor ctor =  
    aClass.getConstructor(String.class);
```


- Get **parameter types**

```
Class[] parameterTypes =  
    ctor.getParameterTypes();
```

- **Instantiating objects** using constructor

```
Constructor constructor =  
MyObject.class.getConstructor(String.class);  
MyObject myObject = (MyObject)constructor  
    .newInstance("arg1");
```

- Obtain **public** fields

```
Field field = aClass.getField("somefield");  
Field[] fields = aClass.getFields();
```

- Obtain **all** fields

```
Field[] fields = aClass.getDeclaredFields();
```

- Get field **name and type**

```
String fieldName = field.getName();  
Object fieldType = field.getType();
```

- Setting value for a field

```
Class aClass = MyObject.class;  
Field field = aClass.getDeclaredField("someField");  
MyObject objectInstance = new MyObject();  
field.setAccessible(true);  
Object value = field.get(objectInstance);  
field.set(objectInstance, value);
```

Change the behavior of the
AccessibleObject

The **objectInstance** parameter passed to the **get** and **set** method should be an instance of the class that owns the field

- Obtain **public** methods

```
Method[] methods = aClass.getMethods();  
Method method =  
    aClass.getMethod("doSomething", String.class);
```

- Get methods without **parameters**

```
Method method =  
    aClass.getMethod("doSomething", null);
```

- Obtain method **parameters** and **return type**

```
Class[] paramTypes = method.getParameterTypes();  
Class returnType = method.getReturnType();
```

- Get methods with **parameters**

```
Method method = MyObject.class  
    .getMethod("doSomething", String.class);  
Object returnValue = method.invoke(null, "arg1");
```

null is for static methods

Problem: Getters and Setters

- Using **reflection** get all methods and print:
- **Sort** getters and setters **alphabetically**
- **Getters:**
 - A getter method have its name start with "get", take 0 parameters, and returns a value
- **Setters:**
 - A setter method have its name start with "set", and takes 1 parameter

```
Method[] methods = Reflection.class.getDeclaredMethods();
Method[] getters = Arrays.stream(methods)
    .filter(m -> m.getName().startsWith("get") &&
        m.getParameterCount() == 0)
    .sorted(Comparator.comparing(Method::getName))
    .toArray(Method[]::new);
Arrays.stream(getters).forEach(m ->
    System.out.printf("%s will return class %s\n",
        m.getName(), m.getReturnType().getName()));
```



Access Modifiers

- Obtain the **class modifiers** like this

```
int modifiers = aClass.getModifiers();
```

- Each modifier is a **flag bit** that is either set or cleared

getModifiers() can be called on constructors, fields, methods

- You can check the modifiers

```
Modifier.isPrivate(modifiers);  
Modifier.isProtected(modifiers);  
Modifier.isPublic(modifiers);  
Modifier.isStatic(modifiers);
```

- Creating arrays via Java Reflection

```
int[] intArray = (int[]) Array.newInstance(int.class, 3);
```

- Obtain parameter annotations

