

Object-Oriented JNI Add-In for Microsoft Visual Studio v.7.1

1 Introduction

1.1 What is OOJNI

Object-Oriented JNI Add-In is a tool developed for MS Visual Studio. It generates C++ code (OOJNI classes) for java byte code selected and includes it into the active C++ project. At the same time OOJNI Add-In makes all project setting for using, compiling and running the code generated. C++ programmer use OOJNI classes as regular C++ classes. Each OOJNI class wraps low-level JNI code to accesses to Java Class fields and methods. All data type conversions (from java-to-C++ and C++-to-java) are hidden from C++ programmer. Each java object reference encapsulated into special C++ class – Java Reference Wrapper, which makes a shallow copy of the java object reference in different OOJNI classes. This approach makes possible to reduce a number of java references used in JNI code.

1.2 Copyright Statement

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2 How OOJNI Works

2.1 Byte code parsing

OOJNI Add-In loads and parses raw byte code for generating JNI wrappers in C++. It is independent of JVM installed and does not use of external modules. The parser implemented in the add-in is designed with ANTLR Tool (see <http://www.antlr.org/>). C++ code generation has three phases

- Parsing Byte Code and building a syntax tree of it
- Analyzing the syntax tree built and, if needed, modification of it
- Generating C++ code with data collected in the syntax tree.

2.2 OOJNI Class model

OOJNI consists of OOJNI Generator that generates OOJNI wrappers for java byte code selected and a library of class helpers for data type mapping (Java-to-C++ and C++-to-Java). These are class templates for java arrays, java string class, JVM API wrappers, etc. By default OOJNI Add-In generates C++ classes that can include wrappers for the all java class members (including inherited from base classes). However, if you want reduce the size of C++ code generated you can restrict a list of class members to be generated. This option makes C++ code created very compact.

3 Setup OOJNI Add-In

3.1 System requirements

Before installing close all instances of MS Visual Studio running and be sure your computer meets the system requirements:

- Operating Systems

- Windows NT 4.0
- Windows 2000
- Windows XP
- Windows Server 2003
- Java Runtime Environment
 - SUN JSE1.3.x and later
 - IBM JDK1.3.x and later
- Integrated Development Environment
 - Microsoft Visual Studio v7.1

3.2 Activating OOJNI Add-In in MS Visual Studio

After installing OOJNI Add-In start MS Visual Studio v.7.1. Then you should activate OOJNI Add-In:

- In the main menu, select *Tools->Customize*. The dialog Customize should appear.
- Press on Tab *Add-ins and Macro Files*.
- In the list *Add-ins and Macro Files* set check on *OOJNI Code Generator...* and close the dialog. OOJNI Toolbar will be shown.

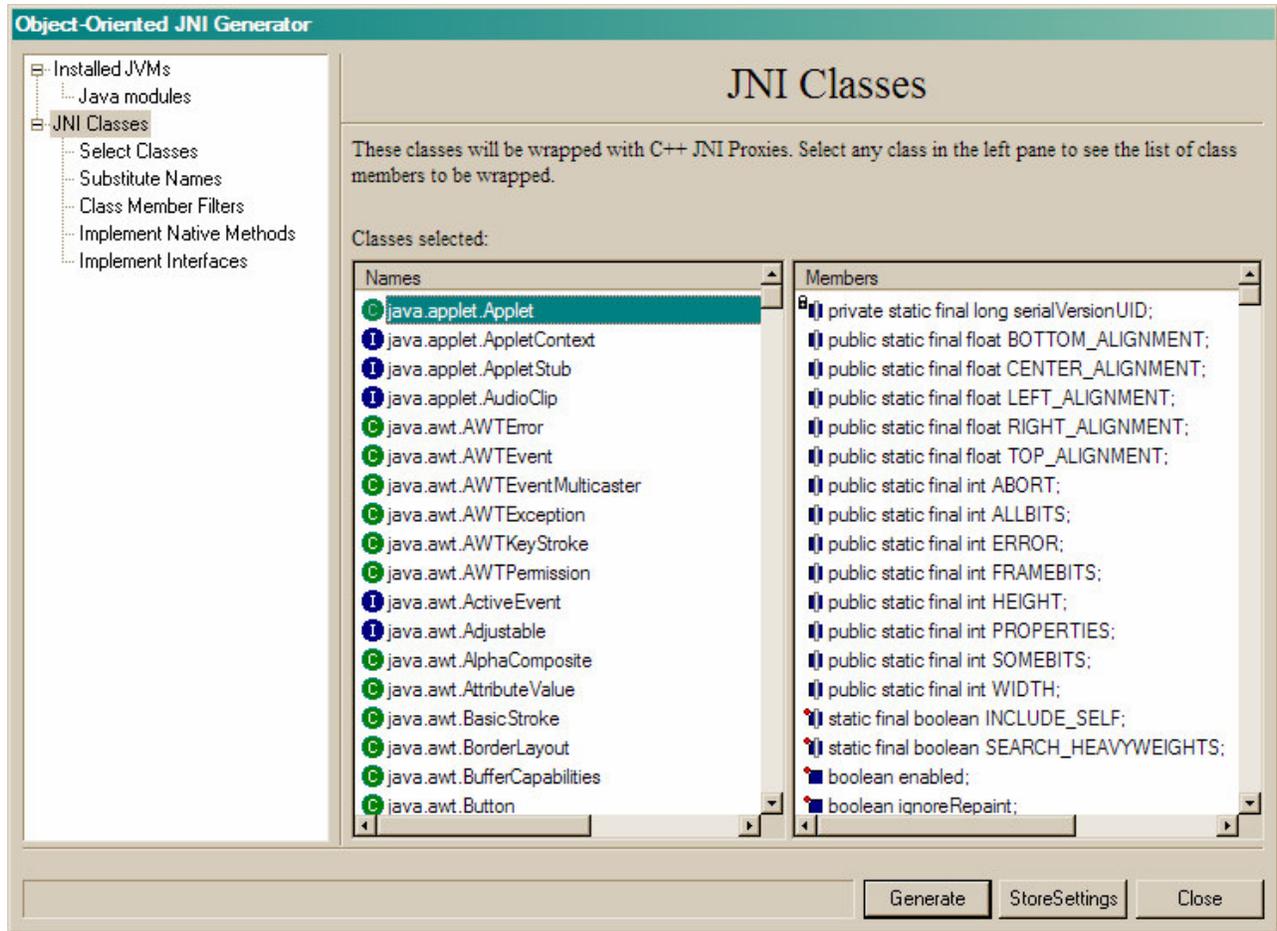
Pressing the button in the toolbar starts OOJNI Dialog. However, the dialog will be blocked if there is no active C++ project. So open or create C++ Project before running OOJNI Add-In and after this press the button in the OOJNI Toolbar to open OOJNI Project Dialog.

4 Guide to the graphical user interface

With graphical user interface, C++ Programmer can select java byte code for which he wants to have the C++ JNI wrappers. A number of wrappers will be the same as a number of java classes selected. Define settings to make C++ code compact. JNI wrapper class names are included to the C++ project. All specific C++ and JVM setting are made by OOJNI Add-In.

4.1 OOJNI GUI structure

OOJNI Add-In Interface has one main dialog with a number of embedded child dialogs and the main menu as a tree for switching these dialogs (see Picture.1).



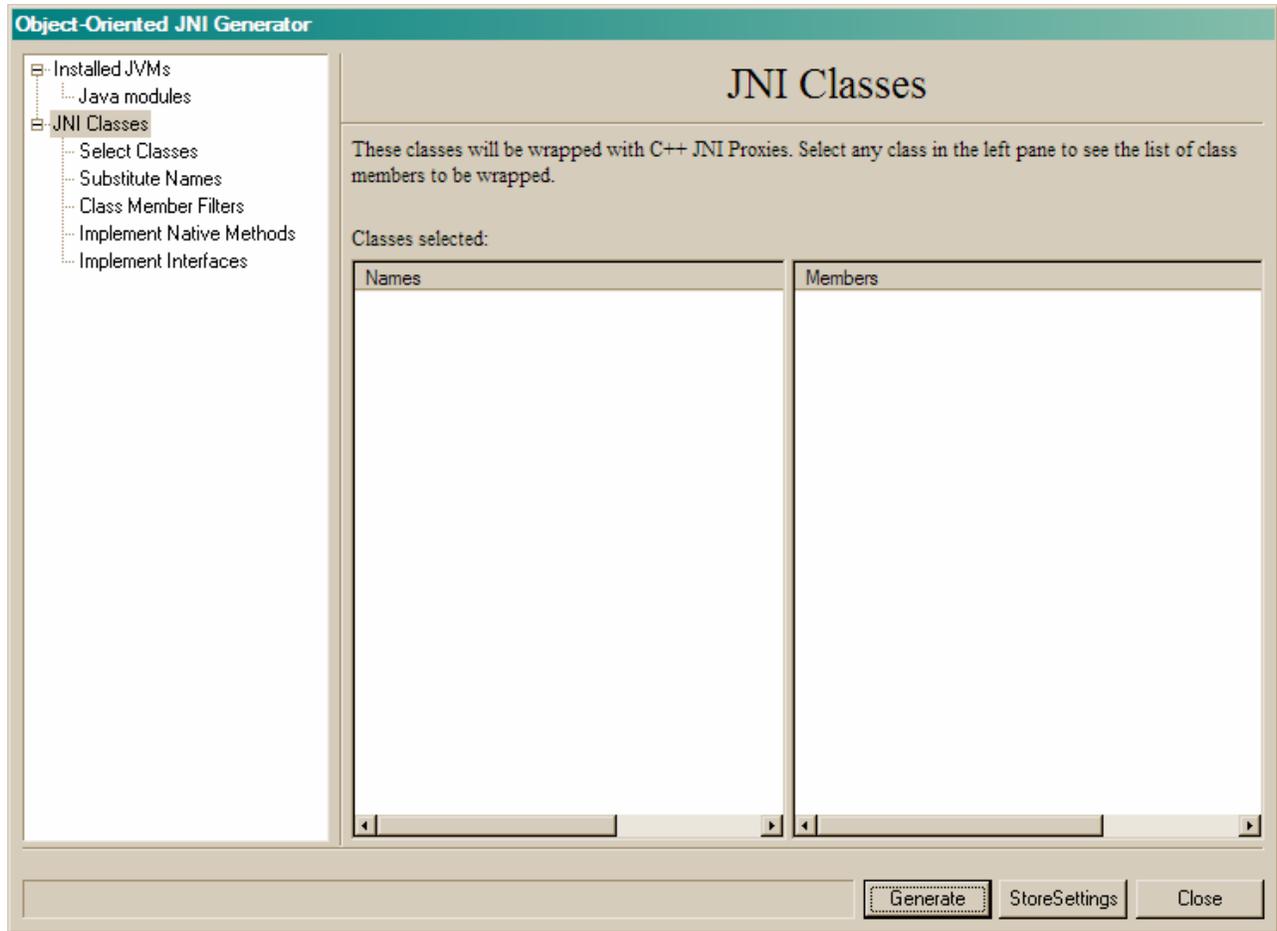
Pic.1. Main OOJNI Add-In Dialog View.

