Department of Information Systems
and Operations Management

Tutorial: Making Java Easy Using ooRexx

The Bean Scripting Framework for ooRexx

Easily exploiting Java from ooRexx on all operating system platforms

The 2024 International Rexx Symposium
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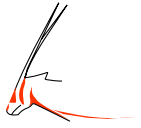


Overview

- Some information on Java and an example of using ooRexx to exploit it
- Some important things to know about Java
- Introducing the ooRexx package (program) BSF.CLS
  - Camouflages Java as ooRexx
  - Makes it possible to simply send ooRexx messages to Java (class) objects
  - Provides some important utility features
- Download links
- Roundup
- *Addenda!*
  - *Also demonstrates how Java can send ooRexx objects messages!*

Java

- Programming language with the following notable features
  - Compiles to machine instructions (*"bytecode"*) of an *artificial processor*
  - Needs a "Java virtual machine (JVM)" to execute the bytecode
    - JVMs are available for all important operating systems and hardware architectures
    - *Hence, a Java class or a Java program, once compiled can be run everywhere!*
  - Distributed with a (huge) "Java runtime environment (JRE)"
    - A *huge Java class library* that offers everything that an application may possibly need
      - E.g. Socket classes for Internet programming, GUI classes for graphical user interfaces, ...
    - Uncountable third party Java class libraries, most available as open-source (e.g. ASF)
  - Most important programs get programmed with Java (even Android applications!)
  - Many professional applications that are not programmed in Java offer Java APIs
    - E.g. SAP, OpenOffice/LibreOffice, ...
- Hence Java is truly a programmer's "treasure trove" for all operating systems!

BSF4ooRexx850

- External Rexx function package
  - Allows to interact with the Java runtime environment (JRE)
    - Exploit functionality of Java classes
    - Exploit functionality of Java objects
  - ooRexx 5.0 or later, Java 8 or later
  - Package "BSF.CLS"
    - Camouflages Java as ooRexx (Java appears to be dynamic and message based)
    - Supplies class BSF and public routines
- "Everything that is available in Java becomes directly available to ooRexx !"
  - Java: "write once, run everywhere!"
    - Windows, MacOS, Linux, ...

BSF4ooRexx: An Example, 1

- The following example
  - Uses the ::requires directive to load the ooRexx-Java bridge
    ```
    ::requires "BSF.CLS"
    ```
    - Directives get processed in the setup phase, right before the program starts
  - Creates an instance of the Java class named java.awt.Dimension and interacts with it via ooRexx messages that denote the method names to run
    - Studying the documentation of the Java class java.awt.Dimension one can see which Java methods are available for use
  - Displays the string that the message toString returns
  - Changes the values for the width and height fields
  - Displays the string that the message toString returns

BSF4ooRexx: An Example, 2

```
dim=.bsf~new("java.awt.Dimension", 100, 200)     -- create with width and height
say dim~toString                                 -- show string value

::requires BSF.CLS      -- get Java support
```

Output:

```
java.awt.Dimension[width=100,height=200]
```

Downloading Java (Usually Free and Open-source)

- JRE versus JDK
  - JRE: "**J**ava **R**untime **E**nvironment", no compiler
  - JDK: "**J**ava **D**evelopment **K**it", compiler & tools
- Java/OpenJDK 8 LTS ("long term support")
  - Released spring 2014, supported until 2030 (Oracle, Azul)
- Java/OpenJDK 21 LTS ("long term support", "modular Java")
  - Released fall 2023, supported at least until 2031 (Oracle, Azul)
- Suggestion: download OpenJDK *with JavaFX* support, e.g.
  - Scroll down to see all versions pick the *JavaFX* installation package
    - **Full JDK:** <https://bell-sw.com/pages/downloads/> ("Liberica", 2023-11-30)
    - **JDK FX:** <https://www.azul.com/downloads/> (2023-11-30)

Things to Know About Java, 1

- Strictly typed language
  - Primitive types
    - boolean, byte, char, short, int, long, float, double
  - Object-oriented types
    - Any Java class, e.g.
      - `java.awt.Dimension`, `java.lang.String`, `java.lang.System`, `...`
    - Wrapper classes for primitive types
      - `java.lang.Boolean`, `java.lang.Byte`, `java.lang.Character`, `java.lang.Short`, `java.lang.Integer`, `java.lang.Long`, `java.lang.Float`, `java.lang.Double`
      - "boxing": wraps up a primitive value into a wrapper object
      - "unboxing": retrieves a primitive value from its wrapper object

