

(BSF4)ooRexx and Java Web Servers

Flatscher, Rony G.

Published in:

The Proceedings of the Rexx Symposium for Developers and Users

Published: 01/01/2020

Document Version

Publisher's PDF, also known as Version of record

[Link to publication](#)

Citation for published version (APA):

Flatscher, R. G. (2020). (BSF4)ooRexx and Java Web Servers. In René Jansen, Chip Davis (Ed.), *The Proceedings of the Rexx Symposium for Developers and Users* (pp. 1 - 25).
<https://www.rexxla.org/events/2020/presentations/202011-ooRexxAndJavaWebServers-article.pdf>

ePub^{WU} Institutional Repository

Rony G. Flatscher

(BSF4)ooRexx and Java Web Servers

Book Section (Published)

Original Citation:

Flatscher, Rony G.

(2020)

(BSF4)ooRexx and Java Web Servers.

In: *Proceedings of the Rexx Symposium for Developers and Users.*

Rexx Language Association, Netherlands.

pp. 1-25. ISBN 1534-8954

This version is available at: <https://epub.wu.ac.at/8117/>

Available in ePub^{WU}: June 2021

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(BSF4) ooRexx and Java Web Servers

*Rony G. Flatscher (Rony.Flatscher@wu.ac.at), WU Vienna
"The 2020 International Rexx Symposium", Web-based Conference
September 29th – October 1st, 2020*

Abstract. BSF4ooRexx is a bi-directional Java bridge for the dynamic scripting language ooRexx which implements the Java scripting framework and can therefore be employed as a scripting language in many Java contexts. Java based web servers like Apache Tomcat implement the Java2EE/JakartaEE JSP (Java server pages) specifications which allow among other things to extend the JSP's functionality by providing tag libraries ("taglibs"). This article introduces such a taglib ("ScriptTagLibs") that allows any Java scripting language – in this article ooRexx [12] – to be employed for servlet programming and creating HTML content that gets returned as a result of a client's request and how to deploy it on Java based web servers in form of a war ("web application archive") file.

1 Introduction

Java web servers have been defined in the form of standardized services that constitute the package "J2EE" ("Java enterprise edition") which has been handed over to the Eclipse foundation by Oracle in the fall of 2017. Eclipse continues to maintain and develop the specifications under the new name "Jakarta EE" ("Jakarta enterprise edition") [1]¹. The implementation of the standardized Jakarta EE services by different companies and organisations should allow the creators of web applications .to deploy them using the "web application archive" ("war") format [2] unchanged on the different Java web servers.

The Apache Software Foundation (ASF, [3]) Tomcat Java web server project² [4] maintains a list of links to the Java/Jakarta specifications at [5].

There is a fundamentally important specification named "Java/Jakarta Servlet"

¹ The Wikipedia article refers to the Oracle trademark for "Java" which Oracle uses to force Eclipse and others to use another term than Java, in the case of web servers (web containers) Eclipse uses the term "Jakarta" instead. This trademark issue also forced the top-level package name to be changed from *javax.* to *jakarta.* instead by Eclipse. It is to be expected that for a few years this naming issue will cause confusion and difficulties during the transition period. In this article "Java/Jakarta" will indicate this transitional name change from "Java EE" to "Jakarta EE" in the context of web server software.

² Apache Tomcat will be used in the context of this article as a proof-of-concept Java based web server for creating web applications using Rexx. Tomcat versions 9 or earlier are using the original "javax." package name in its implementations of the standardized services for servlet, JSP and TagLib implementations, whereas starting with Tomcat version 10 the new package name "jakarta." gets used instead.

which defines how client requests supplying an URL get mapped on the web server to Java programs serving the request and how such Java programs need to be structured.

Another important standardized service in this context is called "Java/Jakarta Server Pages (JSP) and Expression Language (EL)" which allows mixing HTML/XML text with Java code that will create additional HTML/XML text to be returned to the requesting client. In addition this specification allows for creating and implementing so called "tag libraries" in Java to extend this functionality, a feature that gets exploited in the "*ScriptTagLibs*"³ developed by the author in this context in order to allow Java script languages to be deployable within JSP pages. As BSF4ooRexx implements a Java script engine for ooRexx [13], one can use ooRexx to implement the logic at the web server side.

This article will employ the open-source Apache Tomcat Java-based web server [4] and describes the directory layout of the installation (home) directory of the Tomcat 9 and 10 servers at the time of writing. The directory named "webapps" is used to deploy web applications, that themselves need to follow a specific subdirectory layout which will get briefly described.

Then a simple Java servlet will get demonstrated, which implements all logic in a single Java class, thereby introducing the important configuration file "*WEB-INF/web.xml*" for allowing the Tomcat server to determine which Java class needs to be loaded and executed depending on the web client request. This very Java servlet example will then be implemented in form of a "Java Server Page (JSP)" which in essence is an HTML/XML text file that contains the markup for the client's browser, interspersed with Java code snippets. This JSP file gets turned into a Java class that contains the interspersed Java code snippets together with Java output statements that create the markup found in the JSP file which then gets compiled on the fly. Whenever a JSP file's content gets changed, the Java based web server will reprocess the JSP file and recompile the resulting Java class and use that version from then on.

The article then introduces the "*ScriptTagLibs*" taglib library, developed for the purpose of allowing any Java based scripting language to be used in JSPs instead of

³ At the time of writing the "ScriptTagLibs" are offered as "javax.ScriptTagLibs.jar" and "jakarta.ScriptTagLibs.jar" depending on the namespace used in the hosting Java web server. Each jar file includes two tag libraries, one for running scripts using Apache BSF ("Bean Scripting Framework"), one for running scripts using the Java scripting framework in the package "javax.script" (a.k.a. "JSR-223").

Java, empowering anyone who knows e.g., Rexx to create Web server applications with JSPs that contain Rexx code instead of Java code!

2 The Apache Tomcat Java Based Web Server

The free and open-source Apache Tomcat Java based web server is one of the best maintained, very powerful, yet easy to install, to configure, to deploy and to use Java based web servers.

