
proobjectlink-jpi-tuprolog
v. 1.2-SNAPSHOT
User Guide

Table of Contents

1. Table of Contents	i
2. What Is	1
3. Getting Started	3
4. Prolog Programming	5
5. Bidirectional Interface	6
6. Development Tools	18
7. Contribution	20
8. Related Works	23
9. FAQ	25

1 What Is

1.1 What is

1.1.1 Introduction

Java Prolog Interface (JPI) is an Application Provider Interface (API) for interaction between Java and Prolog programming languages. Is a bidirectional interface that communicate Java applications with Prolog program or database and Prolog procedures with Java class and methods.

JPI is an abstraction layer over concrete prolog drivers over Prolog Engines. This API define all mechanism to interact with any Prolog Engine and maintain the application independent to a specific underlying engine. JPI have several connectors to open source prolog engines like SWI, YAP, XSB native engines and tuProlog, jTrolog, jLog Java based prolog engines.

JPI study all related Java-Prolog integration libraries and take the better features from each solution with the propose to achieve a common integration interface. The last feature allows switch the underlying Prolog Engine driver and the application code still be the same.

JPI run over any Java Virtual Machine that support Java SE 5 or above. The project was tested over HotSpot, Open J9 and JRockit Virtual Machines over Operating Systems like Windows (7,8,10), Linux (Debian, Ubuntu) and Mac OS X. Can be deployed on Servlets Containers like Jetty, Tomcat or Glassfish Application Server. JPI can be include in any Java Project using the commonest Java Integration Development Enviroment (IDE) like Eclipse, Netbeans, IntelliJIDEA and so on.

JPI is developed and maintained by Prolobjectlink Project an open source initiative for build logic based applications using Prolog like fundamental Logic Programming Language in the persistence layer and application programming.

The selected license for JPI is Simplified BSD License a permissive license allowing to concrete implementations can use some possibilities like GPL, Apache 2.0 and others in the interface implementation. We suggest adopt the same license from prolog java driver if it is possible. In this way the java prolog driver and your JPI implementation share the same license and can be combined with JPI interface that is less restrictive licensed. Finally, license is the most restrictive licensed, being in many occasions the java prolog driver licenses the most restrictive.

1.1.2 Copyright and License Information

JPI is release under Simplified BSD License:

Copyright © 2019 Prolobjectlink Project. All rights reserved.

Redistribution and use in source and binary forms, with or without modification, are permitted provided that the following conditions are met:

1. Redistributions of source code must retain the above copyright notice, this list of conditions and the following disclaimer.
2. Redistributions in binary form must reproduce the above copyright notice, this list of conditions and the following disclaimer in the documentation and/or other materials provided with the distribution.

THIS SOFTWARE IS PROVIDED BY THE COPYRIGHT HOLDERS AND CONTRIBUTORS "AS IS" AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE COPYRIGHT OWNER OR CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL,

SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

1.1.3 Release Notes

Version 1.0.0: Initial release.

1.1.4 Acknowledgments

Blah, Blah, ...

2 Getting Started

2.1 Getting Started

2.1.1 Install

Java Prolog Interface API is distributed with implementation adapter and concrete prolog driver library until it is possible according to related libraries licenses. The distributions are named normally such that **proobjectlink-jpi-jpl7-swi7-x.y.z-dist.zip** meaning that this distribution is a JPI implementation over JPL version 7 or above and SWI-Prolog version 7 or above. The x.y.z is the distribution version. The distribution can be downloaded in zip or tar.gz compresses format. To install you need perform the following steps:

- Install Java Runtime Environment (JRE) 1.8 or above.
- Install Native Prolog Engine compatible to Operating System and your architecture. If the Prolog Engine to use is Java-based this step is omitted.
- Configure System Path with Prolog Engine routes. If the Prolog Engine to use is Java-based this step is omitted.
- Download Java Prolog Interface compatible to related prolog engine and unzip the distribution over Operating File System.
- Configure System Path with JPI unzip folder route.
- Open a new System console and type `plink -i` to see the product information.

For the JPI beginners we recommended start with a Pure Java-Prolog Engine because have less configuration aspects and native engine are more difficult to link.

2.1.2 Directories

After download and unzip JPI distribution in the final JPI folder you will see the following structure:

Folder/File	Description
bin	Binaries scripts
docs	Documentation
prt	Prolog programs files
lib	Library jars files
obj	Programs to link native engine procedures
src	Adapter source folder
CONTRIBUTING	Binaries scripts
LICENSE	Binaries scripts
NOTICE	Binaries scripts
README	Binaries scripts

2.1.3 Architecture

In general way and in bottom-up order the JPI architecture is composed by the guest Operating System at low level. Over this level we find compatible with guest Operating System and Native Prolog Engines implementations. Over this level we find Pure Java Prolog Engine implementations

and Java Driver libraries to Native Prolog Engine. Over this layer is the JPI interface adapter implementation for your correspondent Java Prolog Driver. In the top level we find a User Application that use the JPI interface.



2.1.4 Getting started Java to Prolog

After installation and architecture compression you can use the hello world sample for test the system integration. This hello world sample show how interacts with JPI from Java programming language with Abstracted Prolog Engine. For the first experience we suggesting use a Java-based Prolog engine like tuProlog because have less configuration aspects.

