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Dynamic Class Loading

Philippe Collet

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Agenda

- Principle of a ClassLoader
- Writing a *custom* ClassLoader
- Architecture to load plugins
- How to reload plugins

Definition of a ClassLoader

- The JVM contains a ClassLoader
- ClassLoaders allows for loading classes from the filesystem, but also from multiple locations (DB, network, etc.)
- Role: convert a class name in an array of bytes representing a class

```
Class c = loadClass(String className, boolean
                    resolveIt);
```

On ClassLoaders

- All JVMs have a « system » ClassLoader
- This default CL implements a method loadClass() that searches in the CLASSPATH for .class, .jar or .zip files
- One can create new CL by deriving from class ClassLoader and by redefining loadClass() and the methods it uses (findClassFromClass, ResolveClass…)

Time of class loading

- It depends!
- In general when:
  - Foo f = new Foo();
  - Static references such as:
    - System.out,
    - Foo.class,
    - forName("Foo");

Writing your own ClassLoader ?

- Interest?
  - Load classes from the web
  - Load classes from a DB
  - Load classes « differently »
- Don’t work with applets!
- From JDK1.2 on, an URLClassLoader is provided

Steps for writing a ClassLoader

- Sub-class ClassLoader and implement the method loadClass
  1. Check the class name, determining whether it has already been loaded
  2. Check whether this is a system class
  3. Attempt to load it
  4. Define the class for the VM
  5. Resolve it by loading its dependencies
  6. Return the class
- From JDK1.3 on: sub-class SecureClassLoader to respect recommendations relative to the new Java security policy

Example of *custom* ClassLoader

```
public synchronized Class loadClass(String className, boolean resolveIt) throws
    ClassNotFoundException {
    Class result;
    Byte []classData;

    // 1) search in the cache whether the class has already been loaded
    result = (Class) classes.get(className);
    if(result != null)
        return result;

    // 2) find out whether this is a system class. Very important because one
    // could change the security manager!
    try {
        result = super.findSystemClass(className);
        return result;
    } catch(ClassNotFoundException e) {
        System.out.println("Pas une classe système !");
    }

    // 3) load the class from OUR REPOSITORY (e.g., web ou DB)
    classData = getImplFromDataBase(className);
    if(classData == null) { throw new ClassNotFOundException() }
```

Example of *custom* ClassLoader (cont'd)

```
...
    // 4) Define the class (by parsing). Actually the method will check the
    // validity of Bytecode and make other verifications
    // The result is stored in a specific data structures within the JVM
    result = defineClass(classData, 0, classData.length);

    // 5) Resolve class, i.e. apply the same process to superclasses and dependent
    // classes.
    if(resolveIt)
        resolveClass(result);

    // Before returning the final result, put the class into the cachehe
    classes.put(className, result);

    // 6) return result
    Return result;

}
```

Example of a code that reads a class

```
…
byte [] result;
try {
  FIS fis = new FIS("store\\ " + className + ".impl");
   result = new byte[fis.available()];
   fis.read(result);
} catch(Exception e) {
   return null;
}
```

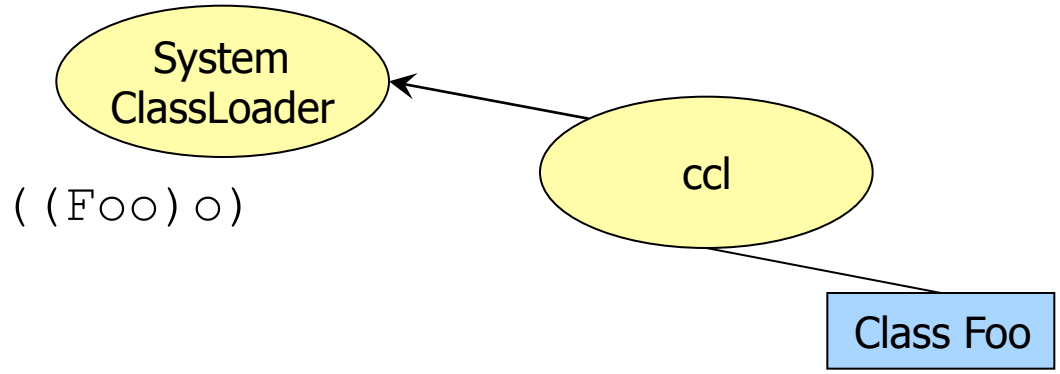
Example of a code that reads a class from the web

```
…
URL url = new URL(urlClassName);
URLConnection uc = new URLConnection(url);
int length = uc.getContentLength();
IS is = uc.getInputStream();
byte []data = new byte[length];
is.read(data);
is.close();
return data;
...
```