2.1 A Brief Overview of the Tomcat Directory Layout

The Apache Tomcat Java based servers have a simple, easy to use directory structure they create upon installation. At the time of this writing the Tomcat 9 and 10 Java based web servers create the following directories in their installation (home) directory⁴:

- `bin`: this directory includes all scripts and binaries (jar – Java archive files) needed to control the Tomcat server, including to start and stop it from the command line.
- `conf`: this directory contains all of the Tomcat global configurations, mostly in form of XML encoded text files. E.g., the file `server.xml` defines the server's characteristics including the TCP/IP port⁵ at which the server listens for client requests. Another important file is `tomcat-users.xml` which allows for defining Tomcat users with their passwords and roles, e.g., for accessing the Tomcat manager console.
- `lib`: this directory contains all *jar* (Java archives) files that should be made available globally.
- `logs`: this directory contains all log files that Tomcat creates at runtime. E.g., output to *stdout* (standard output file) or to *stderr* (standard error file) will be logged and stored in the respective text files in this directory.
- `temp`: this directory is Tomcat's temporary directory.
- `webapps`: this directory serves as the home directory for any web application

⁴ The Tomcat installation refers to its installation (home) directory with the shell variable named `CATALINA_HOME`.

⁵ In this article the Tomcat server is configured to listen to port `8080`. While developing and testing web applications at the server itself, the server name will be `"localhost"`, such that all the URLs in this article are always led in by `"localhost:8080/"`.

that gets deployed. Tomcat creates the three subdirectories

- docs: serves the Tomcat documentation.
- manager: supplies the Tomcat manager console.
- ROOT: serves as the default Apache Tomcat interface, with links to Tomcat documentation, Tomcat wiki, Tomcat mailing lists and the like.
- work: this directory gets usually used by Tomcat whenever a JSP file needs to be turned into a compiled Java class.

Anyone who wishes to add a new web application needs to create a subdirectory in the *webapps* directory. A web application subdirectory may contain the subdirectory *WEB-INF* with a configuration file named *web.xml* that tells the Tomcat server among other things how to map a specific client request to the appropriate web application service.⁶

A web application can be distributed in form of a *war* (web application archive) file which can be deployed on any Java based web server adhering to the Java based web server standards [5] by simply copying it to the *webapps* subdirectory.⁷ The Java based web server will deploy it by creating a subdirectory matching the base name of the *war* file and extracting all of its contents into it. Deleting the *war* file from the *webapps* directory will remove (undeploy) the web application subdirectory from the web server.

2.2 Serving a Client Request with a Java Servlet

In this section a web application will use a single Java program to create the HTML page that gets sent back to the client. The web application directory *rexsla_01_Servlet_Java* will contain the following files:

- *rexsla_01_Servlet_Java/index.html*: as this file is named *index.html* it will be returned to the client by the web server by default. Figure 4 shows the content, Figure 1 shows how it gets rendered in the client's browser.

⁶ A web application may omit the *WEB-INF* subdirectory in which case one of the following files should be available: *index.htm*, *index.html* or *index.jsp*.

⁷ To create a web application *war* file one merely needs to change into the web application subdirectory and create a zip archive of all files contained in it but use the file extension *war* instead of *zip*.

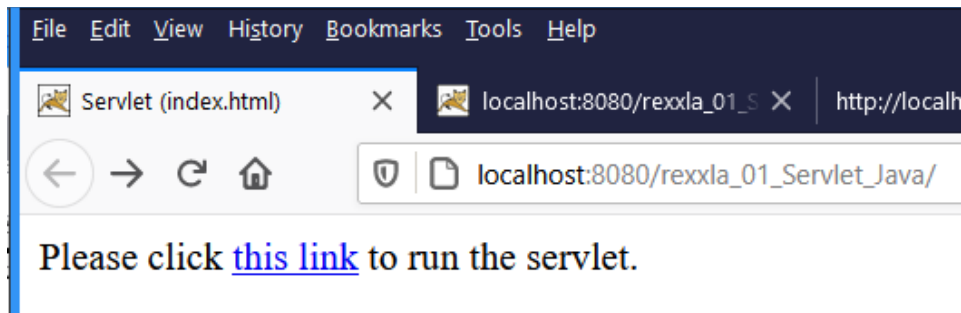


Figure 1: Result of client requesting the web application named "rexxla_01_Servlet_Java".



Figure 3: Response to client which was created by the Java servlet.

```

1 <h1>Hello, world (Java Servlet)</h1>
2
3 <p>This servlet was executed, because of the following URL:<ul>
  <li>URL <em>request.getRequestURL()</em>:
  <br><code>http://localhost:8080/rexxla_01_Servlet_Java
  /runServlet</code>
4 <li>its URI being <em>request.getRequestURI()</em>:
  <br><code>/rexxla_01_Servlet_Java/runServlet</code></ul></p>
5

```

Figure 2: The HTML text created by the Java servlet.

- rexxla_01_Servlet_Java/src/ServletJava.java: the source code of the Java class that creates the HTML text that the client receives from the server. Figure 5 depicts the Java code, Figure 2 displays the text produced by the

```

<html>
  <head>
    <title>Servlet (index.html)</title>
  </head>
  <body>
    Please click <a href="runServlet">this link</a> to run the servlet.
  </body>
</html>

```

Figure 4: Content of "rexsla_01_Servlet_Java/index.html".

Java servlet and Figure 3 shows how this text gets formatted in the client's browser.

- rexsla_01_Servlet_Java/WEB-INF/web.xml: this file gets used to configure this web application, its content is displayed in Figure 6 below. In the *servlet* element it defines a logical name "ServletJavaHelloWorld" for the servlet and the fully qualified name of the compiled Java class "org.rexsla.ServletJava" that should be executed. The *servlet-mapping* element maps the client request (in this case "/runServlet") to the logical name "ServletJavaHelloWorld" that will get executed and create the HTML text to be returned to the client.
- rexsla_01_Servlet_Java/WEB-INF/classes/org/rexsla/ServletJava.class: the compiled Java class that the server will run and which then creates the

```

package org.rexsla;    // define package name for this class
import java.io.*;
import javax.servlet.*;
import javax.servlet.http.*;
// Minimal Java servlet, implements the specific part for HTML body; HttpServlet
// will create, inject and complete HTML to return
public class ServletJava extends HttpServlet {
    public void doGet(HttpServletRequest request, HttpServletResponse response)
        throws ServletException, IOException {
        response.setContentType("text/html"); // set content type
        PrintWriter out = response.getWriter(); // get PrintWriter
        String crlf="\015\012"; // HTML must use CR-LF as newline
        out.println("<h1>Hello, world (Java Servlet)</h1>" + crlf);
        out.println("<p>This servlet was executed, because of the following URL:" +
            "<ul><li>URL <em>request.getRequestURL()</em>: <br><code>" +
            request.getRequestURL()+"</code>" + crlf + // URI
            "<li>its URI being <em>request.getRequestURI()</em>: <br><code>" +
            request.getRequestURI()+"</code></ul></p>"); // URL
    }
}