Create in your preferred development environment an empty project. Set in the project build path the JPI downloaded libraries located at lib folder. Create a Main Java class that look like below code:

```

public class Main {

    public static void main(String[] args) {
        PrologProvider provider = Prolog.
            getProvider(XsbProlog.class);
        PrologEngine engine = provider.newEngine();
        engine.asserta("sample('hello wolrd')");
        PrologQuery query=engine.query("sample(X)");
        System.out.println(query.one());
    }

}

```

2.1.5 Getting started Prolog to Java

Blah, Blah, ...

3 Prolog Programming

3.1 Prolog Programming

3.1.1 Prolog Language

The Prolog belongs to the declarative programming languages paradigm. the Prolog programs are based on valid conclusion over facts. Prolog is a LP language specially indicated to modeling problems that imply objects and relations among objects. Prolog have simple syntax, is weakness typed, have simples data structures, support recursion and is extensible. One Prolog program have two basic components or clause, facts and rules.

All Prolog programs are a succession of clauses where every clause end with dot character. They are two kind of clauses, Facts and Rules. Every Prolog clause have two components, one head and one body. Facts are the case where the clause only have head component but don't have body and they are used to indicate things unconditionally true about some domain. Rule have head and body and both are separate by neck operator (`:-`). Rules are used to indicate things conditionally true about some domain. Neck operator semantic denote that one condition should be satisfy by the clause head to be true. The clause body specify the condition order to verify for the conclusion or head.

4 Bidirectional Interface

4.1 Bidirectional Interface

4.1.1 Getting started Java to Prolog

After installation and architecture compression you can use the hello world sample for test the system integration. This hello world sample show how interacts with JPI from Java programming language with Abstracted Prolog Engine. For the first experience we suggesting use a Java-based Prolog engine like tuProlog because have less configuration aspects.

Create in your preferred development environment an empty project. Set in the project build path the JPI downloaded libraries located at lib folder. Create a Main Java class that look like below code:

```
public class Main {  
    public static void main(String[] args) {  
        PrologProvider provider = Prolog.getProvider();  
        PrologEngine engine = provider.newEngine();  
        engine.asserta("sample('hello wolrd')");  
        PrologQuery query=engine.query("sample(X)");  
        System.out.println(query.one());  
    }  
}
```

4.1.2 Architecture

JPI use a layered architecture pattern where every layer represents a component. The multi-engine Java Prolog connectors provide different levels of abstraction to simplify the implementations of common inter-operability task JPC. Java Prolog Connectors architectures describe three fundamentals layers, High-level API layer, Engine Adapter layer and Concrete Engine layer. High-level API layer define all services to be used by the users in the Java Prolog Application that is the final architecture layer on the architecture stack. High-level API provide the common implementation of Engine Abstraction, Data Type and Inter-Language conversion. The adapter layer adapts before mentioned features to communicate with the concrete Engine Layer, being the last responsible of execute the request services.

All existing Java Prolog Connectors implementation only bring support for Native Prolog Engines that have JVM bindings driver. JPI project is more inclusive and find connect all Prolog Engines Categories, Native and Java Based implementations. Some particular Java Based implementations in the future can be implement in strike forward mode the JPI interface. This particulars implementations reduce the impedance mismatch by remove the adapter layer. Therefore, JPI reference implementations will be faster than other that use adapter layer.

In JPI architecture stack in the bottom layer we have the Operating System. The Operating System can be Windows, Linux or Mac OS. Over Operating System, we have the native implementation of JVM and Prolog Engines like SWI, SWI7 and others. Over JVM and Prolog Engines we have Java Based Prolog Engines implementations and JVM bindings driver that share the runtime environment with JVM and native Prolog Engines. Over Java Based Prolog Engines implementations and JVM bindings drivers we have the JPI correspondent adapters. The adapters artifacts are the JPI implementations for each Prolog Engines. Over each adapter we have the JPI application provider interface and at the top stack we the final user application. The user application only interacts with the JPI providing single sourcing and transparency.

4.1.3 Prolog Provider

Prolog Provider is the mechanism to interact with all Prolog components. Provider classes implementations allow create Prolog Terms, Prolog Engine, Java Prolog Converter, Prolog Parsers and system logger. Using `io.github.proobjectlink.prolog.Prolog` bootstrap class the Prolog Providers are created specifying the provider class in `getProvider(Class ?)` method. This is the workflow start for JPI. When the Prolog Provider is created the next workflow step is the Prolog Terms creation using Java primitive types or using string with Prolog syntax. Provider allow create/parsing all Prolog Terms (Atoms, Numbers, Variables and Compounds). After term creation/parsing the next step is create an engine instance with `newEngine()` method. Using previous term creation and engine instance Prolog Queries can be formulated. This is possible because the engine class have multiples queries creation methods like a query factory. After query creation the Query interface present many methods to retrieve the query results. The result methods are based on result quantities, result terms, result object types, etc... This is the final step in the workflow. In the table 10 is resumed all Prolog Provider Interface methods.

4.1.4 Prolog Terms

All Java Prolog connector libraries provide data type abstraction. Prolog data type abstraction have like ancestor the Term class. Prolog term is coding like abstract class and other Prolog terms are derived classes. In `PrologTerm` is defined the common term operation for all term hierarchy (functor, arity, compare, unify, arguments). The derived classes implement the correct behavior for each before mentioned operations. All Prolog data types `PrologAtom`, `PrologNumber`, `PrologList`, `PrologStructure` and `PrologVariable` are derived from this class. All before mentioned classes extends from this class the commons responsibilities. `PrologTerm` extends from `Comparable` interface to compare the current term with another term based on Standard Order.