Two lists in the right are java classes selected for generating C++ wrappers and members of the class selected. Each class name has a bitmap “C” – Class or “I”- Interface. There are three buttons always exposed:

- **Generate** – starts the process of generating C++ wrappers.
- **StoreSettings** – stores the current OOJNI project.
- **Close** – closes the dialog.

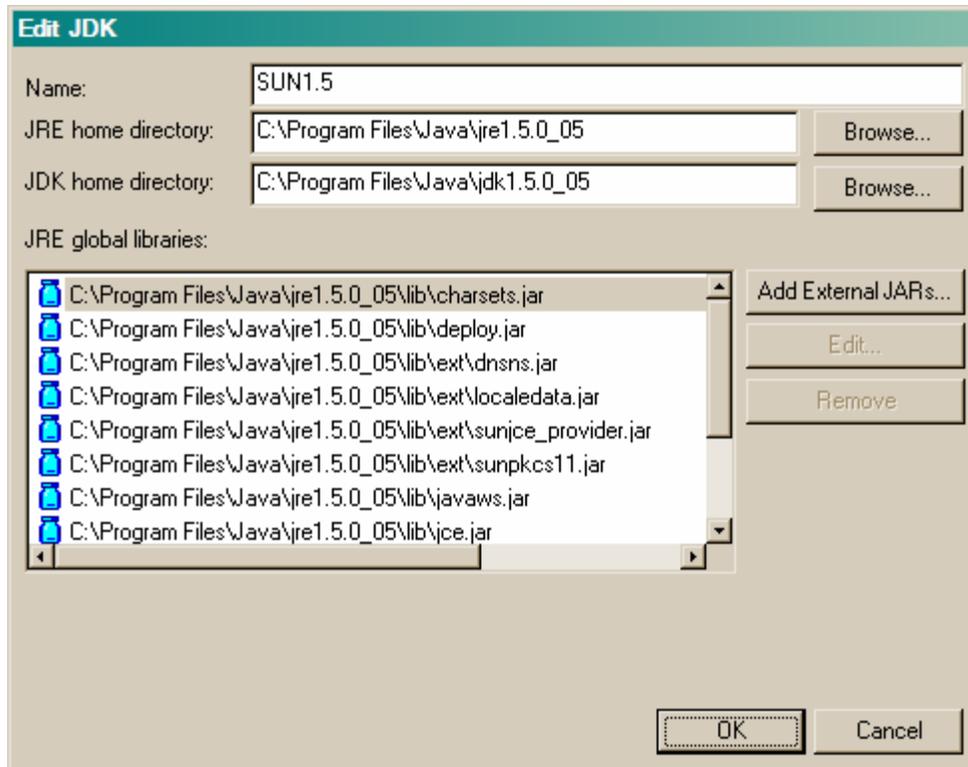
4.2 Creating OOJNI Project

Start OOJNI Dialog for a new C++ project (see Picture.2)



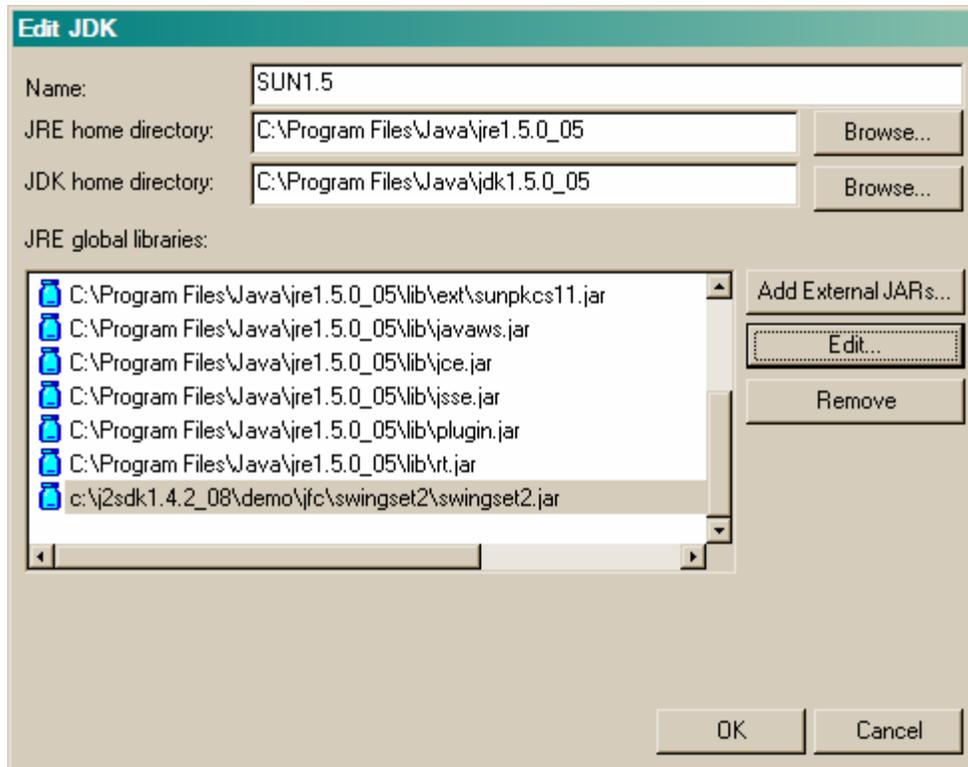
Picture.2. OoJNI Dialog for a new C++ Project.

First, you should select JVM (if in your computer there are more than one installed). In the left tree select *Installed JVMs* and this view check JVM needed (see Picture.3).



Pic.4. Edit JDK Path.

Correct JRE or/and JDK paths, change JDK Name in you want. Beneath there is a list of the system java modules with three buttons: **Add External JARs...**, **Edit...**, **Remove**. The buttons **Edit...** and **Remove** disabled if you select a system module (Any module in this list is accessible for all OOJNI projects). To make any java mode global for all OOJNI projects add it to this list by pressing **Add External JARs** Button (this feature is not supported in Demo version). In the file dialog select any java module you want to be global (jar, zip, class). Let add swinset2.jar (Pic.5)



Picture.5. Adding **swingset2.jar** to the global modules list.