```

Figure 5: Content of "rexsla_01_Servlet_Java/src/ServletJava.java".


```

<?xml version="1.0" encoding="UTF-8"?>
<web-app xmlns="http://xmlns.jcp.org/xml/ns/javaee"
         xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
         xsi:schemaLocation="http://xmlns.jcp.org/xml/ns/javaee
http://xmlns.jcp.org/xml/ns/javaee/web-app_4_0.xsd"
         version="4.0"
         metadata-complete="true">
  <display-name>Minimal org.rexxla.ServletJava Demo</display-name>
  <description>
    Welcome to a minimal ServletJava demo
  </description>
  <!-- 'servlet'-element must precede the 'servlet-mapping'-element ! -->
  <servlet>
    <servlet-name>ServletJavaHelloWorld</servlet-name>
    <servlet-class>org.rexxla.ServletJava</servlet-class>
  </servlet>
  <!-- 'servlet-mapping'-element must follow the 'servlet'-element ! -->
  <servlet-mapping>
    <servlet-name>ServletJavaHelloWorld</servlet-name>
    <url-pattern>/runServlet</url-pattern>
  </servlet-mapping>
</web-app>

```

Figure 6: Content of "rexxla_01_Servlet_Java/WEB-INF/web.xml".

HTML text that the client receives from the server.

The URL gets created using the web server's name "*localhost*", explicitly denoting the port *8080*, the web application's name "*rexxla_01_Servlet_Java*" and the *url-pattern* */runServlet*" can be concatenated with each other to form the URL: "*localhost:8080/rexxla_01_Servlet_Java/runServlet*". The link to the very same Java servlet in the web application's index file "*index.html*" in Figure 4 can be simply denoted as "*runServlet*" which then will be resolved by concatenating it with a slash as a delimiter to the document's base URL "*localhost:8080/rexxla_01_Servlet_Java*".

2.3 Serving a Client Request with a Java Server Page (JSP)

In this section a web application will use a Java server page (JSP) to define the HTML page that gets sent back to the client. The very first time a new or changed JSP file gets requested, the server will create a Java class for it, compile it and run it, which will create the HTML text to be sent back to the requesting client. Successive requests for that same JSP file will cause the immediate execution of the compiled Java class. The web application directory *rexxla_02_JSP* will contain the following files:

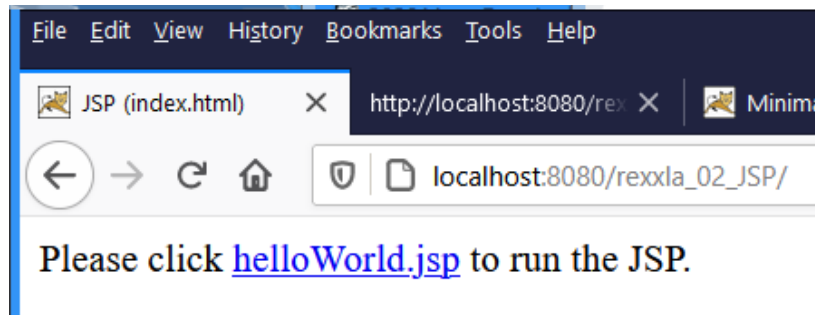


Figure 7: Result of client requesting the web application named "rexxla_02_JSP".

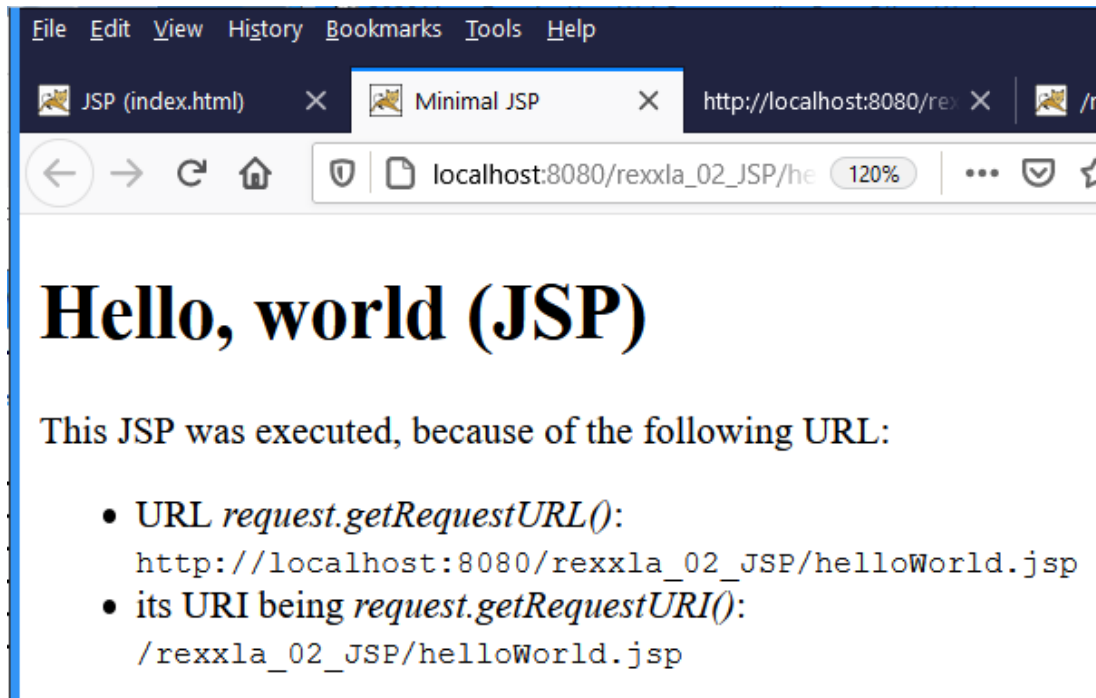


Figure 8: Response to client which was created by the JSP.

- rexxla_02_JSP/index.html: as this file is named *index.html* it will be returned to the client by the web server by default. Figure 10 shows the content, Figure 7 shows how it gets rendered in the client's browser.
- rexxla_02_JSP/helloWorld.jsp: this JSP file includes the same Java statements as the Java servlet in Figure 3 above interspersed with the HTML text. Figure 11 shows the content, Figure 8 shows the result of running this JSP in the client's browser.