`PrologAtom` represent the Prolog atom data type. Prolog atoms are can be of two kinds simple or complex. Simple atoms are defined like a single alpha numeric word that begin like initial lower case character. The complex atom is defining like any character sequence that begin and end with simple quotes. The string passed to build a simple atom should be match with `{a-z}{A-Za-z0-9_}* regular expression`. If the string passed to build an atom don't match with the before mentioned regular expression the atom constructor can be capable of create a complex atom automatically. For complex atom the string value can have the quotes or just can be absent. The printed string representation of the complex atom implementation set the quotes if they are needed.

```
PrologTerm pam = provider.newAtom("pam");
PrologTerm bob = provider.newAtom("bob");
```

`PrologDouble` represent a double precision floating point number. Extends from `PrologNumber` who contains an immutable `Double` instance. The Prolog Provider is the mechanism to create a new Prolog double invoking `PrologProvider.newDouble(Number)`. `PrologFloat` represent a single precision floating point number. Extends from `PrologNumber` who contains an immutable `Float` instance. The Prolog Provider is the mechanism to create a new Prolog float invoking `PrologProvider.newFloat(Number)`. `PrologInteger` represent an integer number. Extends from `PrologNumber` who contains an immutable `Integer` instance. The Prolog Provider is the mechanism to create a new Prolog integer invoking `PrologProvider.newInteger(Number)`. Prolog term that represent a long integer number. Extends from `PrologNumber` who contains an immutable `Long` instance. The Prolog Provider is the mechanism to create a new Prolog long integer invoking `PrologProvider.newLong(Number)`.

```
PrologTerm pi = provider.newDouble(Math.PI);
PrologTerm euler = provider.newFloat(Math.E);
PrologTerm i = provider.newInteger(10);
PrologTerm l = provider.newLong(10);
```

PrologVariable is created using PrologProvider.newVariable(int) for anonymous variables and PrologProvider.newVariable(String, int) for named variables. The Prolog variables can be used and reused because they remain in java heap. You can instantiate a prolog variable and used it any times in the same clause because refer to same variable every time. The integer parameter represents the declaration variable order in the Prolog clause starting with zero.

```
PrologTerm x = provider.newVariable("X", 0);
PrologTerm y = provider.newVariable("Y", 1);
PrologTerm z = provider.newVariable("Z", 2);

engine.assertz(
    provider.newStructure(grandparent, x, z),
    provider.newStructure(parent, x, y),
    provider.newStructure(parent, y, z)
);
```

PrologReference term is inspired on JPL JRef. This term is like a structure compound term that have like argument the object identification atom. The functor is the @ character and the arity is 1. An example of this prolog term is e.g. @(J#000000000000000425). To access to the referenced object, is necessary use PrologTerm.getObject().

PrologList are a special compound term that have like functor a dot (.) and arity equals 2. Prolog list are recursively defined. The first item in the list is referred like list head and the second item list tail. The list tail can be another list that contains head and tail. A special list case is the empty list denoted by no items brackets ([]). The arity for this empty list is zero. The Prolog Provider is the mechanism to create a new PrologList is invoking PrologProvider.newList() for empty list or PrologProvider.newList(PrologTerm) for one item list or PrologProvider.newList(PrologTerm[]) for many items.

```
PrologTerm empty = provider.newList();
PrologTerm one = provider.newInteger(1);
PrologTerm two = provider.newInteger(2);
PrologTerm three = provider.newInteger(3);
PrologTerm list = provider.newList(
    new PrologTerm[] { one, two, three }
);
for (PrologTerm prologTerm : list) {
    System.out.println(prologTerm);
}
```

PrologList implement Iterable interface to be used in for each sentence iterating over every element present in the list.

```
Iterator<PrologTerm> i = list.iterator();
while (i.hasNext()) {
    PrologTerm prologTerm = i.next();
    System.out.println(prologTerm);
}
```

```

        for (Iterator<PrologTerm> i = list.iterator(); i.hasNext();) {
            PrologTerm prologTerm = i.next();
            System.out.println(prologTerm);
        }

```

Prolog structures consist in a relation the functor (structure name) and arguments enclosed between parenthesis. The Prolog Provider is the mechanism to create a new Prolog structures invoking `PrologProvider.newStructure(String, PrologTerm...)`. Two structures are equals if and only if are structure and have equals functor and arguments. Structures terms unify only with same functor and arguments structures, with free variable or with with structures where your arguments unify if they have the same functor and arity. Structures have a special property named arity that means the number of arguments present in the structure. There are two special structures term. They are expressions (Two arguments structure term with operator functor) and atoms (functor with zero arguments). For the first special case must be used `PrologProvider.newStructure(PrologTerm, String, PrologTerm)` specifying operands like arguments and operator like functor.

```

PrologTerm pam = provider.newAtom("pam");
PrologTerm bob = provider.newAtom("bob");
PrologTerm parent = provider.newStructure("parent", pam, bob);

```

4.1.5 Prolog Engine

Prolog Engine provide a general propose application interface to interact with Prolog Programming Language. Is a convenient abstraction for interacting with Prolog Virtual Machine from Java. In Java Prolog Engine connectors libraries, the abstract engine is able to answer queries using the abstract term representation before mentioned. There are several implementation engines and in this project we try connect from top level engine to more concrete or specific Prolog Engine. Based on JPC we have a top level engine that communicate with more concretes engines. Over this concretes engines we offer several services to interact with the concrete engines with low coupling and platform independency.