Things to Know About Java, 2

- Case sensitive
  - Upper- and lowercase significant!
- Classes organized in packages
  - Package names may be compound
    - E.g. "java.lang"
  - Fully "qualified class name" includes package name
    - e.g. "java.lang.String"
  - "Unqualified class name"
    - e.g. "String"

Things to Know About Java, 3

- A Java class may consist of
  - Fields (comparable to ooRexx attributes) and
  - Methods (comparable to ooRexx methods)
- Fields and methods
  - Static fields and static methods
    - Sometimes dubbed "class fields" and "class methods"
    - Available to the class object *and* its instances
  - Otherwise "instance methods"
    - Only available to instances of a Java class

Things to Know About Java, 4

- A Java class, its fields and methods may be
  - "public"
    - These can be accessed by the "world" (everyone)
  - "private"
    - Only accessible within the Java class
  - "protected"
    - Only accessible within Java classes of the same package and subclasses
  - None of the above modifiers given ("package private")
    - Only accessible within Java classes of the same package, but to noone else

Things to Know About Java, 5

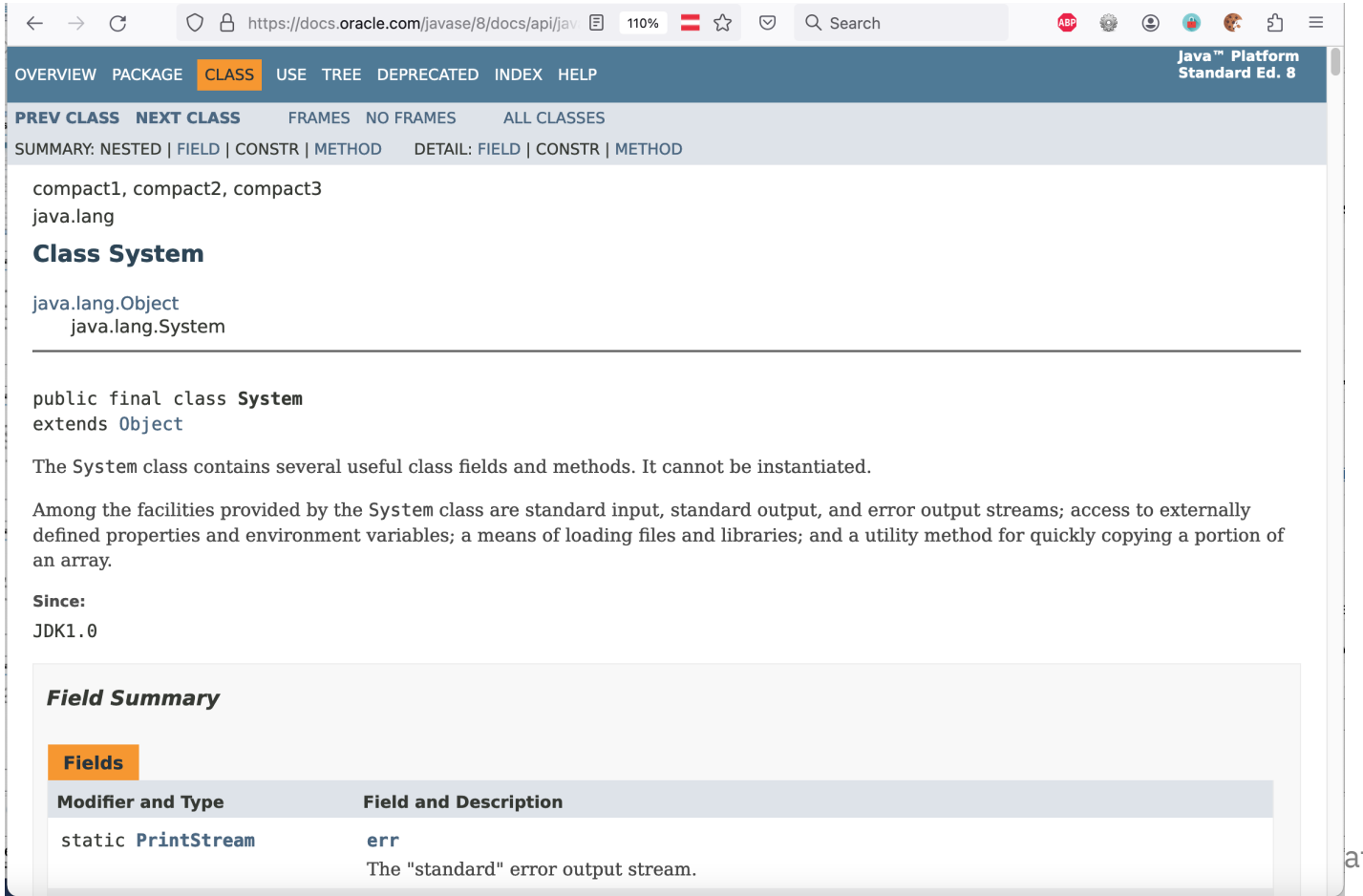
- Excellent documentation ("JavaDoc")
  - Extensive set of interlinked HTML documents
    - Created right from the comments in Java sources
  - Can be studied on the Internet, search e.g. with

```
javadoc 8 java.awt.Dimension
javadoc 8 Dimension
javadoc 21 java.awt.Dimension
javadoc 21 Dimension
```