```
Array.set(intArray, 0, 123);
```

```
Array.set(intArray, 1, 456);
```

- Obtain fields and methods annotations

```
Class stringArrayComponentType =  
    stringArrayClass.getComponentType();
```

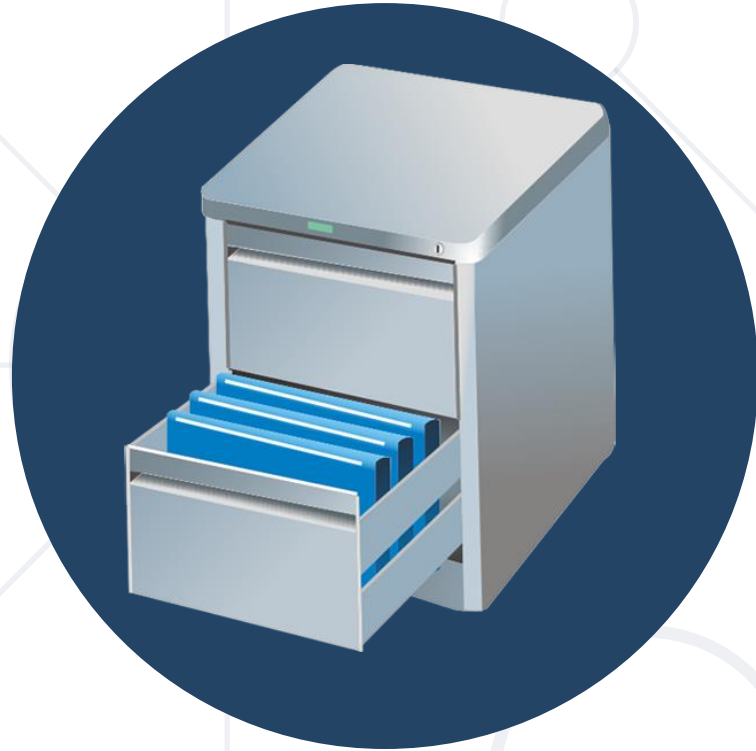
Problem: High Quality Mistakes

- You perfectly know how to write High Quality Code
- Check **Reflection class** and print all mistakes in **access modifiers** which you can find
- Get all fields, getters and setters and sort each category by name
- First print mistakes in **fields**
- Then print mistakes in **getters**
- Then print mistakes in **setters**

Check your solution here: <https://alpha.judge.softuni.org/contests/1604>

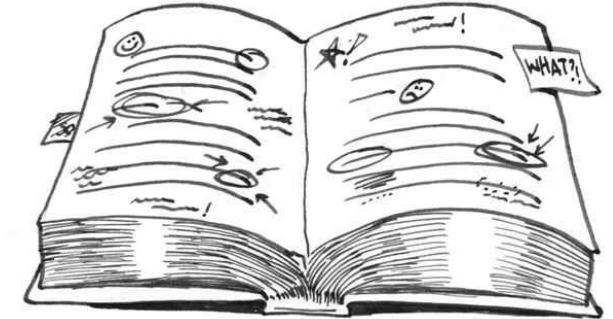
Solution: High Quality Mistakes

```
Field[] fields = Reflection.class.getDeclaredFields();  
Arrays.stream(fields)  
    .filter(f -> !Modifier.isPrivate(f.getModifiers()))  
    .sorted((Comparator.comparing(Field::getName)))  
    .forEach(f -> System.out  
        .printf("%s must be private!\n", f.getName()));  
// TODO: Do the same for getters and setters
```



Annotations

- **Data holding** class
- **Describe** parts of your code
- Applied to: **Classes, Fields, Methods**, etc.



@Deprecated

```
public void deprecatedMethod() {  
    System.out.println("Deprecated!");  
}
```

- To generate **compiler messages** or **errors**

```
@SuppressWarnings("unchecked")  
@Deprecated
```

- As tools
 - **Code generation** tools
 - **Documentation generation** tools
 - **Testing** Frameworks
- At runtime – **ORM, Serialization**, etc.

- **@Override** – generates **compile time error** if the method does not override a method in a parent class

@Override

```
public String toString() {  
    return "new toString() method";  
}
```


- **@SuppressWarnings** – turns off **compiler warnings**

Annotation
with value

```
@SuppressWarnings(value = "unchecked")  
public <T> void warning(int size) {  
    T[] unchecked = (T[]) new Object[size];  
}
```

Generates compiler warning

- **@Deprecated** – generates a **compiler warning** if the element is used

@Deprecated

Generates compiler warning

```
public void deprecatedMethod() {  
    System.out.println("Deprecated!");  
}
```

- **@interface** – the keyword for annotations

```
public @interface MyAnnotation {  
    String myValue() default "default";  
}
```

Annotation element

```
@MyAnnotation(myValue = "value")  
public void annotatedMethod() {  
    System.out.println("I am annotated");  
}
```

Skip name if you have only one value named "value"

- Allowed types for annotation elements:
 - Primitive types (**int**, **long**, **boolean**, etc.)
 - **String**
 - **Class**
 - **Enum**
 - **Annotation**
 - **Arrays** of any of the above

- **Meta annotations** annotate annotations
- **@Target** – specifies where the annotation is applicable

```
@Target(ElementType.FIELD)
```

```
public @interface FieldAnnotation {  
}
```

Used to annotate
fields only

- Available element types – **CONSTRUCTOR**, **FIELD**, **LOCAL_VARIABLE**, **METHOD**, **PACKAGE**, **PARAMETER**, **TYPE**

- **@Retention** – specifies where the annotation is available


```
@Retention(RetentionPolicy.RUNTIME)  
public @interface RuntimeAnnotation {  
    // ...  
}
```

You can get info
at runtime

- Available retention policies – **SOURCE**, **CLASS**, **RUNTIME**

Problem: Create Annotation

- Create annotation **Subject** with a String[] **element** "categories"
 - Should be **available at runtime**
 - Can be **placed only on types**



```
@Subject(categories = {"Test", "Annotations"})  
public class TestClass {  
  
}
```

Solution: Create Annotation

```
@Target(ElementType.TYPE)
@Retention(RetentionPolicy.RUNTIME)
public @interface Subject {
    String[] categories();
}
```


- Obtain class annotations