4.1.6 Prolog Query

Prolog query is the mechanism to query the prolog database loaded in prolog engine. The way to create a new prolog query is invoking `query()` method in the Prolog Engine. When this method is called the prolog query is open an only `dispose()` in `PrologQuery` object close the current query and release all internal resources. Prolog query have several methods to manipulate the result objects. The main difference is in return types and result quantities. The result types enough depending of desire data type. Maps of variables name key and Prolog terms as value, Maps of variables name key and Java objects as value, List of before mentioned maps, Prolog terms array, Prolog terms matrix, list of Java Objects and list of list of Java Objects. Respect to result quantities Prolog query offer one, n-th or all possible solutions. This is an important feature because the Prolog engine is forced to retrieve the necessary solution quantities. Prolog query implement `Iterable` and `Iterator`. This implementation helps to obtain successive solutions present in the query.

```

public class Main {
    public static void main(String[] args) {
        PrologProvider provider = Prolog.getProvider();
        PrologEngine engine = provider.newEngine("zoo.pl");
        PrologVariable x = provider.newVariable("X", 0);
        PrologQuery query = engine.query(provider.newStructure("dark", x));
        while (query.hasNext()) {
            PrologTerm value = query.nextVariablesSolution().get("X");
            System.out.println(value);
        }
        query.dispose();
        engine.dispose();
    }
}

```

```

public class Main {
    public static void main(String[] args) {
        PrologProvider provider = Prolog.getProvider();
        PrologEngine engine = provider.newEngine("zoo.pl");
        PrologVariable x = provider.newVariable("X", 0);
        PrologQuery query = engine.query(provider.newStructure("da
        for (Collection<PrologTerm> col : query) {
            for (PrologTerm prologTerm : col) {
                System.out.println(prologTerm);
            }
        }
        query.dispose();
        engine.dispose();
    }
}

```

4.1.7 Prolog Query Builder

Prolog query builder to create prolog queries. The mechanism to create a new query builder is using `PrologEngine.newQueryBuilder()`. The query builder emulates the query creation process. After define all participant terms with the `begin(PrologTerm)` method, we specify the first term in the query. If the query has more terms, they are created using `comma(PrologTerm)` for everyone. Clause builder have a `getQueryString()` for string representation of the clause in progress. After clause definition this builder have `query()` method that create the final query instance ready to be used. The follow code show how create a Prolog query `?- big(X), dark(X)`. using `PrologQueryBuilder` interface.

```

PrologVariable x = provider.newVariable("X", 0);
PrologStructure big = provider.newStructure("big", x);
PrologStructure dark = provider.newStructure("dark", x);
PrologQueryBuilder builder = engine.newQueryBuilder();
PrologQuery query = builder.begin(dark).comma(big).query();

```

4.1.8 Prolog Clause

Prolog clause is composed by two prolog terms that define a prolog clause, the head and the body. This representation considers the prolog clause body like a single term. If the body is a conjunctive set of terms, the body is a structure with functor/arity (`/2`) and the first argument is the first element in the conjunction and the rest is a recursive functor/arity (`/2`). The functor and arity for the clause

is given from head term functor and arity. This class define some properties for commons prolog clause implementations. They are boolean flags that indicate if the prolog clause is dynamic multi-file and discontiguos. This class have several methods to access to the clause components and retrieve some clause properties and information about it. Additionally, this class contains a prolog provider reference for build terms in some operations.

4.1.9 Prolog Clause Builder

Prolog clause builder to create prolog clauses. The mechanism to create a new clause builder is using `PrologEngine.newClauseBuilder()`. The clause builder emulates the clause creation process. After define all participant terms with the `begin(PrologTerm)` method, we specify the head of the clause. If the clause is a rule, after head definition, the clause body is created with `neck(PrologTerm)` for the first term in the clause body. If the clause body have more terms, they are created using `comma(PrologTerm)` for everyone. Clause builder have a `getClauseString()` for string representation of the clause in progress. After clause definition this builder have `asserta()`, `assertz()`, `clause()`, `retract()` that use the wrapped engine invoking the correspondent methods for check, insert or remove clause respectively.

```
PrologTerm z = provider.newVariable("Z", 0);
PrologTerm darkZ = provider.newStructure("dark", z);
PrologTerm blackZ = provider.newStructure("black", z);
PrologTerm brownZ = provider.newStructure("brown", z);
PrologClauseBuilder builder = engine.newClauseBuilder();
builder.begin(darkZ).neck(blackZ).assertz();
builder.begin(darkZ).neck(brownZ).assertz();
```

The Prolog result in database is showed in the follow code. The table 19 show the Prolog clause builder interface methods.

```
dark(Z) : -
        black(Z) .
dark(Z) : -
        brown(Z) .
```