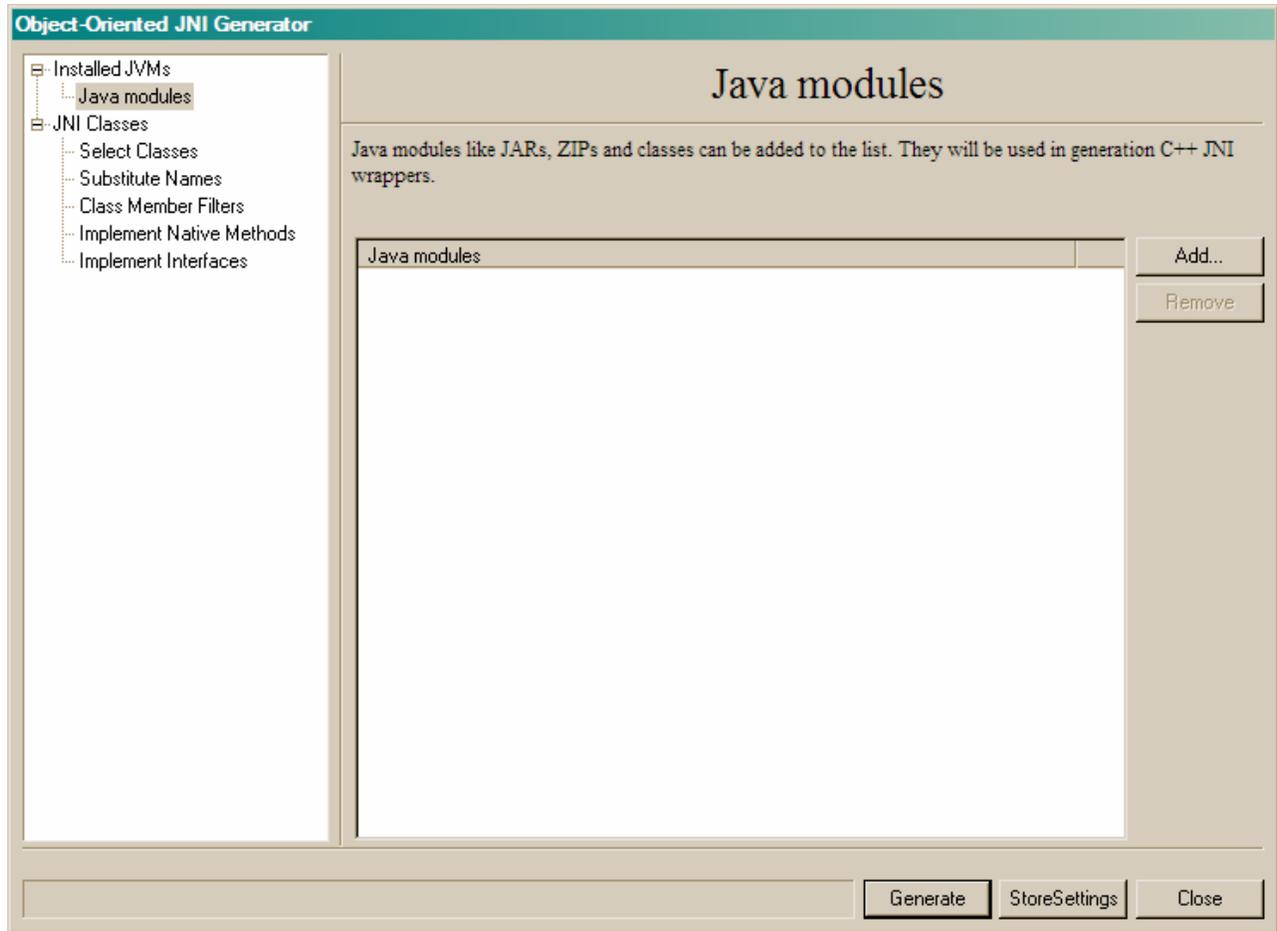
Here *Edit...* and *Remove* buttons enabled and this item you can remove or substitute.

4.3 Connecting to JVM installed

In the JVM List View (see Picture.3) the checked JVM is used for generating JNI wrappers. It means that classes from system/global modules OOJNI generator looks for without special setting. If you set check of another JVM then OOJNI Add-In reloads all classes selected in the list of view in the Picture.1.

4.4 Loading java modules

Now select *Java Modules* item in the left Tree to activate the module selection view (Pic.6).

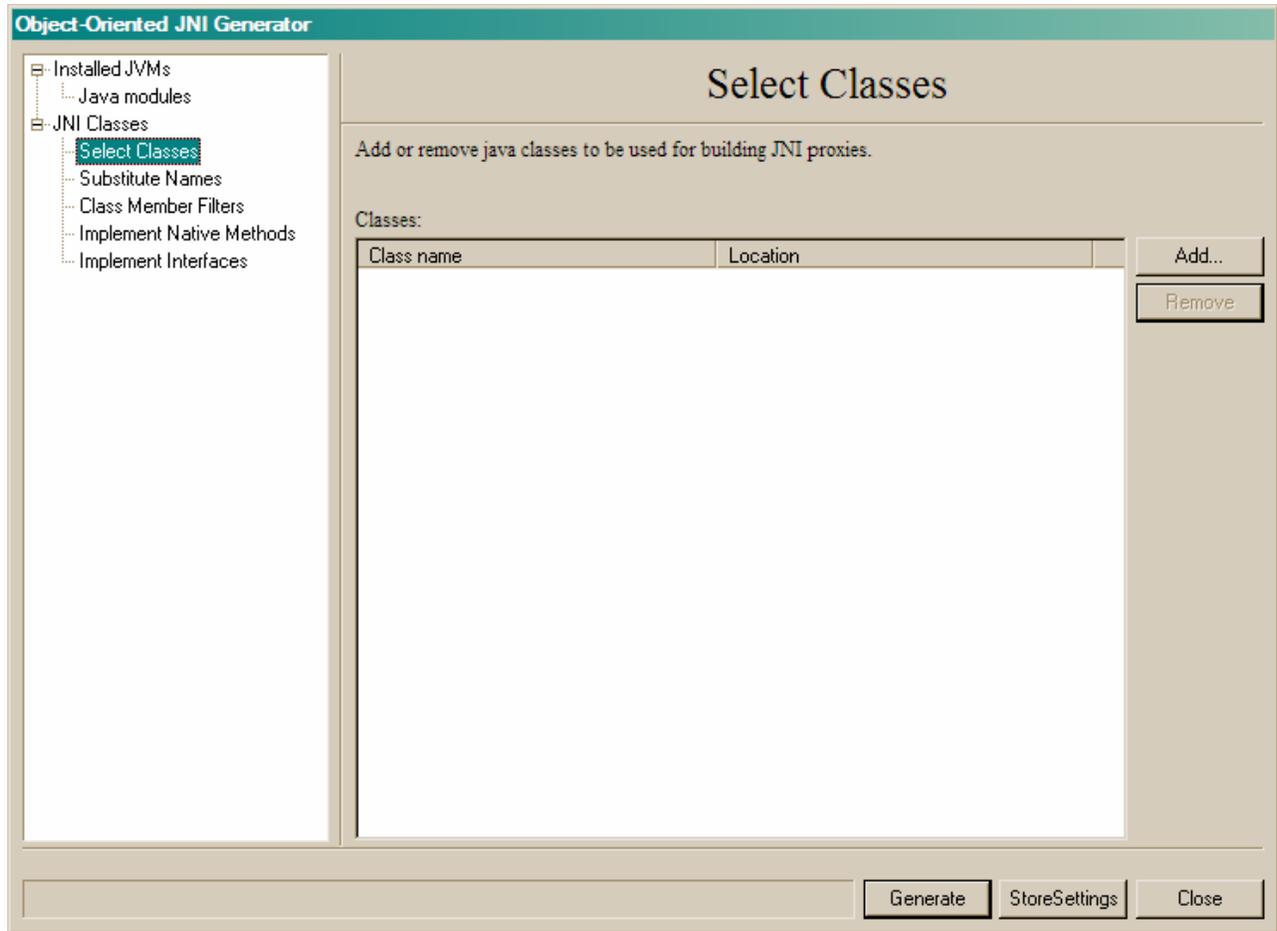


Picture.6. Java Modules List View

With buttons, **Add...** and **Remove**, create a list of java modules (jar, zip, class) you want to use in OJJNI Project.

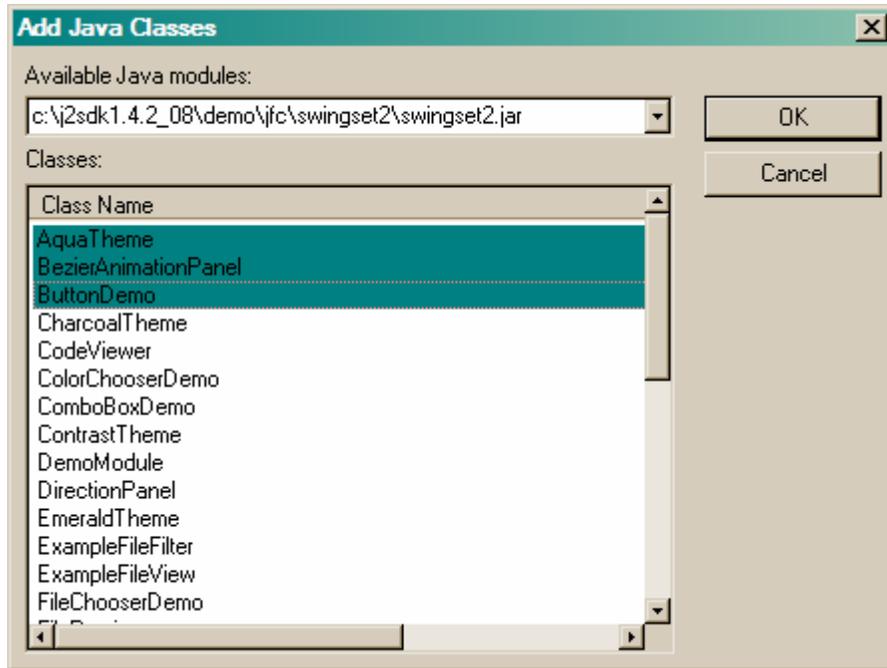
4.5 Selecting java classes to be wrapped with C++ code

Having done the previous steps, you are ready for selecting byte code for JNI wrappers. In the left tree view click on **Select Classes** item and the **Select Classes** View will appear (Pic.7).