- Documentation can be downloaded to local computer, e.g.
  - Java/JDK 8 LTS ("long term support"):
    - <https://www.oracle.com/java/technologies/javase-jdk8-doc-downloads.html> (2023-11-30)
  - Java/JDK 21 LTS ("long term support"):
    - <https://www.oracle.com/java/technologies/javase-jdk21-doc-downloads.html> (2023-11-30)

A Javadoc Example (JDK8LTS), 1

Search keywords:
Javadoc 8 System



A Javadoc Example (JDK8LTS), 2

Method Summary

All Methods	Static Methods	Concrete Methods	Deprecated Methods

Modifier and Type	Method and Description
static void	**arraycopy**(**Object** src, int srcPos, **Object** dest, int destPos, int length) Copies an array from the specified source array, beginning at the specified position, to the specified position of the destination array.
static **String**	**clearProperty**(**String** key) Removes the system property indicated by the specified key.
static **Console**	**console**() Returns the unique **Console** object associated with the current Java virtual machine, if any.
static long	**currentTimeMillis**() Returns the current time in milliseconds.
static void	**exit**(int status) Terminates the currently running Java Virtual Machine.
static void	**gc**() Runs the garbage collector.
static **Map**<**String**,**String**>	**getenv**() Returns an unmodifiable string map view of the current system environment.
static **String**	**getenv**(**String** name) Gets the value of the specified environment variable.
static **Properties**	**getProperties**() Determines the current system properties.
static **String**	**getProperty**(**String** key)

BSF.CLS: Camouflages Java as ooRexx

- ooRexx class "**BSF**"
  - Allows to create Java objects
  - Requires the fully qualified Java class name
- Invoking Java methods
  - Just send the name of the method as a message to the Java object
    - Supply the arguments as documented, if any
      - Type conversions between ooRexx and Java are done automatically by BSF4ooRexx, if necessary
      - Return values are automatically converted by BSF4ooRexx, if necessary

BSF.CLS: Creating Java Objects

- ooRexx class "**BSF**"
  - Allows to create Java objects
  - Needs at least fully qualified Java class name
- Possible arguments for creating Java objects
  - Can be found by studying the "Constructor" section in the Javadocs
  - Supply the arguments as documented after the fully qualified Java class name argument
    - Type conversions between ooRexx and Java are done automatically by BSF4ooRexx, if necessary

BSF.CLS: Creating Java Objects, Example

```
-- see Javadocs: search Internet with "javadoc java.awt.Color"
red=.bsf~new("java.awt.Color",255,0,0)      -- create color red
say "red:" red~toString -- toString will show the RGB values

myColor=.bsf~new("java.awt.Color",100,200,3) -- create an individual color
say "myColor:" myColor~toString
brighter=myColor~brighter   -- get a brighter color
say "brighter:" brighter~toString

::requires "BSF.CLS"   -- get ooRexx-Java bridge
```