The sections in Figure 11 with a yellow background highlight the JSP related text. As can be seen the character sequence "<%>" leads-in and "%>" ends JSP text. Any text outside of these JSP sections represents plain HTML text that will be sent to the client without any changes. The second JSP section contains the Java code that will create and insert additional HTML text at

```

1
2 <!DOCTYPE html>
3 <html>
4 <head>
5 <meta http-equiv="Content-Type" content="text/html; charset=ISO-8859-1">
6 <title>Minimal JSP</title>
7 </head>
8 <body>
9 <h1>Hello, world (JSP)</h1>
10
11 <p>This JSP was executed, because of the following URL:<ul><li>URL
    <em>request.getRequestURL()</em>: <br><code>http://localhost:8080
    /rexxla_02_JSP/helloWorld.jsp</code>
12 <li>its URI being <em>request.getRequestURI()</em>:
    <br><code>/rexxla_02_JSP/helloWorld.jsp</code></ul></p>
13
14 </body>
15 </html>

```

Figure 9: The HTML text created by the JSP.

```

<html>
  <head>
    <title>JSP (index.html)</title>
  </head>
  <body>
    Please click <a href="helloWorld.jsp">helloWorld.jsp</a> to run the JSP.
  </body>
</html>

```

Figure 10: Content of "rexxla_02_JSP/index.html".

```

<%@ page language="java" contentType="text/html; charset=ISO-8859-1"
    pageEncoding="ISO-8859-1"%>
<!DOCTYPE html>
<html>
<head>
<meta http-equiv="Content-Type" content="text/html; charset=ISO-8859-1">
<title>Minimal JSP</title>
</head>
<body>
<%
String crlf="\015\012"; // HTML must use CR-LF as newline
out.println("<h1>Hello, world (JSP)</h1>" + crlf);
out.println("<p>This JSP was executed, because of the following URL:" +
    "<ul><li>URL <em>request.getRequestURL()</em>: <br><code>" +
    request.getRequestURL()+"</code>" + crlf + // URL
    "<li>its URI being <em>request.getRequestURI()</em>: <br><code>" +
    request.getRequestURI()+"</code></ul></p>"); // URI
%>
</body>
</html>

```

Figure 11: Content of "rexxla_02_JSP/helloWorld.jsp".

```

<?xml version="1.0" encoding="UTF-8"?>
<web-app xmlns="http://xmlns.jcp.org/xml/ns/javaee"
          xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
          xsi:schemaLocation="http://xmlns.jcp.org/xml/ns/javaee
http://xmlns.jcp.org/xml/ns/javaee/web-app_4_0.xsd"
          version="4.0"
          metadata-complete="true">
  <display-name>Minimal JSP-Demo</display-name>
  <description>
    Welcome to a minimal JSP demo
  </description>
</web-app>

```

Figure 12: Content of "rexxla_02_JSP/WEB-INF/web.xml".

that location. The resulting HTML text that the requesting client receives from this JSP is shown in Figure 9 above.

- rexxla_02_JSP/WEB-INF/web.xml: this file gets depicted in Figure 12 and is not needed for this simple web application. However its content will be used to describe this web application in the Tomcat manager interface.

2.4 The "ScriptTagLibs" Taglib Library and (BSF4)ooRexx

Java based web servers allow the usage of taglib libraries within JSP pages. A taglib library contains tag handlers that implement the *BodyTag*⁸ interface class making it possible to extend the valid tags of a JSP with custom implementations. Tag libraries need to come with a matching TLD (tag library description) text file, which defines the tag names with their possible attributes and usually gets placed in the web application's *WEB-INF* directory.

Early on in the ASF there were two taglib libraries created to allow "scriptlets" and "expressions" to be used in JSP pages that allow for implementing the code in one of the Apache BSF⁹ [6] scripting languages. These taglib libraries got deprecated over time, but can still be fetched from [8]. As such they served as the starting

⁸ Depending on the targeted Java based web server implementation, the fully qualified name can be either `javax.servlet.jsp.tagext.BodyTag` or `jakarta.servlet.jsp.tagext.BodyTag` (Tomcat 9 or earlier use the `javax.` top level package name, starting with Tomcat 10 the `jakarta.` top level package name gets used, cf. the "History" section in [1]).

⁹ Interestingly, BSF was originally created as an open-source project at IBM for allowing scripting languages to be deployable in Java server pages (JSP)! The code was then later donated to ASF. With Java 6 a proper Java scripting framework (package `javax.script` also dubbed "JSR-223" which defines the specification, cf. [7]) got introduced into the language, which over time made BSF less relevant. Yet, Apache BSF is still being used in some Java based applications and there may be scripting language implementations for Java that support BSF only.

point for implementing the "*ScriptTagLibs*" libraries [9] in the fall of 2020 and which get applied and demonstrated as a proof of concept in this article.

There are two taglib libraries, *javax.ScriptTagLibs.jar* for Tomcat 9 or earlier and *jakarta.ScriptTagLibs.jar* for Tomcat 10, which implement the tags *script* and *expr* identically.

Each tag library comes with two versions, one for deploying script code that gets executed by Apache BSF using the TLD file named *script-bsf.tld* and one where the script code gets executed by the Java scripting framework ("JSR-223") named *script-jsr223.tld*. The *script* and *expr* tags are implemented for both, BSF and JSR-223, note however, that JSR-223 has additional attributes due to additional features available in the Java scripting framework, notably the ability to compile and execute compiled scripts.

Table 1 gives a brief overview of the attributes¹⁰ that can be supplied to the *script* and *expr* tags in JSP.

Attribute Name	Tag Name		Comment
	<i>script</i>	<i>expr</i>	
<i>type</i>	Must	Must	Scripting language name, e.g., "rexx". <i>Hint:</i> In JSR-223 it is possible to supply alternatively a mime-type or file-extension .
<i>arguments</i>	Optional	Optional	Defaults to "true": supply the implicit objects "request", "response" and "out" as arguments (in the listed order) to the script.
<i>cacheSrc</i>	Optional	Optional	Defaults to "true". Will read the script from the external file once and then reuse the cache. <i>Advice:</i> while developing the script logic, set this attribute to "false" in order to force always reading from the file system in order to reflect any code changes in the external script file.
<i>compile</i>	Optional	Optional	<i>JSR-223 only</i> , defaults to "true". Upon first execution compile the script and execute the compiled version.
<i>debug</i>	Optional	Optional	Defaults to "false": injects debug information at the top of the JSP page.
<i>name</i>	Optional	Optional	Any string, to ease locating exceptions (for debugging).
<i>reflect</i>	Optional	Optional	Defaults to "false": causes an implicit HashMap object named "ScriptTaglibs.TaglibNamespaceAttributevalues"

¹⁰ The current values of these attributes can be fetched from the invoked script by accessing the implicit object named "*ScriptTaglibs.Attributes*", which is a *java.util.Map*.