```
Annotation[] annotations = aClass.getAnnotations();  
Annotation annotation = aClass.getAnnotation(MyAnno.class);
```

- Obtain parameter annotations

```
Annotation[][] parameterAnnotations =  
    method.getParameterAnnotations();
```

- Obtain fields and methods annotations

```
Annotation[] fieldAnots = field.getDeclaredAnnotations();  
Annotation[] methodAnot = method.getDeclaredAnnotations();
```

- Some annotations can be accessed **at runtime**

```
@Author(name = "Gosho")
public class AuthoredClass {
    public static void main(String[] args) {
        Class c1 = AuthoredClass.class;
        Author author = (Author) c1.getAnnotation(Author.class);
        System.out.println(author.name());
    }
}
```

- Some annotations can be accessed **at runtime**

```
Class c1 = AuthoredClass.class;
Annotation[] annotations = c1.getAnnotations();
for (Annotation annotation : annotations) {
    if (annotation.annotationType().equals(Author.class)) {
        Author author = (Author) annotation;
        System.out.println(author.name());
    }
}
```

Problem: Coding Tracker

- Create annotation **Author** with a String **element** "name"
 - Should be **available at runtime**
 - Should be **placed only on methods**
- Create a class **Tracker** with a method:
 - **public static void printMethodsByAuthor()**

```
@Author(name = "George")
public static void main(String[] args) {
    Tracker.printMethodsByAuthor(Tracker.class);
}
```

```
@Author(name = "Peter")
public static void printMethodsByAuthor(Class<?> cl) {...}
```



```
George: main()
Peter: printMethodsByAuthor()
```

```
public class Tracker {  
    public static void printMethodsByAuthor(Class<?> c1) {  
        Map<String, List<String>> methodsByAuthor = new HashMap<>();  
        Method[] methods = c1.getDeclaredMethods();  
  
        for (Method method : methods) {  
            Author annotation = method.getAnnotation(Author.class);  
  
            // Continues on next slide  
        }  
    }  
}
```

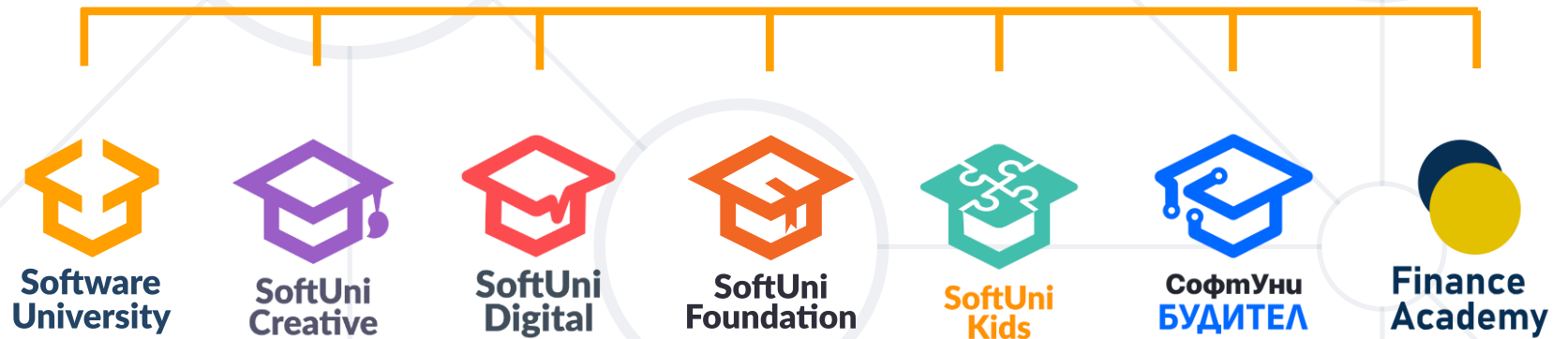
Solution: Coding Tracker

```
if (annotation != null) {  
    methodsByAuthor  
        .putIfAbsent(annotation.name(), new ArrayList<>());  
    methodsByAuthor  
        .get(annotation.name()).add(method.getName() + "()");  
}  
}  
  
// TODO: print the results  
}  
}
```

- What is **Reflection**
- Reflection **API**
 - Reflecting Classes, Constructors, Fields, Methods
 - Access Modifiers
- **Annotations**
 - Used to describe our code
 - Provide the possibility to work with non-existing classes
 - Can be accessed through **reflection**



Questions?



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