Output (maybe):

```
red: java.awt.Color[r=255,g=0,b=0]
myColor: java.awt.Color[r=100,g=200,b=3]
brighter: java.awt.Color[r=142,g=255,b=4]
```

BSF.CLS: Camouflages Java as ooRexx

- Allows to load any Java class
  - **bsf.loadClass(JavaClassName)**
    - Java class name
      - Use of the exact case is mandatory !
      - Java class name must be fully qualified !
- Allows accessing static (class) methods and fields (attributes)
  - Example uses java.lang.System's static getProperty() method to query the Java version from ooRexx

BSF.CLS: Loading a Java Class, Example

```
-- see Javadocs: search Internet with "javadoc java.lang.System"
clz=bsf.loadClass("java.lang.System")   -- loads the Java class
say "java.version:" clz~getProperty("java.version")

::requires "BSF.CLS"   -- get ooRexx-Java bridge
```

Output (maybe):

```
java.version: 1.8.0_162
```

BSF.CLS: Camouflages Java as ooRexx

- Allows to import any Java class
  - **bsf.import(JavaClassName)**
    - Java class name
      - Use of the exact case is mandatory !
      - Java class name must be fully qualified !
- Imported Java class can be treated as if it were an ooRexx class
  - Allows to use the ooRexx "**new**"-method to create instances of the imported Java class
    - Possible arguments for creating Java objects can be found by studying the "Constructor" section in the Javadocs

BSF.CLS: Loading a Java Class, Example

```
-- see Javadocs: search Internet with "javadoc java.awt.Color"
clzColor=bsf.importClass("java.awt.Color")  -- import Java class

red=clzColor~red         -- get static field for red color
say "red:" red~toString -- toString will show the RGB values

myColor=clzColor~new(100,200,3) -- create an individual color
say "myColor:" myColor~toString
brighter=myColor~brighter   -- get a brighter color
say "brighter:" brighter~toString

::requires "BSF.CLS"   -- get ooRexx-Java bridge
```

Output (maybe):

```
red: java.awt.Color[r=255,g=0,b=0]
myColor: java.awt.Color[r=100,g=200,b=3]
brighter: java.awt.Color[r=142,g=255,b=4]
```

BSF.CLS: Camouflages Java as ooRexx

- Accessing, setting Java fields
  - ooRexx treats public fields as ooRexx attributes
  - Java "get" and "set" pattern methods for Java fields honored by BSF4ooRexx
    - Just use the field name following "get" and "set" only
  - Static fields can be accessed via the
    - Java class object or
    - Any of its instances

BSF.CLS: Use Java Fields As Attributes

```
-- see Javadocs: search Internet with "javadoc java.awt.Dimension"
dim=.bsf~new("java.awt.Dimension", 100, 200)
say dim~toString
dim~height=321       -- treat field height as if it was an ooRexx attribute
dim~width =1024      -- treat field width as if it was an ooRexx attribute
say dim~toString

::requires BSF.CLS      -- get Java support
```

Output:

```
java.awt.Dimension[width=100,height=200]
java.awt.Dimension[width=1024,height=321]
```

BSF.CLS

- About respecting case
  - Case of fully qualified Java class name
    - Always significant!
- Case of fields and method names insignificant!
  - Eases coding considerably

BSF.CLS: Creating Java Arrays, 1

- Java arrays
  - Strictly typed
  - Fixed capacity
  - Indices start with value "**0**"
- Public routine "**bsf.createJavaArray(...)**"
  - Arguments
    - First argument gives the Java type
      - Fully qualified Java class name or Java class object
    - Each further argument is an integer value, denoting the maximum elements in that dimension

BSF.CLS: Creating Java Arrays, 2

- Public routine "**bsf.createJavaArray(...)**"
  - Resulting Java array can be used as if it was an ooRexx array object!
    - Indices start at "**1**" as with ooRexx arrays!
    - Possesses the fundamental *ooRexx array methods* like "**AT**", "**[]**", "**PUT**", "**[]=**", "**supplier**", and "**makeArray**"
    - Can, therefore, be used in ooRexx "**DO ... OVER**" and "**DO WITH ... OVER**" loops