4.1.10 Prolog Scripting in Java

Java 6 added scripting support to the Java platform that lets a Java application execute scripts written in scripting languages such as Rhino JavaScript, Groovy, Jython, JRuby, Nashorn JavaScript, etc. All classes and interfaces in the Java Scripting API are in the `javax.script` package. Using a scripting language in a Java application provides several advantages, dynamic type, simple way to write programs, user customization, easy way to develop and provide domain-specific features that are not available in Java. For achieve this propose Java Scripting API introduce a scripting engine component. A script engine is a software component that executes programs written in a particular scripting language. Typically, but not necessarily, a script engine is an implementation of an interpreter for a scripting language. To run a script in Java is necessary perform the following three steps, create a script engine manager, get an instance of a script engine from the script engine manager and Call the `eval()` method of the script engine to execute a script.

```

public class Main {
    public static void main(String[] args) {
        ScriptEngineManager manager = new ScriptEngineManager();
        ScriptEngine engine = manager.getEngineByName("prolog");
        Boolean result = engine.eval("?- X is 5+3.");
        Integer solution = engine.get("X");
        System.out.println(solution);
    }
}

```

Using script engine, it possible read Prolog source file. Read Prolog source file allow coding all prolog source in separate mode respect to Java program.

```

public class Main {
    public static void main(String[] args) {
        ScriptEngineManager manager = new ScriptEngineManager();
        ScriptEngine engine = manager.getEngineByName("prolog");
        Boolean read = engine.eval(new FileReader("family.pl"));
        Boolean eval = engine.eval("?- parent( Parent, Child)");
        Object parent = engine.get("Parent");
        Object child = engine.get("Child");
        System.out.println(parent);
        System.out.println(child);
    }
}

```

4.1.11 Getting started Prolog to Java

One of the main advantages of tuProlog open architecture is that any Java component can be directly accessed and used from Prolog, in a simple and effective way, by means of the JavaLibrary library: this delivers all the power of existing Java components and packages to tuProlog sources. In this way, all Java packages involving interaction (such as Swing, JDBC, the socket package, RMI) are immediately available to increase the interaction abilities of tuProlog: “one library for all libraries” is the basic motto.

4.1.11.1 Mapping data structures

Complete bi-directional mapping is provided between Java primitive types and tuProlog data types. By default, tuProlog integers are mapped into Java int or long as appropriate, while byte and short types are mapped into tuProlog's Int instances. Only Java double numbers are used to map tuProlog reals, but float values returned as result of method invocations or field accesses are handled properly anyway, without any loss of information. Boolean Java values are mapped into specific tuProlog Term constants. Java chars are mapped into Prolog atoms, but atoms are mapped into Java Strings by default. The any variable () can be used to specify the Java null value.

4.1.11.2 General predicates description

The library offers the following predicates: (i) the java object/3 predicate is used to create a new Java object of the specified class, according to the syntax:

```
java_object(ClassName, ArgumentList, ObjectRef )
```

ClassName is a Prolog atom bound to the name of the proper Java class (e.g. 'Counter', 'java.io.FileInputStream'), while the parameter ArgumentList is a Prolog list used to supply the

required arguments to the class constructor: the empty list matches the default constructor. Also Java arrays can be instantiated, by appending [] at the end of the ClassName string. The reference to the newly-created object is bound to ObjectRef, which is typically a ground Prolog term; alternatively, an unbound term may be used, in which case the term is bound to an automatically-generated Prolog atom '\$obj-N', where N is a progressive integer. In both cases, these atoms are interpreted as object references – and therefore used to operate on the Java object from Prolog – only in the context of JavaLibrary's predicates. The predicate fails whenever ClassName does not identify a valid Java class, or the constructor does not exist, or arguments in ArgumentList are not ground, or ObjectRef already identifies an object in the system.

According to the default behaviour of java object, when a ground term is bound to a Java object by means of the predicate, the binding is kept for the full time of the demonstration (even in the case of backtracking). This behaviour can be changed, getting the bindings created by the java object undone by backtracking, by changing the value of the flag java object backtrackable to true (the default is false).

(ii) the $\text{!}/2$ predicate is used to invoke a method on a Java object according to a send-message pattern:

```
ObjectRef <- MethodName (Arguments )
ObjectRef <- MethodName (Arguments ) returns Term
```

ObjectRef is an atom interpreted as a Java object reference as explained above, while MethodName is the Java name of the method to be invoked, along with its Arguments. The returns keyword is used to retrieve the value returned from non-void Java methods and bind it to a Prolog term: if the type of the returned value can be mapped onto a primitive Prolog data type (a number or a string), Term is unified with the corresponding Prolog value; if, instead, it is a Java object other than the ones above, Term is handled as ObjectRef in the case of java object/3. Static methods can be invoked using the compound term class(ClassName) in the place of ObjectRef. If MethodName does not identify a valid method for the object (class), or arguments in ArgumentList are not valid (because of a wrong signature or not ground values) the predicate fails.

(iii) the . infix operator is used, in conjunction with the set / get pseudo- method pair, to access the public fields of a Java object. The syntax is based on the following constructs:

```
ObjectRef . Field <- set(GroundTerm )
ObjectRef . Field <- get(Term )
```

As usual, ObjectRef is the Prolog identifier for a Java object. The first construct set the public field Field to the specified GroundTerm, which may be either a value of a primitive data type, or a reference to an existing object: if GroundTerm is not ground, the infix predicate fails. The second construct retrieves the value of the public field Field, where Term is handled once again as ObjectRef in the case of java object/3. As for methods, static fields of classes can be accessed using the compound term class(ClassName) in the place of ObjectRef. Some helper predicates are provided to access Java array elements:

```
java_array_set(ArrayRef, Index, Object )
java_array_set_Basic_Type(ArrayRef, Index, Value )
```

to set elements,

```
java_array_get(ArrayRef, Index, Object )
java_array_get_Basic_Type(ArrayRef, Index, Value )
```

to get elements,

```
java_array_length(ArrayObject,Size )
```

to get the array length.