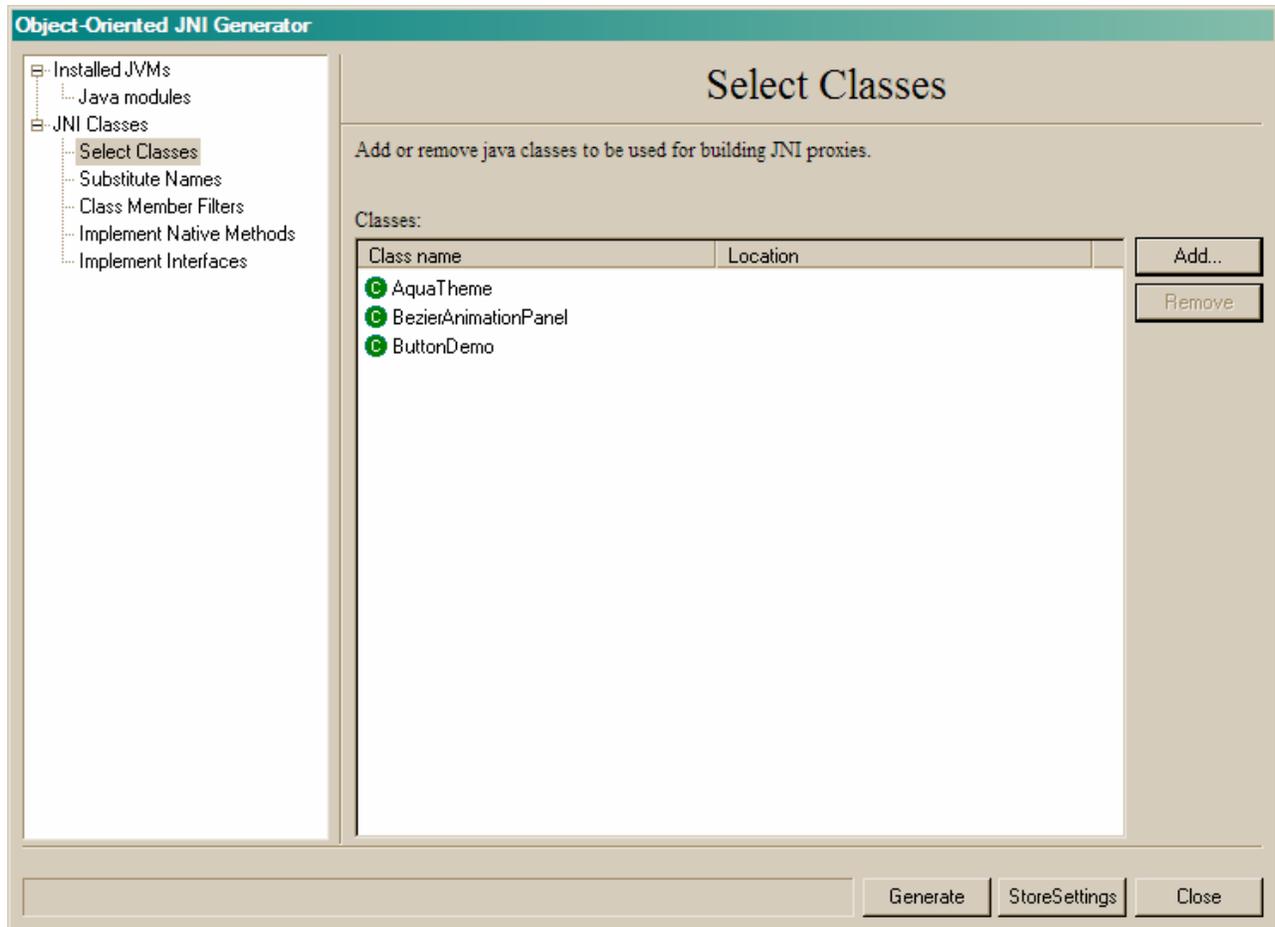
Picture.7. *Select Classes* View

To add byte code to be wrapped open with *Add...* button *Add Java Classes* Dialog (see Pic.8).



Picture.8. *Add Java Classes* Dialog

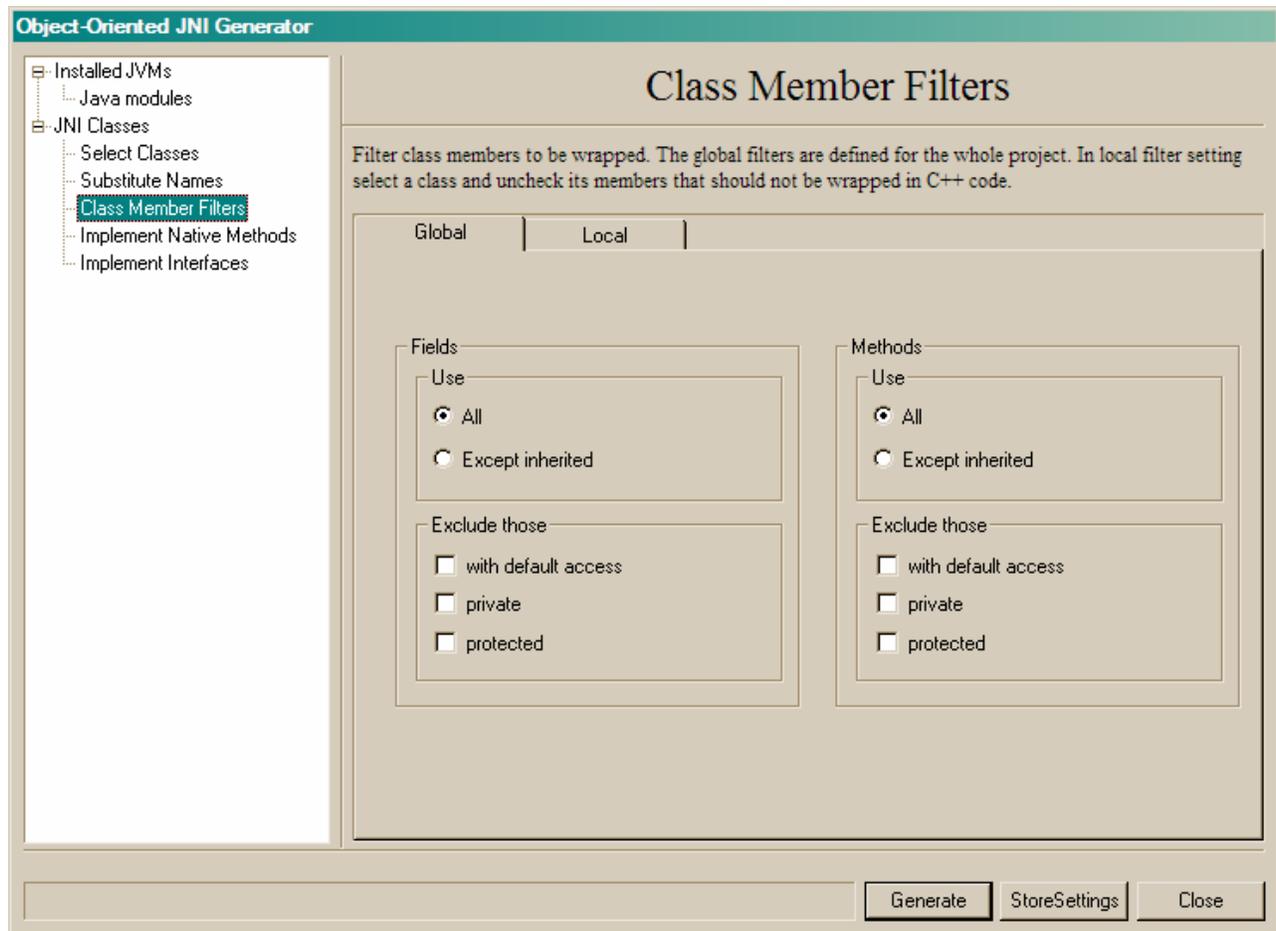
Select jar/zip module from the combo box and highlight class names you want to use. Then click **OK** button (see Picture.9).



Picture.9. Byte code selected for generating JNI wrappers.