If using the BSF taglib (*script-bsf.tld*), then the ooRexx programmer may use the function *bsf.lookup(name)*, if using the JSR-223 taglib (*script-jsr223.tld*) then the *javax.script.ScriptContext.getAttribute(name)* method to get access to implicitly registered objects.

		Tag Name	
Attribute Name	<i>script</i>	<i>expr</i>	Comment
			to be created that contains taglib and namespace related information as well as the current values of all attributes.
<i>slot</i>	Optional	Optional	Any string that a JSP/script developer can use for any purpose (can be fetched from the invoked script).
<i>src</i>	Optional	Optional	URL of external script code, must reside in the web application directory.
<i>throwException</i>	Optional	Optional	Defaults to "false": controls whether the execution of the JSP page should continue in the case that an exception gets thrown in a script.

Table 1: ScriptTagLibs: Tags and their Attributes.

The web application *rexsla_03_ScriptTagLib* demonstrates usages of the *script* tag from the *ScriptTagLibs* Java archives:

- a simple JSP containing Rexx code in a *script* tag to create part of the HTML text to be sent to the requesting client (*helloWorld-bsf-01.jsp*, *helloWorld-jsr223-01.jsp*),
- a simple JSP using a *script* tag with the *src* attribute to point to the Rexx script stored in the external file named *helloWorld.rex* in the web application's directory which will get loaded and executed (*helloWorld-bsf-02.jsp*, *helloWorld-jsr223-02.jsp*).

Note: due to the supplying of the implicit objects "request", "response" and "out" as arguments to the invoked scripts by the implementation of the *ScriptTagLibs* taglib library one can regard such scripts to implement the *javax.servlet.Servlet* interface method *servlet(ServletRequest request, ServletResponse response)*!

The JSP files containing "*bsf*" in their name will use Apache BSF and those with "*jsr223*" will use the Java scripting framework (JSR-223) to execute the Rexx scripts in the JSP pages. In order to run these examples one needs to install the latest version of ooRexx 5 (at the time of this writing in beta) from [10] together with the latest version of ooRexx-Java bridge BSF4ooRexx from [11], which supports both, Apache BSF and the Java scripting framework (JSR-223).

The *bsf4ooRexx-v641-20201217-bin.jar* (or newer) from BSF4ooRexx and the *ScriptTagLibs* Java archives *javax.ScriptTagLibs.jar* (Tomcat 9 or earlier) or *jakarta.ScriptTagLibs.jar* (Tomcat 10 or later) can be copied to Tomcat's home/installation directory ("*CATALINA_HOME*") and there into the subdirectory

named *lib*, which causes Tomcat to make them available to all web applications. Alternatively these Java archives can be copied to the web application's WEB-INF/lib directory which is searched by Tomcat before Tomcat's *lib* directory in its home/installation directory.

To allow the tags of the *ScriptTagLibs* to be used in JSP pages its *tld* files need to be copied into the web application's WEB-INF directory. The file `script-bsf.tld` allows one to use BSF to execute the scripts contained in a JSP page, the file `script-jsr223.tld` allows one to use the Java scripting framework (JSR-223) to execute the scripts, which is advised.

The web application named *rexsla_03_ScriptTagLib* demonstrates how to use BSF and execute scripts interspersed in a JSP and an external script, and do exactly the same with the Java scripting framework (JSR-223). As the reader can see for himself, the only difference between these two versions of the JSPs is which *tld* file gets referred to!

The web application directory *rexsla_03_ScriptTagLib* will contain the following files:

- `rexsla_03_ScriptTagLib/index.html`: as this file is named *index.html* it will be returned to the client by the web server by default. It makes the JSPs `helloWorld-bsf-01.jsp`, `helloWorld-bsf-02.jsp`, `helloWorld-jsr223-01.jsp`, and `helloWorld-bsf-02.jsp` available via links and also allows the

```
<html>
  <head>
    <title>JSP ScriptTagLibs (index.html)</title>
  </head>
  <body>
    <p>Please click on any of the following minimal Rexx programs:
    <ul>
      <li>Employing the Apache Bean Scripting Framework (BSF):
      <ul>
        <li><a href="helloWorld-bsf-01.jsp">helloWorld-bsf-01.jsp</a>
        <li><a href="helloWorld-bsf-02.jsp">helloWorld-bsf-02.jsp</a>
          (employing Rexx program <a href="helloWorld.rex">helloWorld.rex</a>)
      </ul>
      <li>Employing the Java Scripting Framework (a.k.a. &quot;jsr-223&quot;):
      <ul>
        <li><a href="helloWorld-jsr223-01.jsp">helloWorld-jsr223-01.jsp</a>
        <li><a href="helloWorld-jsr223-02.jsp">helloWorld-jsr223-02.jsp</a>
          (employing Rexx program <a href="helloWorld.rex">helloWorld.rex</a>)
      </ul>
    </ul>
  </body>
</html>
```

Figure 13: Content of "rexsla_03_ScriptTagLib/index.html".