It is worth to point out that the set and get formal pseudo-methods above are not methods of some class, but just part of the construct of the . infix operator, according to a JavaBeans-like approach.

(iv) the as infix operator is used to explicitly specify (i.e., cast) method argument types:

```
ObjectRef as ClassName
```

By writing so, the object represented by ObjectRef is considered to belong to class Classname : both ObjectRef and Classname have the usual meaning explained above. The operator works also with primitive Java types, specified as Classname (for instance, myNumber as int). The purpose of this predicate is both to provide methods with the exact Java types required, and to solve possible overloading conflicts a-priori.

(v) The java class/4 predicate makes it possible to create and load a new Java class from a source text provided as an argument, thus supporting dynamic compilation of Java classes:

```
java_class(SourceText, FullClassName, ClassPathList, ObjectRef )
```

SourceText is a string representing the text source of the Java class, FullClassName is the full Java class name, and ClassPathList is a (possibly empty) Prolog list of class paths that may be required for a successful dynamic compilation of this class. ObjectRef is a reference to an instance of the class java.lang.Class that represents the newly-created class. The predicate fails whenever SourceText contains errors, or the class cannot be located in the package hierarchy as specified, or ObjectRef already identifies an object in the system.

4.1.11.3 Predicates

Here follows a list of predicates implemented by this library, grouped in categories corresponding to the functionalities they provide.

4.Method Invocation, Object and Class Creation

- java_object/3 java_object(ClassName, ArgList, ObjId) is true iff ClassName is the full class name of a Java class available on the local file system, ArgList is a list of arguments that can be meaningfully used to instantiate an object of the class, and ObjId can be used to reference such an object; as a side effect, the Java object is created and the reference to it is unified with ObjId. It is worth noting that ObjId can be a Prolog variable (that will be bound to a ground term) as well as a ground term (not a number). According to the value of the flag java object retractable, the binding that is established between the ObjId term and the Java object is not destroyed with backtrack- ing (false value, default case) or destroyed (true value).

```
Template: java_object(+full class name,+list,?obj id)
```

- java_object_bt/3 java_object_bt(ClassName, ArgList, ObjId) has the same behaviour of java_object/3 when the value of java object backtrackable is true.

```
Template: java object bt(+full class name,+list,?obj id)
```

- java_object_nb/3 java_object_nb(ClassName, ArgList, ObjId) has the same behaviour of java object/3 when the value of java object backtrackable is false.

```
Template: java_object_nb(+full class name,+list,?obj id)
```

- `destroy_object/1` `destroy_object(ObjId)` is true and as a side effect the binding between `ObjId` and a Java object, possibly established, by previous predicates is destroyed.

Template: `destroy_object(@obj id)`

- `java_class/4` `java_class(ClassSourceText, FullClassName, ClassPathList, ObjId)` is true iff `ClassSourceText` is a source string describing a valid Java class declaration, a class whose full name is `FullClassName`, according to the classes found in paths listed in `ClassPathList`, and `ObjId` can be used as a meaningful reference for a `java.lang.Class` object representing that class; as a side effect the described class is (possibly created and) loaded and made available to the system.

Template: `java_class(@java source,@full class name,@list,?obj id)`

- `java_call/3` `java_call(ObjId, MethodInfo, ObjIdResult)` is true iff `ObjId` is a ground term currently referencing a Java object, which provides a method whose name is the functor name of the term `MethodInfo` and possible arguments the arguments of `MethodInfo` as a compound, and `ObjIdResult` can be used as a meaningful reference for the Java object that the method possibly returns. As a side effect the method is called on the Java object referenced by the `ObjId` and the object possibly returned by the method invocation is referenced by the `ObjIdResult` term. The anonymous variable used as argument in the `MethodInfo` structure is interpreted as the Java null value.

Template: `java_call(@obj id,@method signature,?obj id)`

- `'<-'/2` `'<-'(ObjId, MethodInfo)` is true iff `ObjId` is a ground term currently referencing a Java object, which provides a method whose name is the functor name of the term `MethodInfo` and possible arguments the arguments of `MethodInfo` as a compound. As a side effect the method is called on the Java object referenced by the `ObjId`. The anonymous variable used as argument in the `MethodInfo` structure is interpreted as the Java null value.

Template: `'<-'(@obj id,@method signature)`

- `return/2` `return('<-'(ObjId, MethodInfo), ObjIdResult)` is true iff `ObjId` is a ground term currently referencing a Java object, which provides a method whose name is the functor name of the term `MethodInfo` and possible arguments the arguments of `MethodInfo` as a compound, and `ObjIdResult` can be used as a meaningful reference for the Java object that the method possibly returns. As a side effect the method is called on the Java object referenced by the `ObjId` and the object possibly returned by the method invocation is referenced by the `ObjIdResult` term. The anonymous variable used as argument in the `MethodInfo` structure is interpreted as the Java null value. It is worth noting that this predicate is equivalent to the `java_call` predicate.