4.6 Filtering class members while C++ code generating

By default OOJNI Add-In creates wrappers for all class members (including inherited). However, the most of this code may be useless in the current C++ project. To exclude this overhead from the process of generating JNI wrappers you should set member filters. To do this open **Class Member Filters** View (see Picture.10)



Pic.10. *Class Member Filters* View (Global Filters)

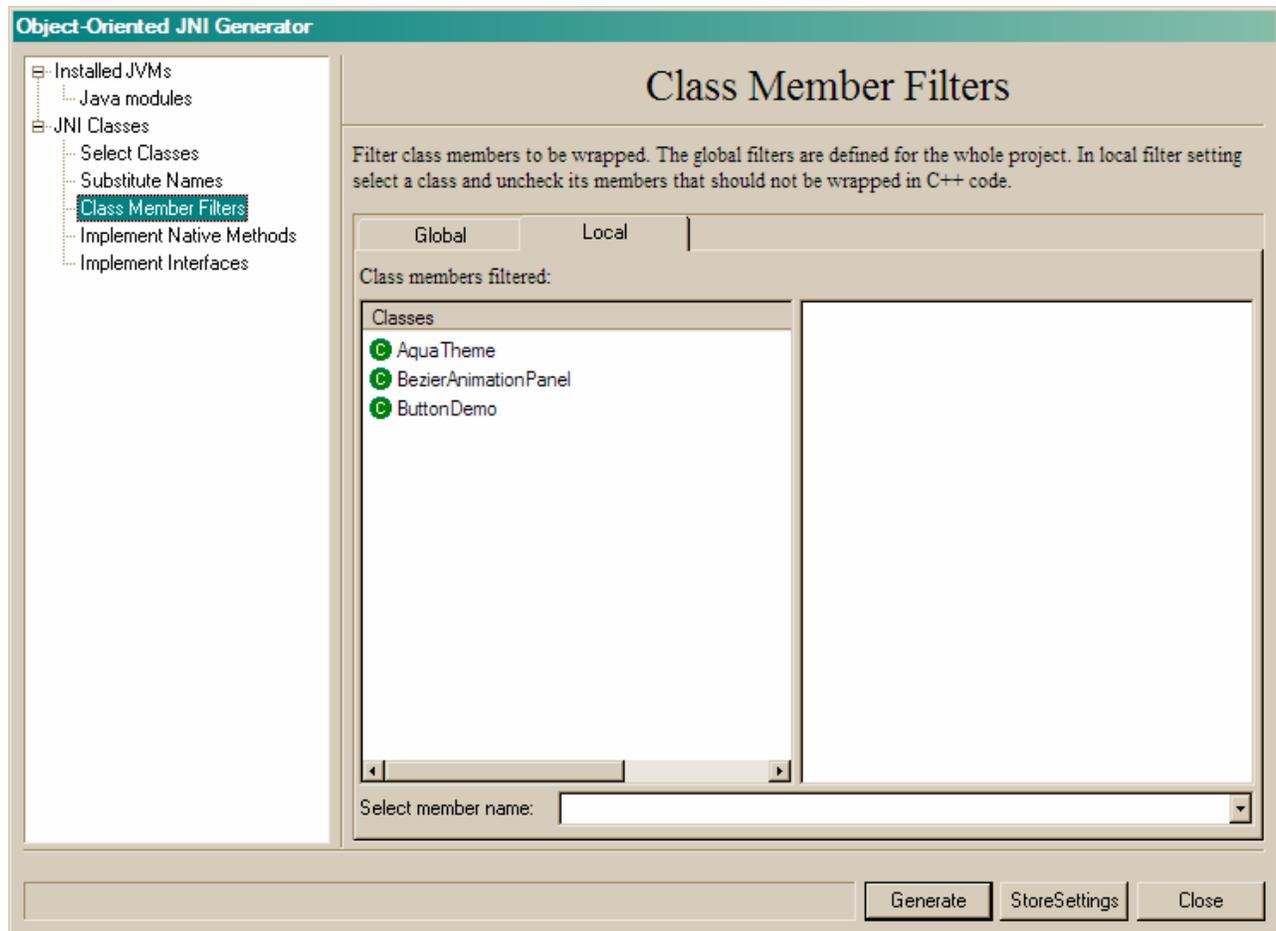
There are two types of filters

- Global filters that define filter conditions for the whole project.
- Local filters can be set for specific classes.

Global filters are defined for fields and methods separately. You have two filtering options:

- Usage of all members (**All** radio button) or exclude members inherited from base classes (**Except inherited** radio button),
- Exclude members by access type (default access, private, protected).

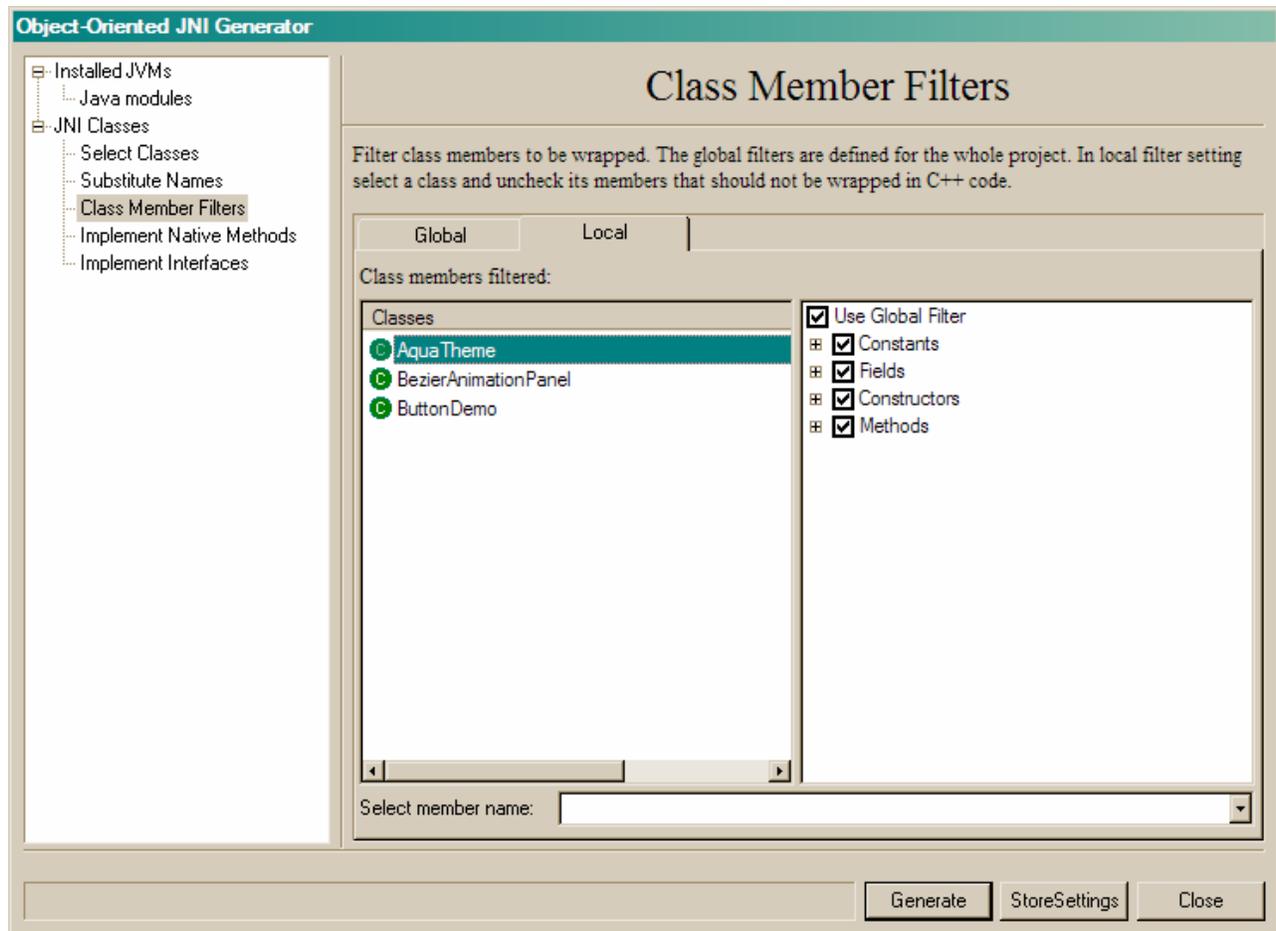
Now click on **Local** Tab to the view local filters settings (see Picture.11). Here select specific class name and set member filters you want (see Picture.12).



Picture.11. *Local Filter* view.

In the right tree view of the panel (see Picture.12) will appear a list of members grouped by