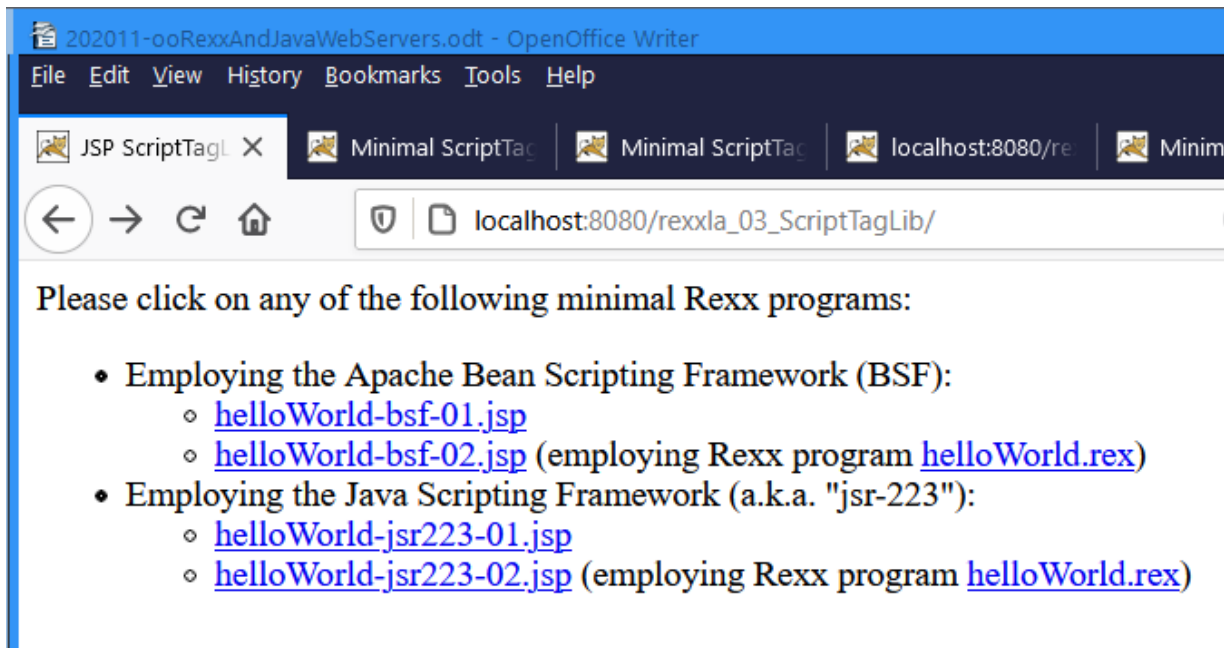


Figure 14: Result of client requesting the web application "rexxla_03_ScriptTagLib".

external REXX program in `helloWorld.rex` to be displayed directly in a browser by supplying an appropriate link. Figure 13 shows the file's content, Figure 14 shows how it gets rendered in the client's browser.

- `rexxla_03_ScriptTagLib/helloWorld-bsf-01.jsp`: this JSP file includes REXX code in a `script` element which gets executed via BSF. Its content is

```
<%@ page session="false" pageEncoding="ISO-8859-1" contentType="text/html;
charset=ISO-8859-1" %>
<%@ taglib uri="WEB-INF/script-bsf.tld" prefix="s" %>
<!DOCTYPE html>
<html>
<head>
<meta http-equiv="Content-Type" content="text/html; charset=ISO-8859-1">
<title>Minimal ScriptTagLibs-JSP</title>
</head>
<body>
<s:script type="rexx">
use arg request
say "<h1>Hello, world (ScriptTagLibs JSP)</h1>"
say "<p>This JSP was executed, because of the following URL:"
say "<ul><li>URL <em>request~getRequestURL()</em>: <br>"
say "<code>"request~getRequestURL~toString"</code>"
say "<li>its URI being <em>request~getRequestURI()</em>: <br>"
say "<code>"request~getRequestURI"</code></ul></p>"
</s:script>
</body>
</html>
```

Figure 15: Content of "rexxla_03_ScriptTagLib/helloWorld-bsf-01.jsp".



Figure 16: Response to client which was created by "helloWorld-bsf-01.jsp".

```

1
2
3
4 <!DOCTYPE html>
5 <html>
6 <head>
7 <meta http-equiv="Content-Type" content="text/html; charset=ISO-8859-1">
8 <title>Minimal ScriptTagLibs-JSP</title>
9 </head>
10 <body>
11 <h1>Hello, world (ScriptTagLibs JSP)</h1>
12 <p>This JSP was executed, because of the following URL:
13 <ul><li>URL <em>request~getRequestURL()</em>: <br>
14 <code>http://localhost:8080/rexxla_03_ScriptTagLib/helloWorld-bsf-01.jsp</code>
15 <li>its URI being <em>request~getRequestURI()</em>: <br>
16 <code>/rexxla_03_ScriptTagLib/helloWorld-bsf-01.jsp</code></ul></p>
17
18 </body>
19 </html>
20

```

Figure 17: HTML text created and returned by "helloWorld-bsf-01.jsp".

shown in Figure 15 at page 14 above. At the top of that JSP page the JSP tag "<%@ taglib" (first yellow background section) defines the location of the *tld* file "script-bsf.tld" in the web application to be used and the prefix "s" to denote the namespace for it causing the *script* tag to be written as "<s:script>" in the JSP.

The second section with yellow background in Figure 15 highlights the *script* element with the *type* attribute having the value "rexx" declaring the scripting language Rexx to be used for executing the script's code which creates some HTML text using information from the "request" argument.

```

<%@ page session="false" pageEncoding="ISO-8859-1" contentType="text/html;
charset=ISO-8859-1" %>
<%@ taglib uri="WEB-INF/script-jsr223.tld" prefix="s" %>
<!DOCTYPE html>
<html>
<head>
<meta http-equiv="Content-Type" content="text/html; charset=ISO-8859-1">
<title>Minimal ScriptTagLibs-JSP</title>
</head>
<body>
<s:script type="rexx">
use arg request
say "<h1>Hello, world (ScriptTagLibs JSP)</h1>"
say "<p>This JSP was executed, because of the following URL:"
say "<ul><li>URL <em>request~getRequestURL()</em>: <br>"
say "<code>"request~getRequestURL~toString"</code>"
say "<li>its URI being <em>request~getRequestURI()</em>: <br>"
say "<code>"request~getRequestURI"</code></ul></p>"
</s:script>
</body>
</html>

```

Figure 18: Content of "rexxla_03_ScriptTagLib/helloWorld-jsr223-01.jsp".



Figure 19: Response to client which was created by "helloWorld-jsr223-01.jsp".

Figure 16 shows the client's browser formatting the returned HTML text which gets depicted in Figure 17.

- rexxla_03_ScriptTagLib/helloWorld-jsr223-01.jsp: this JSP file includes Rexx code in a *script* element which gets executed via the Java scripting framework (JSR-223). Its content gets depicted in Figure 18 at page 16 above, the client's browser presenting the returned HTML text is shown in Figure

```

<%@ page session="false" pageEncoding="ISO-8859-1" contentType="text/html;
charset=ISO-8859-1" %>
<%@ taglib uri="WEB-INF/script-bsf.tld" prefix="s" %>
<!-- external Rexx script will create all of the HTML! -->
<s:script type="rexx" src="helloWorld.rex" />

```

Figure 20: Content of "rexsla_03_ScriptTagLib/helloWorld-bsf-02.jsp".