Template: `return('<-'(@obj id,@method signature),?obj id)`

4. Java Array Management

- `java_array_set/3` `java_arrayset(ObjArrayId, Index, ObjId)` is true iff `ObjArrayId` is a ground term currently referencing a Java array object, `Index` is a valid index for the array and `ObjId` is a ground term currently referencing a Java object that could be inserted as an element of the array (according to Java type rules). As side effect, the object referenced by `ObjId` is set in the array referenced by `ObjArrayId` in the position (starting from 0, following the Java convention) specified by `Index`. The anonymous variable used as `ObjId` is interpreted as the Java null value. This predicate can be used for arrays of Java objects: for arrays whose elements are Java primitive types (such as `int`, `float`, etc.) the following predicates can be used, with the same semantics of `java_array_set` but specifying directly the term to be set as a tuProlog term (according to the mapping described previously):

```

java_array_set_int(ObjArrayId, Index, Integer)
java_array_set_short(ObjArrayId, Index, ShortInteger)
java_array_set_long(ObjArrayId, Index, LongInteger)
java_array_set_float(ObjArrayId, Index, Float)
java_array_set_double(ObjArrayId, Index, Double)
java_array_set_char(ObjArrayId, Index, Char)
java_array_set_byte(ObjArrayId, Index, Byte)
java_array_set_boolean(ObjArrayId, Index, Boolean)

```

Template: `java_array_set(@obj id,@positive integer,+obj id)`

• `java_array_get/3 java_array_get(ObjArrayId, Index, ObjIdResult)` is true iff `ObjArrayId` is a ground term currently referencing a Java array object, `Index` is a valid index for the array, and `ObjIdResult` can be used as a meaningful reference for a Java object contained in the array. As a side effect, `ObjIdResult` is unified with the reference to the Java object of the array referenced by `ObjArrayId` in the `Index` position. This predicate can be used for arrays of Java objects: for arrays whose elements are Java primitive types (such as `int`, `float`, etc.) the following predicates can be used, with the same semantics of `java_array_get` but binding directly the array element to a tuProlog term (according to the mapping described previously):

```

java_array_get_int(ObjArrayId, Index, Integer)
java_array_get_short(ObjArrayId, Index, ShortInteger)
java_array_get_long(ObjArrayId, Index, LongInteger)
java_array_get_float(ObjArrayId, Index, Float)
java_array_get_double(ObjArrayId, Index, Double)
java_array_get_char(ObjArrayId, Index, Char)
java_array_get_byte(ObjArrayId, Index, Byte)
java_array_get_boolean(ObjArrayId, Index, Boolean)

```

Template: `java_array_get(@obj id,@positive integer,?obj id)`

• `java_array_length/2 java_array_length(ObjArrayId, ArrayLength)` is true iff `ArrayLength` is the length of the Java array referenced by the term `ObjArrayId`.

Template: `java_array_length(@term,?integer)`

4.Helper Predicates

• `java object string/2 java object string(ObjId,String)` is true iff `ObjId` is a term referencing a Java object and `PrologString` is the string representation of the object (according to the semantics of the `toString` method provided by the Java object).

Template: `java object string(@obj id,?string)`

4.Java Swing GUI from tuProlog

What about creating Java GUI components from the tuProlog environment? Here is a little example, where a standard Java Swing open file dialog windows is popped up:

```
open_file_dialog( FileName ):-  
    java_object( 'javax.swing.JFileChooser', [], Dialog ),  
    Dialog <- showOpenDialog(_) returns Result,  
    write(Result),  
    Dialog <- getSelectedFile returns File,  
    File <- getName returns FileName,  
    class('java.lang.System') . out <- get(Out),  
    Out <- println('you want to open file '),  
    Out <- println(FileName).
```

5 Development Tools

Paragraph 1, line 1. Paragraph 1, line 2.

Paragraph 2, line 1. Paragraph 2, line 2.

5.1 Section title

5.1.1 Sub-section title

5.1.1.1 Sub-sub-section title

5.Sub-sub-sub-section title

5.Sub-sub-sub-sub-section title

- List item 1.
- List item 2.
Paragraph contained in list item 2.
 - Sub-list item 1.
 - Sub-list item 2.
- List item 3. Force end of list:

Verbatim text not contained in list item 3

1. Numbered item 1.

A.Numbered item A.

B.Numbered item B.

2. Numbered item 2.

List numbering schemes: [[1]], [[a]], [[A]], [[i]], [[I]].

Defined term 1

of definition list.

Defined term 2

of definition list.

Verbatim text
in a box

--- instead of +++ suppresses the box around verbatim text.

Figure caption

Centered cell 1,1	Left-aligned cell 1,2	Right-aligned cell 1,3
cell 2,1	cell 2,2	cell 2,3

Table caption

No grid, no caption:

cell	cell
cell	cell

Horizontal line:

5.2 ^L New page.

Italic font. **Bold** font. Monospaced font.

Anchor. Link to [anchor](#). Link to <http://www.pixware.fr>. Link to [showing alternate text](#). Link to [Pixware home page](#).

Force line
break.

Non breaking space.

Escaped special characters: ~, =, -, +, *, [,], <, >, {, }, \.

Copyright symbol: ©, ©, ©.

6 Contribution

6.1 Contribution

6.1.1 Issues

See the issue tracker at <https://github.com/proobjectlink/proobjectlink-jpi-tuprolog> to create a new issue or take an existing one.