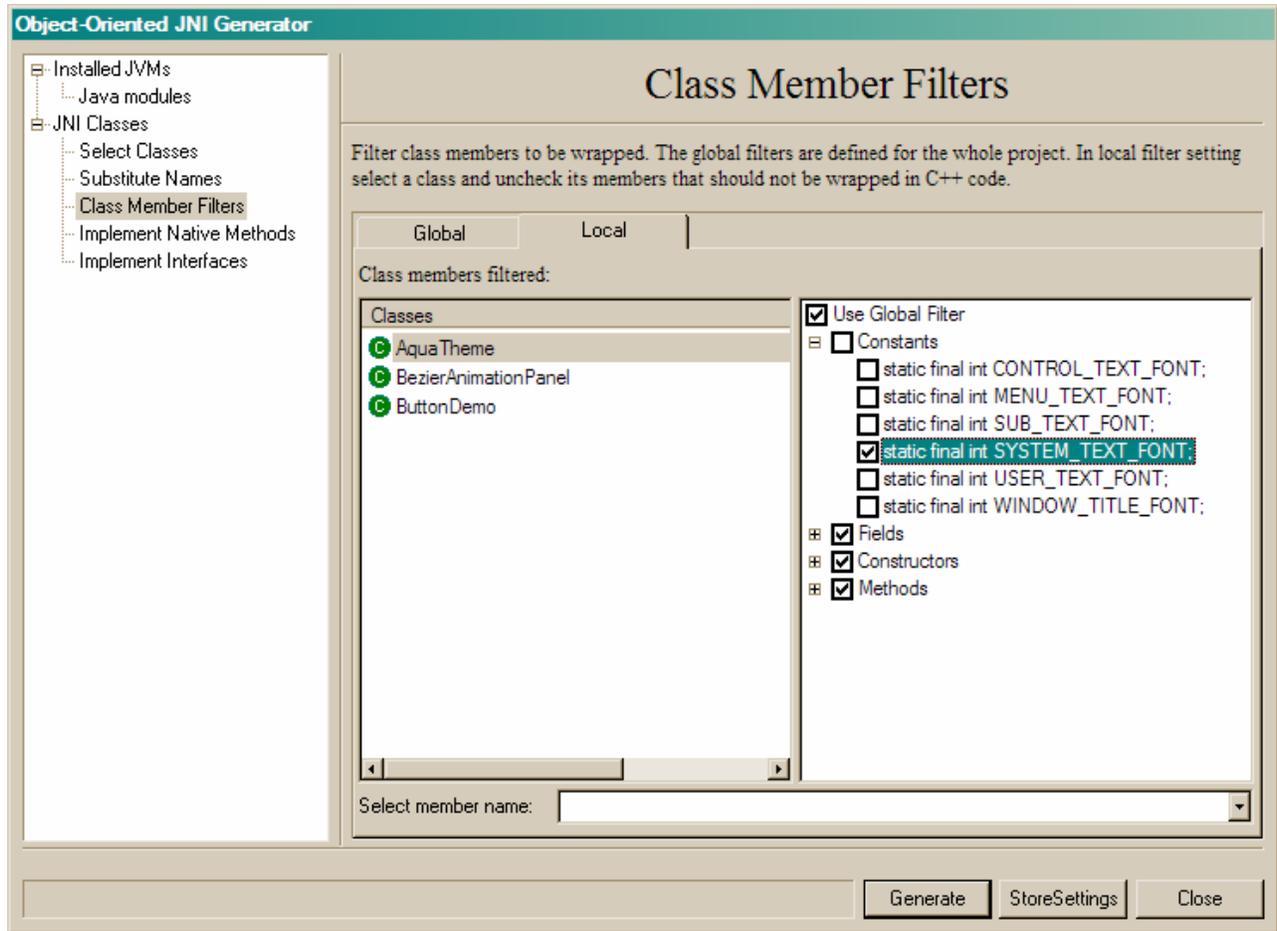
- Constants, these members are represented in C++ code as constants and accessed without JNI code use,
- Fields
- Constructors
- Methods



Picture.12. Specific Class Members Filter View

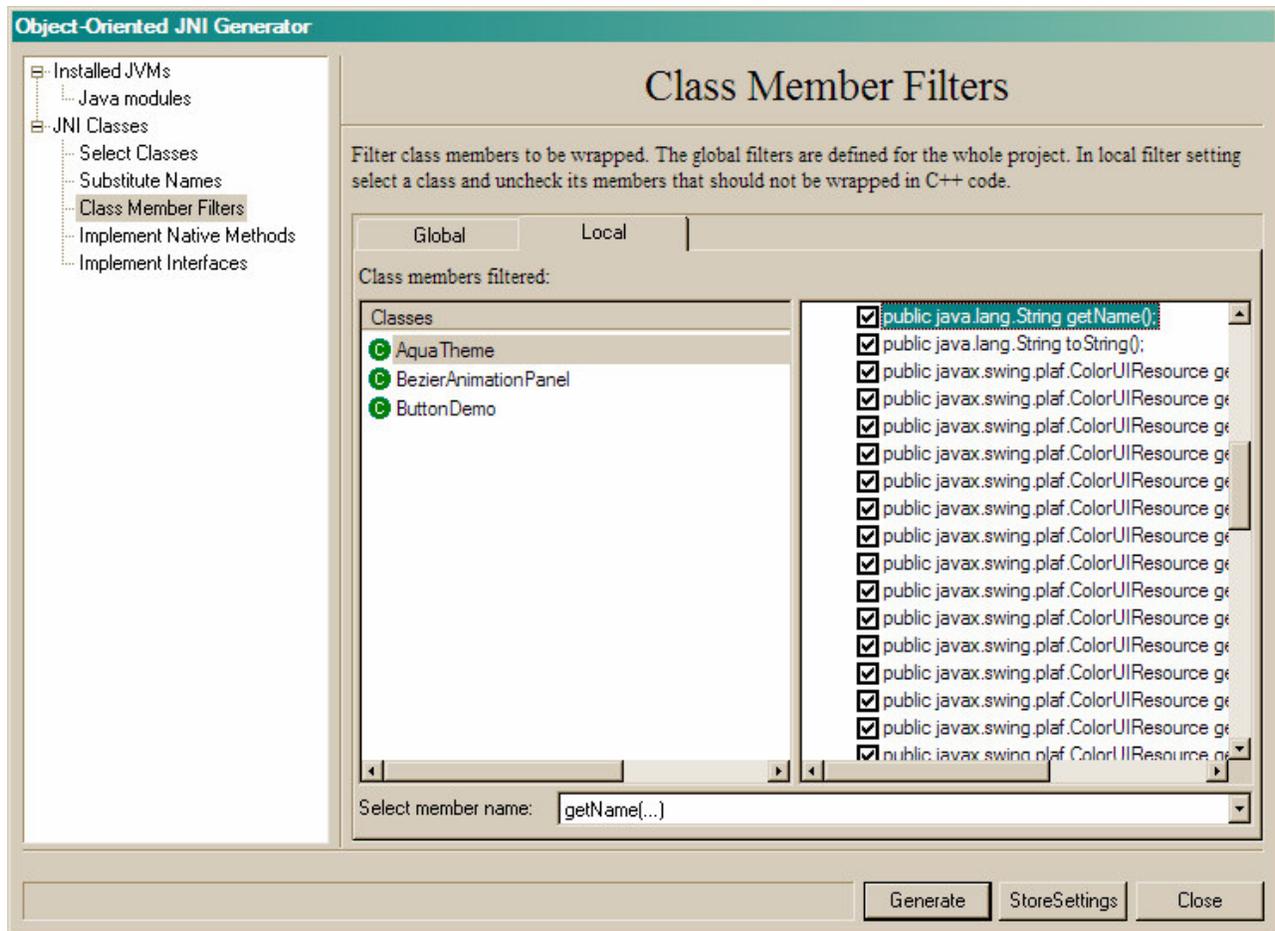
Any group checked means that all members of it are wrapped. If *Use Global Filter* item is checked then this tree view includes only members filtered with Global Filters. To do selection of specific members for wrapping, (see Picture.13)

- Uncheck the group,
- Expand it
- Check only members needed.



Pic.13. Filtering specific members

If the class you selected has a huge number of members, then finding specific member name in the tree view takes much time. In this case, you can use Search Helper beneath the view (see Picture.14). Select a member name you want in this combo box to highlight the first class member with this name in the tree view.

