

# Reflection



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- ▶ Reflection is also a key strategy for **metaprogramming**.
- ▶ Reflection is powerful, but should not be used indiscriminately. If it is possible to perform an operation without using reflection, then it is preferable to avoid using it.

# Advantages of Reflection

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- ▶ **Debuggers and Test Tools:** Debuggers need to be able to examine private members on classes. Test harnesses can make use of reflection to systematically call a discoverable set APIs defined on a class, to insure a high level of code coverage in a test suite.

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- ▶ **Security Restrictions:** Reflection requires runtime permission, which may not be present when running under a security manager.
- ▶ **Exposure of Internals:** Since reflection allows code to perform operations that would be illegal in non-reflective code, such as accessing private fields and methods, the use of reflection can result in unexpected side-effects, which may render code dysfunctional and may destroy portability. Reflective code breaks abstractions and therefore may change behavior with upgrades of the platform.

# Reflection Classes

- ▶ The main reflection package is `java.lang.reflect`. The `Type` interface represents all types that can exist in a Java program. All concrete types are represented by an instance of the class `java.lang.Class`. The classes `Constructor`, `Method` and `Field` represent constructors, methods and fields. There is also a `java.lang.Package` class for package meta-data.

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- ▶ The `Class` class is the starting point for reflection. It also provides a tool to manipulate classes, primarily to create objects of types whose names are specified by strings, and for loading classes using specialized techniques such as across the network.

# The Class class

- ▶ The `getClass()` method of `Object` returns a reference to the `Class` object that produced the object instance.

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String myString = "Moo!";  
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- ▶ We can produce a new instance of a class using the reference to the `Class`.

```
Class strClass = String.class;  
try { String s2 = (String)strClass.newInstance(); }  
catch (InstantiationException e) {...} //for an abstract class  
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- ▶ We can also look for a `Class` reference by name.

```
try { Class sneakersClass = Class.forName("Sneakers");  
} catch (ClassNotFoundException e) {...}
```

“Bewilderment increases in the presence of the mirrors.”

— Tarjei Vesaas, The Boat in the Evening

## Example 1: SelfReflect

```
public class SelfReflect {  
    public static void main(String [] args) {  
        Class<Color> type = Color.class;  
  
        Method [] methods = type.getMethods();  
        for (int i=0; i< methods.length; i++)  
            System.out.println( methods[i]);  
  
        Field [] fields = type.getFields();  
        for (int i=0; i< fields.length; i++)  
            System.out.println( fields[i]);  
    }  
}
```

## Example 2: ReflectOnAnother

```
public class ReflectOnAnother {
    public static void main(String [] args) {
        if (args.length == 0) {
            System.err.println("Usage: java ReflectOnAnother <class name>");
            System.exit(1);
        }
        Class<?> type = null;
        try {
            type = Class.forName(args[0]);
        } catch (ClassNotFoundException e) {
            System.err.println(e);
        }
        Method [] methods = type.getMethods();
        for (Method m: methods)
            if (Modifier.isPublic(m.getModifiers()))
                System.out.println("  " + m);

        Field [] fields = type.getFields();
        for (Field f: fields)
            if (Modifier.isPublic(f.getModifiers()))
                System.out.println("  " + f);
    }
}
```

# Reflection versus Method Overriding

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- ▶ Would reflection determine the right version of a overridden method that will be used?
- ▶ Suppose we have the following classes:

`Animal.java`

`Cat.java`

`Calico.java`

`Animal` has a `makeNoise()` method.

`Cat` extends `Animal` and overrides the `makeNoise()` method. `Calico` extends `Cat`, but does not override any method.

- ▶ What would `ReflectOnAnother` program do with each of the above classes?

## Example 3: TraceAncestry

```
public class TraceAncestry {  
    public static void main(String[] args) {  
        if (args.length == 0) {  
            System.err.println("Usage: java TraceAncestry <class name>");  
            System.exit(1);  
        }  
        Class<?> type = null;  
        try {  
            type = Class.forName(args[0]);  
        } catch (ClassNotFoundException e) {  
            System.err.println(e);  
        }  
        System.out.println("class " + type.getSimpleName());  
        Class<?> superclass = type;  
        do {  
            superclass = superclass.getSuperclass();  
            if (superclass == null) break;  
            System.out.println("extends " + superclass.getCanonicalName());  
        } while (!superclass.getCanonicalName().equals("java.lang.Object"));  
    }  
}
```



# Reflection on reflection

*With reflection one could write an interpreter in Java that could access the full Java API, create objects, invoke methods, modify variables, and do all the other things that a Java program can do at compile-time, while it is running!*

## Example 4: Dynamic Invocation of static method

```
// invoke a static method without any arguments
public class invoke {
    public static void main (String [] args) {
        try {
            Class c = Class.forName(args[0]);
            Method m = c.getMethod(args[1]);
            Object ret = m.invoke(null);
            System.out.println("Invoked static method: "+ args[1] +
                               " of class: " + args[0] + " with no args\n Results: "+ret);
        } catch (ClassNotFoundException e1) {
            // cannot find the class
        } catch (NoSuchMethodException e2) {
            // that method doesn't exist
        } catch (IllegalAccessException e3) {
            // don't have permission to invoke that method
        } catch (InvocationTargetException e4) {
            // an exception occurred while invoking that method
            System.out.println("Method threw an: "+e4.getTargetException());
        }
    }
}
```

## Example 5: Dynamic Invocation of a non-static method

```
public class InvokeDynamic
{
    public static void main (String [] args) throws Throwable
    {
        String str = "java.lang.reflect";
        Throwable failure = null;
        try {
            Method indexM = String.class.getMethod("indexOf",
                String.class, int.class);
            System.out.println(indexM.invoke(str, ".", 8));
        } catch (NoSuchMethodException e) {
            failure = e;
        } catch (IllegalAccessException e) {
            failure = e;
        } catch (InvocationTargetException e) {
            failure = e;
        }
        if (failure != null)
            throw failure;
    }
}
```

# Recommended Exercises

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- ▶ Modify your Interpret program further to let users invoke constructors of an arbitrary class, displaying any exceptions. If a construction is successful, let users invoke methods on the returned object.

From Chapter 16 of the *The Java Programming Language, 4th Ed.*

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