Hello Java World! A Tutorial for Interfacing to Java Archives inside R Packages.

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2014-09-03

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1 Introduction

This document provides detailed guidance on interfacing R to Java archives inside an R package. The package we will create in this tutorial, the helloJavaWorld package, will invoke a very simple Java class, the HelloJavaWorld class, from inside an R function of the package, the helloJavaWorld function. The objective is to help other people to make available Java algorithms to the R world, be it to compare results, or for their own sake.

2 Structure of the package

We create a folder, helloJavaWorld, which will be the root folder of our helloJavaWorld package. For detailed information on R packages and their structure, the reader is referred to the Writing R Extensions manual. This section only highlights elements that are relevant to our situation. Before detailing the contents of the individual files and folders, we provide a summary overview in Figure 1.

DESCRIPTION Inside this folder, we create DESCRIPTION file, which can be considered to be the 'identity card' of the package. The most important changes when comparing to regular DESCRIPTION files are that

```
helloJavaWorld
    `- inst
        `- doc
            `- helloJavaWorld.Rnw
                                         (this document)
        `- java
            `- hellojavaworld.jar
    `- java
        `- HelloJavaWorld.java
    `- man
        `- helloJavaWorld.Rd
    `- R
        `- helloJavaWorld.R
        `- onLoad.R
    `- DESCRIPTION
    `- NAMESPACE
```



- there must be a package dependency on the **rJava** package (Depends field) as well as
- a system dependency on Java (SystemRequirements field).

inst/java We create the folder inst/java to host our JAR file. This JAR file contains a single HelloJavaWorld.class file, generated from the following HelloJavaWorld.java file.

```
public class HelloJavaWorld {
   public String sayHello() {
     String result = new String("Hello Java World!");
     return result;
   }
   public static void main(String[] args) {
   }
}
```

As one can see, this is not the typical example of a Hello World application. The string Hello Java World! is namely not printed to the console, but returned by the sayHello method. The reason to deviate from this tradition is that in practice the interfacing to Java classes will nearly always result in return values being returned to R by the methods of the classes in the JAR file(s). java/ The Writing R Extensions Manual recommends to make Java source files available in a top-level java/ directory inside the package. This will ensure source files are not installed, but makes these files available as required when the package is published under an open source license.

R/ Two functions are contained in the R/ subfolder of the package. The first function is the function that will assure that the Java code is made available. The second function will be the R wrapper to execute the Java HelloWorld class.

Namespaces are recommended in R packages, so we will only detail how to include the first function when the package has a namespace. We include a file onLoad.R with the following content :

```
.onLoad <- function(libname, pkgname) {
  .jpackage(pkgname, lib.loc = libname)
}</pre>
```

The .onLoad function is a hook function that will be run immediately after loading the package. The function .jpackage that is called inside the .onLoad function takes care to initialize the JVM and to add the java/ folder of the package to the class path. If users make use of custom R library paths, they can rely on the libname argument. Note that when building the package the inst level is 'taken out', so that in the built package the java/ subfolder will be directly in the root folder.

The second function we included in the R/ folder is responsible for making the Java class available to the user and is a simple wrapper:

```
helloJavaWorld <- function(){
    hjw <- .jnew("HelloJavaWorld")  # create instance of HelloJavaWorld class
    out <- .jcall(hjw, "S", "sayHello")  # invoke sayHello method
    return(out)
}</pre>
```

The .j* functions such as .jnew and .jcall are part of the rJava package and documented in their respective documentation files¹. For convenience, we provide some minimal explanation here as well.

The .jnew function creates a new instance of a Java object. The first argument (here "HelloJavaWorld") indicates the class of the object to be created. If other arguments are needed to construct the Java object, these can be passed as R arguments to the .jnew function as well. In this very simple case, however, no supplementary arguments are required to create a "HelloJavaWorld" object. By assigning the result of .jnew to a variable,

¹The rJava package can be obtained from CRAN; more information on the package can be found at the package home page http://www.rforge.net/rJava/

Abbreviation	Туре
"V"	void
"I"	integer
"D"	double (numeric)
"J"	long
"F"	float
"Z"	boolean
"C"	char (integer)
"S"	String
"B"	byte (raw)
"L <class>"</class>	Java object of class <class> (e.g.</class>
	"Ljava/lang/Object")
"[<type>"</type>	Array of objects of type <type> (e.g. "[D" for</type>
	an array of doubles)

Table 1: Overview of the abbreviations that can be used as a shortcut to indicate the return type of a Java method in the .jcall function of the rJava package.

we obtain a reference to the object (here hjw) that we can use to further work with the object, or to call Java methods on the newly created object.

The .jcall function allows to call a method ("sayHello") on a Java object. The first argument will be a reference to the object, which we stored in the hjw variable in the previous statement. The second argument contains a character indicating the return type of the method we call. In this example, the return type will be a String, which has been mapped to the "S" character. An overview of all return types is offered in Table 1.

It is important to note that the **out** object is no longer a reference to the resulting Java object, but has been evaluated directly to a string, i.e. an R character vector of length one. The explanation is that the .jcall method has an argument evalString that is set to TRUE by default. If we would have wanted to obtain the reference to the Java object to further work with it, we would have explicitly set evalString to FALSE as in

outRef <- .jcall(hjw, "S", "sayHello", evalString = FALSE)</pre>

To explicitly obtain a string from a Java object reference, we could then use the function.jstrVal, as in

.jstrVal(outRef)

The string returned would, of course, be exactly the same

"Hello Java World!"

NAMESPACE In the R functions of our package, some functions were used from the **rJava** package. As this package has a namespace as well, it is necessary to import the relevant functions or the whole package into the package namespace to ensure that the **rJava** package will be loaded as well. Importing the whole package can be done using the **import** directive.

If, on the other hand, we want to make our functions (or other objects) available to the package user, we need to export these objects using the **export** directive. We will of course not export the .onLoad function as it is not meant to be used by the package user. The only function exported, therefore, is the helloJavaWorld function. The NAMESPACE file will thus have the following contents²:

```
import("rJava")
export("helloJavaWorld")
```

3 Use of the package

Once the package is checked, built and installed, we can load the package with

```
library(helloJavaWorld)
```

and demonstrate it by simply calling

```
> helloJavaWorld()
[1] "Hello Java World!"
```

4 Acknowledgements

We would like to thank Simon Urbanek for his continuous efforts on the **rJava** package, without which it would not have been possible to say Hello from Java to R. The following persons provided feedback and suggestions that helped improve the document: Duncan Murdoch, Prof. Ripley, Simon Urbanek, Hadley Wickham.

 $^{^{2}}$ For more information on package namespaces, please consult Section 1.6 from the Writing R Extensions manual.