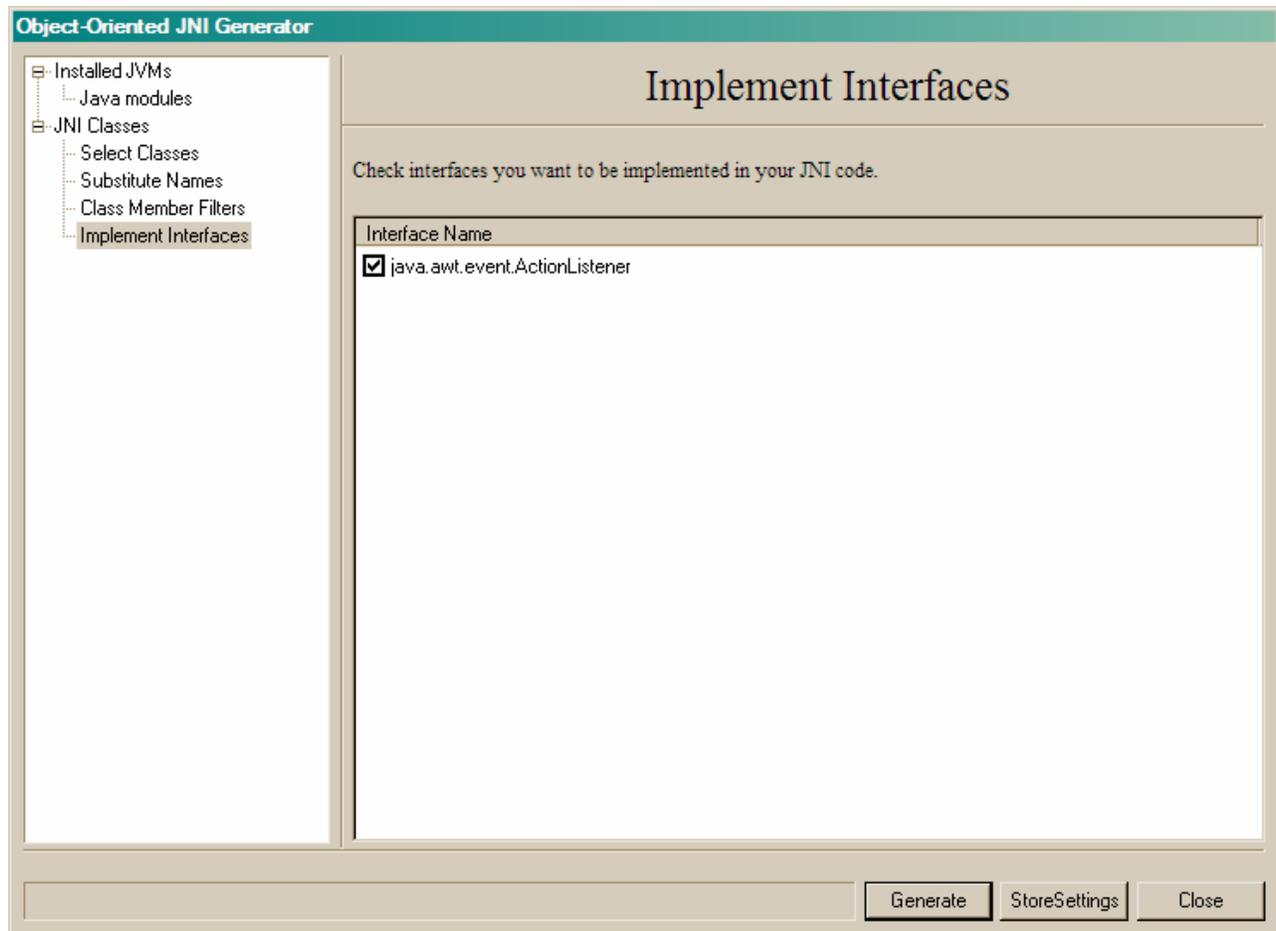


Pic.14. Class Member Name Highlighting

4.7 Implementing Java Interface with OOJNI Class

Java runtime includes a number of listener interfaces, which are implemented for receiving events. For example, the interface `java.awt.event.ActionListener` is used for receiving action events from GUI component. The class that is interested in processing an action event implements this interface, and the object created with that class is registered with a component, using the component's `addActionEvent` method. When the action event occurs, that object's `actionPerformed` method is invoked. Let you want to process component events in OOJNI code then you must to have C++ functions to be called when event occurs. OOJNI Add-in gives you means to do it easy with minimum code written by hand.

In *Select classes* Dialog add `java.awt.event.ActionListener` to the list of classes selected. Then open Dialog *Implement interfaces* and set checked `java.awt.event.ActionListener` (see Picture 15).



Pic.15. Implementing java interface.

After you pressed the button **Generate** OOJNI Add-in does two things

- Creates the class bytecode that implements *java.awt.event.ActionListener* interface,
- Generates C++ class named
`CPP_Java_Bridge::java::awt::event::ActionListenerJNIImpl` with virtual method
`actionPerformed(CPP_Java_Bridge::java::awt::event::ActionEvent p0)`

4.8 Disambiguating C++ code generated

In common, Java and C++ have just the same syntax. However, in some cases java classes have features that not supported in C++. Let see the java class:

```
public class A {
public int sfm;
public long sfm;
public void sfm(){};
}
```

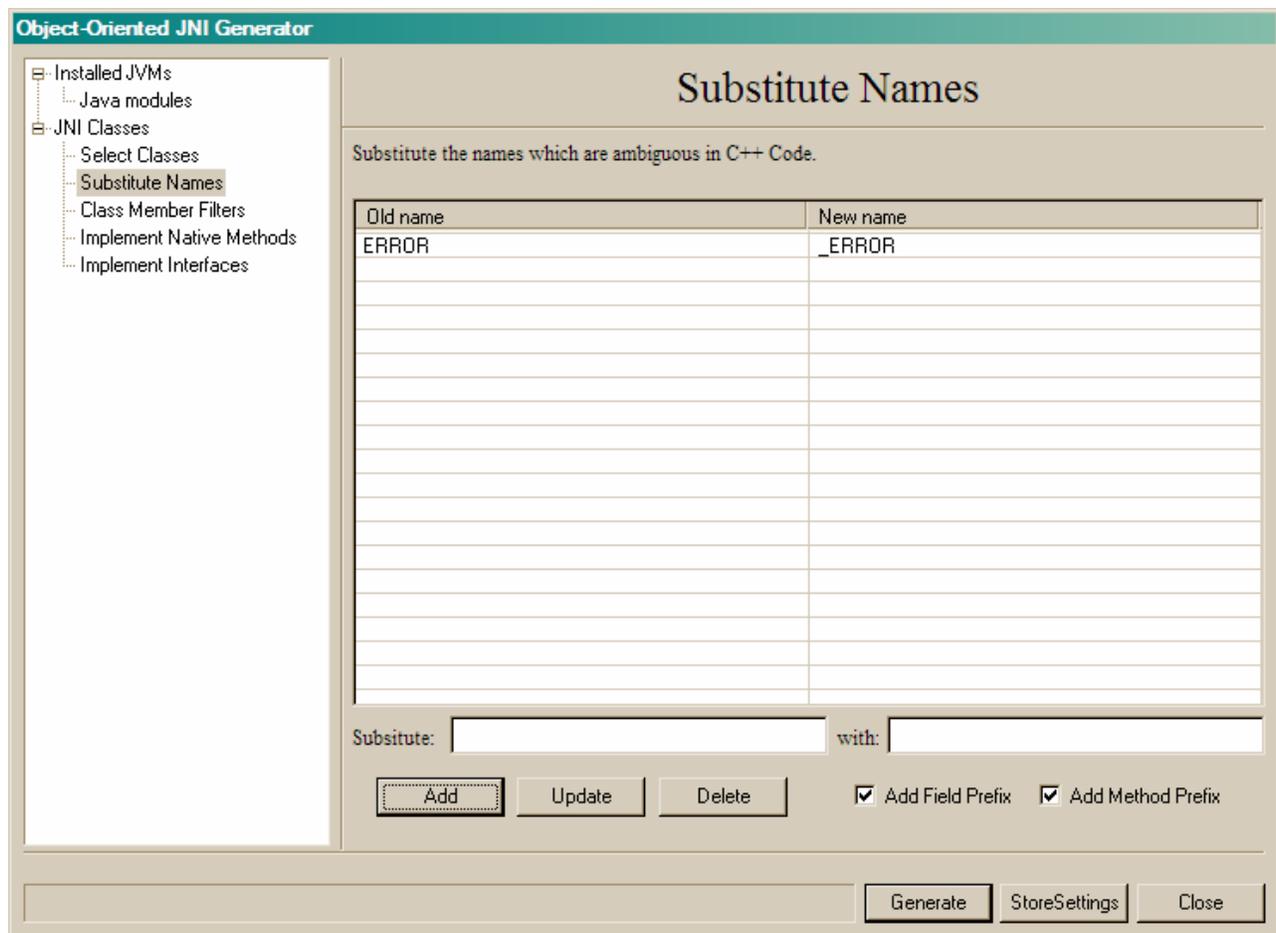
Here are the same name is used for the method and fields. There are two fields with the same name but with different type. Such declarations are not acceptable in C++ code. So while generating an OOJNI class Add-In makes the code:

```
class A {  
public:  
    . . .  
    jint sfm;  
    . . .  
    jlong sfm1;  
    . . .  
}
```

Alternatively, you can select options to prefix field and method names like:

```
class A {  
public:  
    . . .  
    jint fld_sfm;  
    . . .  
    jlong fld_sfm1;  
    . . .  
    void mth_sfm(){};  
public void sfm(){};  
}
```

Another problem is that C++ preprocessor may have the same names macros as ID/key names in java code. For example, in C++ code the name ERROR used by the C++ preprocessor and the class generated with OOJNI Add-In may have field name ERROR. To solve this problem create substitution name list. For example, substitute the name ERROR with _ERROR (see Picture.16). To prefix field and/or method names set check boxed in this view.



Pic.16. *Substitute Names* View

4.9 Generating C++ wrappers for java classes selected

Having selected java classes and having made all setting you can generate OOJNI wrappers. To generate wrappers simply press **Generate** button. OOJNI Add-in

- Deletes from the disk previously generated files;
- Generates new OOJNI wrapper's H and CPP files;
- Adds OOJNI wrapper file names to the C++ project;
- Makes all project settings needed.

4.10 Implementing Java Native Methods

Java is a popular cross-platform programming language in use today, with ports available for almost any operating system. However, with the panacea of platform-independence comes the price of potentially reduced performance and the inability to directly access hardware-dependent features, a major problem in the field of 3D graphics and other hardware-accelerated areas.