Using a *custom* ClassLoader

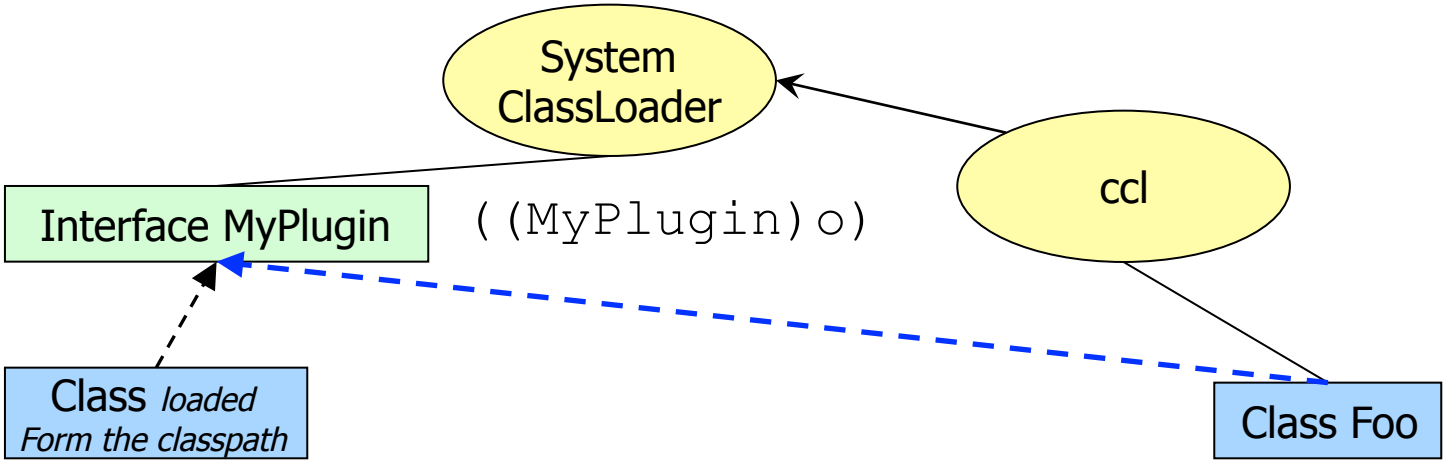
```
Class c = ccl.loadClass("Foo");
Object o = c.newInstance();
((Foo) o).f();
```

- Don't work, as only the new cl knows Foo!



The need for an interface

- Only the new CL knows Foo. If one wants to cast the object, a common Interface must be created and be known by the default (system) CL.
- For example, Plugin is known by the default CL (SystemClassLoader).



Writing some plugins

- Simple rule: read plugins from a directory
- Define a usage interface on plugins
- Each plugin must implement this interface
- Each class will be a plugin
- Then, one simply needs:
  1. Read the content of a directory
  2. For each class name in the plugins directory
     - `Class c = Class.forName(className);`
     - `Plugin p = (PluginDraw) c.newInstance();`
     - `p.draw(); // methode present in Plugin.java`

Plugins again...

- Difficulties when
  - No default constructor
  - Plugins are in a .jar or in a DB
    - Look for ressources? Images, sounds, etc.
- Class.forName(className) is the equivalent of loadClass(className) that was studied for the custom ClassLoader
- Plugins are everywhere!!!
  - Photoshop, IE, Firefox, Chrome…

Plugins: ideal model

- Ideal model =
  - A directory for plugins
  - (.class files) and jar files in the directory
  - The application « discovers » files and « absorbs » plugins that are inside

- Each jar contains
  - A class that implements the interface Plugin.java
  - Other classes it needs (ie depends on)
  - Images, icons, sounds, docs, etc. that the plugin needs as well

Plugins: ideal model

- But there is a problem when two many classes are present in the plugin
  - How to test that a class is *really* a plugin without trying to load it, which is taking time
  - Class.forName() is long…
  - Class.newInstance() too…
- Eclipse, for example, contains more than 800 plugins that are loaded at startup
- Some plugins extend other plugins and thus depend on them
- The loading order is important for consistency…

How to manage plugins?

- The solution often uses a descriptor, a « map » of plugins
  - Eclipse follows a specific format to describe plugins, their dependencies (with some XML files)
- Problem #1 with plugins is the loading time
- But advantages are numerous…

Developing an application extensible by plugins

- A SDK to develop plugins must be provided
  - So that developers can compile and test plugins without the code of the main application
- What must be provided?
  - Necessary classes and interfaces
  - One or more exemple plugins, with a compiling aid (ant file for example)
  - Documentation, tutorials, etc.

Changing plugins without restarting the main application/server

- Principle of Servlet/Jsp servers:
  - Classes and jars are added
  - The server is not restarted

- Example
  - Java application servers (large majority of front-end/ business tier on current linux based servers)
  - 24/7 exploitation (never stopped nor rebooted)
  - Plugins are dropped down and discovered on the fly…

Hot (Re-)Loading

- Principle : change the classloader for each plugin loading…
  - Each classloader manages its own « cache » of classes
  - If the classloader is reinstantiated, one can load/reload plugins at runtime
  - An URLClassLoader will be used for this implementation
  - One only needs to
    - re-scan every X (5 for example) seconds the plugin directory
    - re-scan on-demand (a menu for example)