BSF.CLS: Creating a Java Array

```
-- create a two-dimensional (5x10) Java Array of type String
arr=.bsf~bsf.createJavaArray("java.lang.String", 5, 10)

arr[1,1]="First Element in Java array."       -- place an element
arr~put("Last Element in Java array.", 5, 10) -- place another one

do o over arr      -- loop over elements in array (makearray)
   say o
end
say

do with index i item o over arr  -- loop over elements in array (supplier)
   say i":" o
end

::requires BSF.CLS -- loads Java support
```

Output:

```
First Element in Java array.
Last Element in Java array.

1,1: First Element in Java array.
5,10: Last Element in Java array.
```

BSF4ooRexx: BSFCreateRexxProxy, 1

- RexxProxy
  - A *Java object* that proxies an ooRexx object
  - Allows Java to send messages to ooRexx objects
  - Any method invocations on the Java object will be forwarded as an ooRexx message to the proxied ooRexx object
    - All arguments supplied to the Java method are forwarded in the same sequence with the ooRexx message
    - BSF4ooRexx always appends an additional argument, "**slotDir**" (an ooRexx directory object) to the ooRexx message, which will contain information about the Java method invocation

BSF4ooRexx: BSFCreateRexxProxy, 2

- RexxProxy
  - **BSFCreateRexxProxy(rexxObj [, userData])**
    - Creates and returns a Java object that proxies "**rexxObj**"
    - If "**userData**" (any Rexx object) supplied, then it will be added to the "**slotDir**" directory
  - **BSFCreateRexxProxy(rexxObj [, [userData], jiClz[, ...]])**
    - "**jiClz**" can be one or more Java interface classes the returned RexxProxy can be used for!
  - **BSFCreateRexxProxy(rexxObj [, [userData], jaClz[, arg[,...]])**
    - "**jaClz**" is an abstract Java class, "**arg**" can be one or more arguments for creating an instance of it

BSF4ooRexx: RexxProxy, 1

```
rexxObj=.myClass~new
rexxObj~hello
say "---"
rp=BSFCreateRexxProxy(rexxObj)    -- create a Java RexxProxy object
rp~sendMessage0("hello")          -- send via Java

::requires BSF.CLS    -- get Java support

::class myClass
::method hello
  say "hello from" pp(self)
```

Output:

```
hello from [a MYCLASS]
---
hello from [a MYCLASS]
```

BSF4ooRexx: RexxProxy, 2

```
rexxObj=.myClass~new
rexxObj~hello
say "---"
userData="This is some Rexx string."      -- sent only if invoked via Java
rp=BSFCreateRexxProxy(rexxObj,userData)   -- create a Java RexxProxy object
rp~sendMessage0("hello")          -- send via Java

::requires BSF.CLS   -- get Java support

::class myClass
::method hello
  use arg slotDir    -- available only, if called from Java
  if slotDir~isA(.directory) then
     say "hello from" pp(self) "userData:" pp(slotDir~userData)
  else
     say "hello from" pp(self)
```

Output:

```
hello from [a MYCLASS]
---
hello from [a MYCLASS] userData: [This is some Rexx string.]
```

Addendum “Rosetta Code”

- BSFCreateRexxProxy()
  - Wraps up an ooRexx object in a Java object
  - Allows to send messages to ooRexx from Java
  - Very powerful if used with Java interface classes or Java abstract classes
    - Java abstract methods can be implemented in ooRexx!

Links (As of: 2024-03-03)

- ooRexx

  https://sourceforge.net/projects/oorexx/files/oorexx/5.1.0beta/

- Java/OpenJDK
  - Try to get the installation package that contains *JavaFX*
  - From Amazon, Azul, IBM, Microsoft, Oracle, …
- BSF4ooRexx850 (external ooRexx function and class package)

  https://sourceforge.net/projects/bsf4oorexx/files/GA/BSF4ooRexx-850.20240304-GA/
  - Checkout samples that start with “1-” in BSF4ooRexx850/samples
- Slides introducing the ooRexx-Java bridge
  - https://wi.wu.ac.at/rgf/wu/lehre/autojava/material/foils/

BSF4ooRexx: Roundup, 1/2

- External Rexx function package
  - BSF4ooRexx version *850* needs at least Java *8* or later, and ooRexx *5.0* or later
  - Allows interacting with Java classes and objects
- "**BSF.CLS**"
  - Camouflages Java as ooRexx
  - Allows easy creation of Java objects
    - Java class name *must be fully qualified and in exact case*
  - Allows sending ooRexx messages to Java objects
    - No strict casing, no strict typing necessary!