6.1.2 Changes and Build

Fork the repository in GitHub.

Clone your forked repository in your preferred IDE

Proobjectlink development requires.

- Java 1.8 - Maven 3.1.0 or above

Make changes in your cloned repository

Run all test to see if the system still consistent after your changes

Create unit-tests and make sure that the include changes are covered to 100%

Run the benchmark to see if the system performance still consistent after your changes

Add a description of your changes in CHANGELOG.txt and src/changes/changes.xml

Commit the changes.

Run an integration test on Travis-CI

Submit a pull request.

6.1.3 New Implementations

The project start with some adapters implementations over most used open source prolog engines.

We accept any new adapter implementation of another prolog engine not covered at this moment.

For this propose create a new GitHub source code repository naming this follow the project convesion:

proobjectlink-jpi- new engine implementation name

Create an new maven project in your preferred IDE named like repository.

Copy the src/assembly/dist.xml descriptor

Copy the src/build/filters folder and change by your console main entry point

Copy and clean src/changes/changes.xml to go reporting every change

Copy src/site folder to generate a similar project site.

Copy the pom.xml properties, build, report, etc... from another implementation

Change the project information.

Add your dependencies including Java Prolog Interface API


```

<repositories>
  <repository>
    <id>ossrh</id>
    <name>Sonatype Nexus Snapshots</name>
    <url>https://oss.sonatype.org/content/repositories/snapshots</url>
    <releases>
      <enabled>>false</enabled>
    </releases>
    <snapshots>
      <enabled>true</enabled>
    </snapshots>
  </repository>
</repositories>
...
<dependencies>
  ...
  <dependency>
    <groupId>org.proobjectlink</groupId>
    <artifactId>proobjectlink-jpi</artifactId>
    <version>[1.0.0, )</version>
  </dependency>
  ...
  <dependency>
    <groupId>junit</groupId>
    <artifactId>junit</artifactId>
    <version>[4.10, )</version>
    <scope>test</scope>
  </dependency>
  ...
</dependencies>

```

In test package copy the unit-tests cases from another implementation to develop in test driven mode.

We suggest like adapter implementation order begin with data types, parsers, engine and finally query.

Run all test to see if the system to see if your implementation pass all.

Create unit-tests and make sure that the include changes are covered to 100%

Create the benchmark to see if the system performance.

Add a description of your changes in CHANGELOG.txt and src/changes/changes.xml

Commit the changes.

Run an integration test on Travis-CI or another CI system

6.1.4 Version Numbering

Proobjectlink version signature is Major.Minor.Micro.

Major version is change when the API compatibility is broken. Minor version is change when a new feature is include in the release. Micro version is change when some bug is fixed or some maintenance take place

Proobjectlink suggest work over the started 1.Y.Z version to preserve compatibility all the time. You are free of make any change adding new features, fixing bugs or code maintenance.

6.1.5 Contact us

Please contact us at our project mailing list <https://groups.google.com/group/proobjectlink> to debate over project evolution

Thanks for contributing to Proobjectlink!

7 Related Works

Paragraph 1, line 1. Paragraph 1, line 2.

Paragraph 2, line 1. Paragraph 2, line 2.

7.1 Section title

7.1.1 Sub-section title

7.1.1.1 Sub-sub-section title

7.Sub-sub-sub-section title

7.Sub-sub-sub-sub-section title

- List item 1.
- List item 2.
Paragraph contained in list item 2.
 - Sub-list item 1.
 - Sub-list item 2.
- List item 3. Force end of list:

Verbatim text not contained in list item 3

1. Numbered item 1.

A.Numbered item A.

B.Numbered item B.

2. Numbered item 2.

List numbering schemes: [[1]], [[a]], [[A]], [[i]], [[I]].

Defined term 1

of definition list.

Defined term 2

of definition list.

Verbatim text
in a box

--- instead of +- suppresses the box around verbatim text.

Figure caption

Centered cell 1,1	Left-aligned cell 1,2	Right-aligned cell 1,3
cell 2,1	cell 2,2	cell 2,3

Table caption

No grid, no caption:

cell	cell
cell	cell

Horizontal line:

7.2 ^L New page.

Italic font. **Bold** font. Monospaced font.

Anchor. Link to [anchor](#). Link to <http://www.pixware.fr>. Link to [showing alternate text](#). Link to [Pixware home page](#).

Force line
break.

Non breaking space.

Escaped special characters: ~, =, -, +, *, [,], <, >, {, }, \.

Copyright symbol: ©, ©, ©.

8 FAQ

8.1 Frequently Asked Questions

General

1. [Why Java Prolog Interface?](#)
2. [How can use Java Prolog Interface?](#)
3. [How include Java Prolog Interface into Maven project?](#)

8.2 General

Why Java Prolog Interface?

Blah, Blah, ...

[\[top\]](#)

How can use Java Prolog Interface?

You can use Java Prolog Interface following these steps:

- Step One
- Step Two
- Step Three

[\[top\]](#)

How include Java Prolog Interface into Maven project?

Blah, Blah, ...

```
...
    <dependencies>
      <dependency>
        <groupId>io.github.proobjectlink</groupId>
        <artifactId>proobjectlink-jpi</artifactId>
        <version>1.0</version>
      </dependency>
    </dependencies>
    ...
```

Blah, Blah, ...

[\[top\]](#)