Figure 21: Response to client which was created by "helloWorld-bsf-02.jsp".

19 above.

Comparing the JSP text (cf. Figure 18) with the one for "helloWorld-bsf-01.jsp" (cf. Figure 15) it appears to be identical. The only difference is the name of the *tld* file that gets referenced in the second JSP tag from the top of both JSP files!

- `rexsla_03_ScriptTagLib/helloWorld-bsf-02.jsp`: this JSP file (cf. Figure 20 above) includes a *script* element that defines the *type* attribute with the value "rexx" and refers to an external file containing the code because of the presence of the *src* attribute with the value "helloWorld.rex". Note that the external Rexx program in this case needs to create all of the HTML text that gets returned to the requesting client as the JSP itself has no HTML text defined as it consists of JSP tags only. The Rexx code from the external file gets executed using BSF. Its content is shown in Figure 24 at page 19 below the client's browser rendering the returned HTML data is shown in Figure 21.

```

<%@ page session="false" pageEncoding="ISO-8859-1" contentType="text/html;
charset=ISO-8859-1" %>
<%@ taglib uri="WEB-INF/script-jsr223.tld" prefix="s" %>
<!-- external Rexx script will create all of the HTML! -->
<s:script type="rex" src="helloWorld.rex" />

```

Figure 22: Content of "rexcla_03_ScriptTagLib/helloWorld-jsr223-02.jsp".



Figure 23: Response to client which was created by "helloWorld-jsr223-02.jsp".

- rexxla_03_ScriptTagLib/helloWorld-jsr223-02.jsp: this JSP file (cf. Figure 22 below) includes a *script* element that defines the *type* attribute with the value "rex" and refers to an external file containing the code because of the presence of the *src* attribute with the value "helloWorld.rex". Note that the external Rexx program in this case needs to create all of the HTML text that gets returned to the requesting client as the JSP itself has no HTML text defined as it consists of JSP tags only. The Rexx code from the external file gets executed using BSF. Its content is shown in Figure 24 at page 19 below the client's browser rendering the returned HTML data is shown in Figure 23 below

Comparing the JSP text (cf. Figure 22) with the one for "helloWorld-bsf-01.jsp" (cf. Figure 20 above) it appears to be identical. The only difference is the name of the *tld* file that gets referenced in the second JSP tag from the top of both JSP files!

- rexxla_03_ScriptTagLib/helloWorld.rex: this file contains the Rexx code

```

use arg request
say .resources~top_part      -- write top HTML block
say "          <code>"request~getRequestURL~toString"</code>"
say .resources~middle_part  -- write middle HTML block
say "          <code>"request~getRequestURI"</code>"
say .resources~bottom_part  -- write bottom HTML block
-- constant HTML texts
::resource top_part        -- top HTML block
<!DOCTYPE html>
<html>
  <head>
    <meta http-equiv="Content-Type" content="text/html; charset=ISO-8859-1">
    <title>Minimal ScriptTagLibs-JSP</title>
  </head>
  <body>
    <h1>Hello, world (ScriptTagLibs JSP)</h1>
    <p>This JSP was executed, because of the following URL:
    <ul><li>URL <em>request~getRequestURL()</em>: <br>
::END
::resource middle_part     -- middle HTML block
    <li>its URI being <em>request~getRequestURI()</em>: <br>
::END
::resource bottom_part    -- bottom HTML block
    </ul>
  </body>
</html>
::END

```

Figure 24: Content of "helloWorld.rex".

referred to in helloWorld-bsf-02.jsp and helloWorld-jsr223-02.jsp. Figure 24 below depicts its content.

- This Rexx program uses the *resource* directive introduced with ooRexx 5 which allows one to define the different sections of the HTML text

```

<?xml version="1.0" encoding="UTF-8"?>
<web-app xmlns="http://xmlns.jcp.org/xml/ns/javaee"
          xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
          xsi:schemaLocation="http://xmlns.jcp.org/xml/ns/javaee
http://xmlns.jcp.org/xml/ns/javaee/web-app_4_0.xsd"
          version="4.0"
          metadata-complete="true">
  <display-name>Minimal JSP-ScriptTagLibs Demo</display-name>
  <description>
    Welcome to a minimal JSP-ScriptTagLibs demo
  </description>
</web-app>

```

Figure 25: Content of "rexsla_03_ScriptTagLib/WEB-INF/web.xml".

```

1. <?xml version="1.0" encoding="ISO-8859-1" ?>
2. <!DOCTYPE taglib
3.   PUBLIC "-//Sun Microsystems, Inc.//DTD JSP Tag Library 1.1//EN"
4.   "http://java.sun.com/j2ee/dtds/web-jsptaglibrary_1_1.dtd">
5. <!-- a tag library descriptor -->
6. <taglib>
7.   <tlibversion>2.0</tlibversion>
8.   <jspversion>1.1</jspversion>
9.   <shortname>BSF JSP Support</shortname>
10.  <uri>http://rexlla.org/taglibs/bsf</uri>
11.  <info> Uses Apache BSF to execute scripts and expressions </info>
12.  <tag>
13.    <name>script</name>
14.    <tagclass>org.rexlla.taglibs.bsf.Scriptlet</tagclass>
15.    <bodycontent>tagdependent</bodycontent>
16.    <info>Run script</info>
17.    <attribute>
18.      <name>type</name>
19.      <required>>true</required>
20.    </attribute>
21.    <attribute>
22.      <name>name</name>
23.      <required>>false</required>
24.    </attribute>
25.    <attribute>
26.      <name>src</name>
27.      <required>>false</required>
28.    </attribute>
29.    <attribute>
30.      <name>cacheSrc</name>
31.      <required>>false</required>
32.    </attribute>
33.    <attribute>
34.      <name>throwException</name>
35.      <required>>false</required>
36.    </attribute>
37.    <attribute>
38.      <name>debug</name>
39.      <required>>false</required>
40.    </attribute>
41.    <attribute>
42.      <name>arguments</name>
43.      <required>>false</required>
44.    </attribute>
45.    <attribute>
46.      <name>slot</name>
47.      <required>>false</required>
48.    </attribute>
49.  </tag>

```

... continued in Figure 27 below...