BSF4ooRexx: Roundup, 2/2

- BSFCreateRexxProxy()
  - Wraps up an ooRexx object in a Java object
  - Allows to send messages to ooRexx from Java
  - Very powerful if used with Java interface classes or Java abstract classes
    - Java abstract methods can be implemented in ooRexx!

Addendum “Rosetta Code”

- Chapter 1: show a translation of a Rexx class to Java (and vice versa)
  - Then, use the Java translation from ooRexx as well! :)
- Chapter 2: show a Java class that uses a Rexx class
  - Java can send Rexx messages to Rexx objects! :)

Addendum “Rosetta Code”: Chapter 1

- Demonstrate and use a Rexx class RexxDimension
  - Consisting of two attributes, width and height
    - If no arguments for width and height are supplied at object creation time, then their values should be set to 0 by default
      - In ooRexx the constructor method routine is named INIT and will get invoked via the NEW method of an ooRexx class which will forward the received arguments, if any, in the same order to the INIT method routine
  - Showing the Rexx object with the SAY keyword instruction should indicate the name of the Rexx class and the values for the attributes width and height
    - Can be easily done in ooRexx by defining a method routine named makeString that returns a string

Addendum “Rosetta Code”: Chapter 1 ooRexx Program “RexxDimension.rex”

```
rd = .RexxDimension~new
say rd
rd~width = 123             -- assigning a new value to
attribute
rd~height = 456            -- assigning a new value to
attribute
say rd
say
rd = .RexxDimension~new(321,654)
say rd

::class "RexxDimension" public -- creates the Rexx class

      --- define instance fields and methods ---
::attribute width   -- creates getter and setter method
::attribute height  -- creates getter and setter method

::method init       -- constructor method
  expose width height      -- establish direct access
  if arg()=0 then   -- no arguments, set attributes to 0
  do
    width = 0
    height = 0
  end
  else              -- fetch and assign arguments
    use arg width, height

::method makeString -- override default makeString
  expose width height      -- establish direct access
  return self~class~id"[width="width",height="height"]"
```

Output:

```
RexxDimension[width=0,height=0]
RexxDimension[width=123,height=456]

RexxDimension[width=321,height=654]
```

Addendum "Rosetta Code": Chapter 1
Java Program "JavaDimension.java"

```java
public class JavaDimension
{
        // --- define static (class) fields and methods ---
        public static void main(String[] args) // optional static main() method
        {
                JavaDimension jd=new JavaDimension();  // create instance
                System.out.println(jd.toString());     // show String representation
                jd.setWidth(123);                      // set width
                jd.setHeight(456);                     // set height
                System.out.println(jd.toString());     // show String representation
                System.out.println();                  // output empty line
                jd = new JavaDimension(321,654);       // create instance
                System.out.println(jd.toString());     // show String representation
        }

        // --- define instance fields and methods ---
        int width = 0;          // define field
        int height = 0;         // define field

        public JavaDimension()          // default constructor method
        {}

        public JavaDimension(int w, int h)     // constructor method
        {
                width=w;
                height=h;
        }

        public int getWidth ()          // getter method
        {
                return width;
        }

        public void setWidth(int w)     // setter method
        {
                width=w;
        }

        public int getHeight ()         // getter method
        {
                return height;
        }

        public void setHeight(int h)    // setter method
        {
                height=h;
        }

        public String toString()        // override default toString()
        {
                return this.getClass().getName()+"[width="+width+
                                                 ",height="+height+"]";
        }
}
```

Output:

```
JavaDimension[width=0,height=0]
JavaDimension[width=123,height=456]

JavaDimension[width=321,height=654]
```

Addendum "Rosetta Code": Chapter 1 ooRexx Program Using Java Class, 1

- Demonstrate and use a Java class JavaDimension that is equivalent to RexxDimension
- Some notes
  - Compile with javac JavaDimension.java which creates the compiled file JavaDimension.**class**
    - Make sure that the environment variable CLASSPATH contains a dot (".", current directory) such that Java can find the class in the current directory as well , otherwise a *ClassNotFoundException* gets thrown by Java
      - Programs, including Rexx programs, that use this Java class need to run off tthe current directory where the JavaDimension class is located
    - Run the program with java JavaDimension (no file extension!)

Addendum “Rosetta Code”: Chapter 1 ooRexx Program Using Java Class, 2

```
-- main program ("prolog"), compare to Java's static main method
jd = .bsf~new("JavaDimension")
say jd~toString
jd~width = 123          -- treat Java fields as Rexx attributes!
jd~height = 456         -- treat Java fields as Rexx attributes!
say jd~toString
say
jd = .bsf~new("JavaDimension",321,654)
say jd~toString

::requires "BSF.CLS"    -- load ooRexx-Java bridge
```

Output:

```
JavaDimension[width=0,height=0]
JavaDimension[width=123,height=456]

JavaDimension[width=321,height=654]
```

Addendum “Rosetta Code”: Chapter 1 ooRexx Program Using Java Class, 2

```
-- main program ("prolog"), compare to Java's static main method
jd = .bsf~new("JavaDimension")
say jd~toString
jd~setWidth(123)       -- use Java setter method
jd~setHeight(456)      -- use Java setter method
say jd~toString
say
jd = .bsf~new("JavaDimension",321,654)
say jd~toString

::requires "BSF.CLS"   -- load ooRexx-Java bridge
```

Output:

```
JavaDimension[width=0,height=0]
JavaDimension[width=123,height=456]

JavaDimension[width=321,height=654]
```

Addendum “Rosetta Code”: Chapter 2

- Demonstrate a Java class that uses the Rexx class RexxDimension
  - Java program uses the Java scripting framework to load the Rexx engine
  - Java program executes a small Rexx program that calls RexxDimension.rex and which returns the Rexx class object for “RexxDimension“
    - Note # 1: will run its main program (prolog), hence output from Rexx will occur
    - Note # 2: using the Java scripting framework wll cause a prefix to the standard monitor objects (.input, .output, .error, .traceOutput, .debugInput) to be prepended
  - Java program creates a RexxDimension instance without supplying arguments
    - It uses the attribute setters (the messages append an equal sign to the attribute name)
    - It uses makeString to have the Rexx object show its representing string value
  - Java program creates another RexxDimension instance this time supplying arguments
    - It uses makeString to have the Rexx object show its representing string value

Addendum “Rosetta Code”: Chapter 2
Java Program “JavaUseRexxDimension.java”

```
import javax.script.ScriptEngineManager;
import javax.script.ScriptEngine;
import org.rexxla.bsf.engines.rexx.RexxProxy;
public class JavaUseRexxDimension {
       public static void main(String[] args)    // optional static main() method
       {
              try {
                     ScriptEngine engine = new ScriptEngineManager().getEngineByName("rexx");
                     String code = "call RexxDimension.rex \n" +
                                   "return .RexxDimension -- return ooRexx class object \n";
                     RexxProxy rpClz = (RexxProxy) engine.eval(code);
                            // create a RexxDimension object
                     RexxProxy ro = (RexxProxy) rpClz.sendMessage0("NEW");
                     System.out.println("Java: "+ro.sendMessage0("makeString"));
                     ro.sendMessage1("WIDTH=", 666);
                     ro.sendMessage1("HEIGHT=", 777);
                     System.out.println("Java: "+ro.sendMessage0("makeString")+"\n");
                            // create a RexxDimension option
                     ro = (RexxProxy) rpClz.sendMessage2("NEW", 888, 999);
                     System.out.println("Java: "+ro.sendMessage0("makeString")+"\n");
              } catch (Throwable t) {
                     System.err.println("Java: error occurred: " + t);
              }
              System.exit(0);              // end Java
       }
}
```

Output:

```
REXXout>RexxDimension[width=0,height=0]
REXXout>RexxDimension[width=123,height=456]
REXXout>
REXXout>RexxDimension[width=321,height=654]
Java: RexxDimension[width=0,height=0]
Java: RexxDimension[width=666,height=777]

Java: RexxDimension[width=888,height=999]
```