Figure 26: Content of "script-bsf.tld", part 1, continued in Figure 27 below.

... continued from previous Figure 26 above...

```
46. <tag>
47.   <name>expr</name>
48.   <tagclass>org.rexxla.taglibs.bsf.Expression</tagclass>
49.   <bodycontent>tagdependent</bodycontent>
50.   <info>Evaluate script expression</info>
51.   <attribute>
52.     <name>type</name>
53.     <required>>true</required>
54.   </attribute>
55.   <attribute>
56.     <name>name</name>
57.     <required>>false</required>
58.   </attribute>
59.   <attribute>
60.     <name>src</name>
61.     <required>>false</required>
62.   </attribute>
63.   <attribute>
64.     <name>cacheSrc</name>
65.     <required>>false</required>
66.   </attribute>
67.   <attribute>
68.     <name>throwException</name>
69.     <required>>false</required>
70.   </attribute>
71.   <attribute>
72.     <name>debug</name>
73.     <required>>false</required>
74.   </attribute>
75.   <attribute>
76.     <name>arguments</name>
77.     <required>>false</required>
78.   </attribute>
79.   <attribute>
80.     <name>slot</name>
81.     <required>>false</required>
82.   </attribute>
83. </tag>
84. </taglib>
```

Figure 27: Content of "script-bsf.tld", part 2, continued from Figure 26 above.

verbatimly. The Rexx code makes sure to write these HTML sections interspersed with dynamically acquired information from the Java web server at the time this program runs.

- It is this servlet-like Rexx program that creates the HTML text for both, the helloWorld-bsf-01.jsp and helloWorld-jsr223-01.jsp JSP files.

- `rexxla_03_ScriptTagLib/WEB-INF/web.xml`: this file gets depicted in Figure 25 and is not needed for this web application. However its content will be used to describe this web application in the Tomcat manager interface.
- `rexxla_03_ScriptTagLib/WEB-INF/script-bsf.tld` (BSF taglib library) and `rexxla_03_ScriptTagLib/WEB-INF/script-jsr223.tld` (JSR-223 taglib library). These *tld* files accompany the *ScriptTagLibs* Java archives and their content does not get changed by the web application programmer. Both files are almost identical except for the *shortname*, *uri*, *info* elements and the *tagclass* element (denotes the fully qualified Java class name that must be used to process the respective tag). Figures 26 and 27 depict the content of "*script-bsf.tld*" and highlight the most important definitions in it. The content of "*script-jsr223.tld*" is not shown for brevity, as it is almost identical except for the lines # 9, 10, 11, , 14 and having an additional attribute named "*compile*" for the *script* and *expr* tags.
- `rexxla_03_ScriptTagLib/WEB-INF/lib`: this directory may contain the Java archives `bsf4ooRexx-v641-20201217-bin.jar`¹¹ (or newer) from BSF4ooRexx and the *ScriptTagLibs* Java archive `javax.ScriptTagLibs.jar` (Tomcat 9 or earlier) or `jakarta.ScriptTagLibs.jar` (Tomcat 10 or later). If these archives are present then they get used first when looking for Java classes by Tomcat, otherwise these two Java archives must reside in Tomcat's home/installation directory's and its immediate subdirectory named `lib`.

The *ScriptTagLib* implementations make sure for Rexx, that each Rexx script's standard output file will be transparently redirected to the supplied implicit "*out*" Java object, thereby causing Rexx *SAY* and ooRexx *.output~say* statements to be transparently redirected. As a result it is quite easy for Rexx programmers to create the HTML text to be sent back to the requesting client by merely using the standard Rexx output statements.¹²

¹¹ Note: if there may be more than one web application that uses BSF4ooRexx, then one must copy `bsf4ooRexx-v641-20201217-bin.jar` (or newer) to the `CATALINA_HOME/lib` directory. The reason being that Tomcat uses different classloaders for different web applications and that the native BSF4ooRexx library caches Java classes for performance reasons. If cached Java classes get used by a classloader that did not load them then Java runtime errors may occur as a result. Placing `bsf4ooRexx-v641-20201217-bin.jar` (or newer) only into the `CATALINA_HOME/lib` directory foregoes this problem.

¹² The JSR-223 support of ooRexx is realized with the *RexxScriptEngine* [13] that automatically prepends prompt strings when accessing standard files to ease the analysis of Java log files. In the case of accessing the standard output file the prompt "*REXXout>*" gets prepended which is undesired in the context of Java server pages as the requesting client would (unexplainably) get

3 Roundup and Outlook

This article briefly introduced and discussed Java based web servers, Servlets, JSPs and taglib libraries. The author created a few taglib libraries ("*ScriptTagLibs*") that allow script code to be deployed via Apache BSF or the Java scripting framework (a.k.a. JSR-223) as long as there are appropriate scripting engines available for each framework. As BSF4ooRexx creates a bidirectional ooRexx-Java bridge and implements BSF and JSR-223 it becomes possible to exploit Java server pages also for ooRexx where the JSP's code is not implemented in Java, but rather in [oo]Rexx! As a matter of fact, these new taglib libraries allow for mixing multiple programming languages (Java as well as Java scripting languages) in the same JSP page should a need arise. In addition one can mix execution of scripts via Apache BSF and the Java scripting framework which allows one to deploy older Java scripting languages for which only Apache BSF engine implementations are available.

The article demonstrated with ooRexx nutshell examples the usage of the *script* tag from the BSF and the JSR-223 *ScriptTagLibs*. Using the new resource directive in ooRexx 5.0 it becomes possible to easily define static HTML text in the ooRexx program and use it for creating the HTML text that gets returned to the requesting client. Taken together with the *ScriptTagLibs* default behaviour of always supplying the implicit Java objects *request*, *response*, and *out* for each script invocation as arguments one can create external script programs that mimicry the *{javax/jakarta}.servlet.Servlet*'s *service* method.

The script taglibs are available for both namespaces, *javax* (e.g., Tomcat 9 or earlier) and *jakarta* (e.g., Tomcat 10 or later), the distributions carry the top level package names as their first word: *javax.ScriptTagLibs.jar* and *jakarta.ScriptTagLibs.jar*, respectively.

Acknowledgements

The author wishes to thank DI Walter Pachl for his feedback and proofreading.

4 References

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this prompt as part of the HTML text sent back to it. Therefore the *ScriptTagLib* implementation for JSR-223 makes sure, that *RexxScriptEngine*'s automatic standard output prompt gets removed.

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