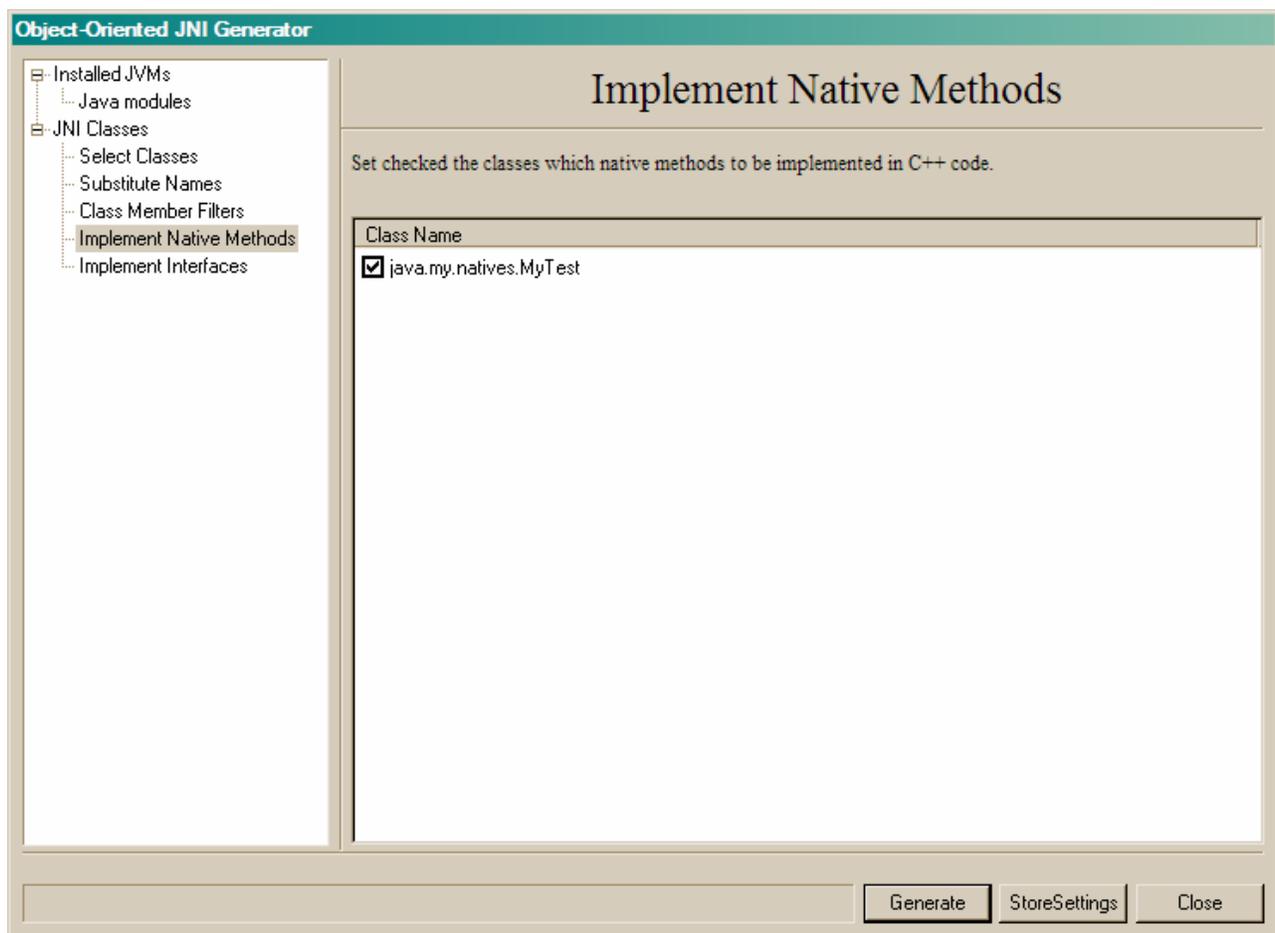
To address these issues and provide the developer with a way to access this important functionality, Java provides a mechanism called *native methods*, an technique that allows your code to seamlessly switch execution from Java into compiled, platform-specific code. OOJNI API provides you with means to implement native methods in C++ in Object-Oriented manner. So you can use java class

wrappers in programming your native methods that makes your code simple for reading and debugging.

Let, for example, you implement native methods in `java.my.natives.MyTest`

```
package java.my.natives;  
  
public class MyTest {  
    public native void impl_k_ev(Object o);  
    public native int[] impl_ev(Integer a0,  
                                double a1, Object a2);  
    public native byte impl_ev(Long a0, Float a1);  
    public native void impl_ev(Long a0, Float a1,  
                                Object[][] a);  
    public static native String[] StaticMth(Class[] cc);  
}
```

To implement this class native methods in your C++ code insert it with **Select classes** Dialog to the list of classes selected, open View **Implement Native Methods** and set this class checked. (see Picture 17).



Pic.17. **Implement Native Methods** View

OOJNI Tool generates static method implementations in javah.exe style. Each of them wraps jobject reference with C++ class

CPP_Java_Bridge::java::my::natives::MyTestJNIProxy. In this class you should only implement methods that correspond to java class native methods:

```
CPP_Java_Bridge::java::lang::StringArray1D
CPP_Java_Bridge::java::my::natives::MyTestJNIProxy::StaticMth
(
    CPP_Java_Bridge::java::lang::ClassArray1D
);
CPP_Java_Bridge::JIntArray1D
CPP_Java_Bridge::java::my::natives::MyTestJNIProxy::impl_ev
(
    CPP_Java_Bridge::java::lang::Integer,
    jdouble,
    CPP_Java_Bridge::java::lang::Object
);
jbyte CPP_Java_Bridge::java::my::natives::MyTestJNIProxy::impl_ev
(
    CPP_Java_Bridge::java::lang::Long,
    CPP_Java_Bridge::java::lang::Float
);
void CPP_Java_Bridge::java::my::natives::MyTestJNIProxy::impl_ev
(
    CPP_Java_Bridge::java::lang::Long,
    CPP_Java_Bridge::java::lang::Float,
    CPP_Java_Bridge::java::lang::ObjectArray2D
);
void CPP_Java_Bridge::java::my::natives::MyTestJNIProxy::impl_k_ev
(
    CPP_Java_Bridge::java::lang::Object
);
```

5 Programming with Oojni

See Oojni2 help file.

6 Examples

All Oojni examples are Console Applications. As java code has no the main thread loop each example (except *EmbeddedAWTFrame* example) has a primitive loop:

```
while(true){
    Sleep(50);
};
```

Before the first use of any JNI wrapper class you should activate JVM (attach JVM to the current thread). So each example starts Default JVM installed on your computer:

```
JVM::load();
```

The rest example source looks like java code. Package names are mapped to C++ namespaces and fields are mapped to properties with names prefixed: “get_”, “put_”.

6.1 RowLayoutTest

This code creates Frame window with Flow Layout and two push buttons inside.
Java classes wrapped:

```
java.awt.BorderLayout,  
java.awt.Button,  
java.awt.Color,  
java.awt.Frame,  
java.awt.Panel
```

Implemented interfaces:

```
java.awt.event.ActionListener  
java.awt.event.WindowListener
```

The main code:

```
#include "stdafx.h"  
#include "defproxies.h"  
#include <stdio.h>  
  
using namespace CPP_Java_Bridge;  
using namespace jni_helpers;  
  
// Implement WindowListener interface  
class WindowListener: public  
CPP_Java_Bridge::java::awt::event::WindowListenerJNIImpl {  
public:  
    void windowClosing(CPP_Java_Bridge::java::awt::event::WindowEvent p0);  
};  
// Implement Left Button ActionListener interface  
class LeftActionListener:public java::awt::event::ActionListenerJNIImpl {  
public:  
    void actionPerformed(java::awt::event::ActionEvent p0);  
};  
  
// Implement Right Button ActionListener interface  
class RightActionListener:public java::awt::event::ActionListenerJNIImpl {  
public:  
    void actionPerformed(java::awt::event::ActionEvent p0);  
};  
  
void WindowListener::windowClosing(java::awt::event::WindowEvent p0)  
{  
    exit(0);  
}  
  
void LeftActionListener::actionPerformed(java::awt::event::ActionEvent p0)  
{  
    printf("Left BUTTON Clicked\n");  
}  
  
void RightActionListener::actionPerformed(java::awt::event::ActionEvent p0)
```

```

{
    printf("Right BUTTON Clicked\n");
}

class SouthPanel : public java::awt::PanelJNIProxy {
    java::awt::ButtonJNIProxy button1;
    java::awt::ButtonJNIProxy button2;
    LeftActionListener lbl;
    RightActionListener rbl;
public:
    SouthPanel() {
        button1.setLabel("Button1");
        button2.setLabel("Button2");
        add((java::awt::Component)button1);
        add((java::awt::Component)button2);
        setBackground(java::awt::ColorJNIProxy::get_red());
        button1.addActionListener(lbl);
        button2.addActionListener(rbl);
    }
};

class FlowLayoutTest : public java::awt::FrameJNIProxy {
    SouthPanel south;
    WindowListener l;
public:
    FlowLayoutTest(LPSTR title):java::awt::FrameJNIProxy(title) {
        setBackground(java::awt::ColorJNIProxy::get_green());
        add((java::awt::Component)south,
            java::awt::BorderLayoutJNIProxy::get_SOUTH());
        addWindowListener(l);
    }
};

int main(int argc, char* argv[])
{
    JVM::load();
    //
    FlowLayoutTest test("FlowLayout Test1");
    test.setBounds(0, 0, 320, 240);
    test.show();

    // Main Primitive Loop
    while(true){
        Sleep(50);
    };
    return 0;
}

```

6.2 Grid11

This is a demo of GridLayout painted.

Java classes wrapped:

java.awt.Color,
java.awt.Frame,
java.awt.GridLayout

java.awt.Label

Implemented interfaces:

java.awt.event.WindowListener

The main code:

```
#include "stdafx.h"
#include "defproxies.h"

using namespace CPP_Java_Bridge;
using namespace jni_helpers;

// Implement WindowListener interface
class WindowListener: public
CPP_Java_Bridge::java::awt::event::WindowListenerJNIImpl {
public:
    void windowClosing(CPP_Java_Bridge::java::awt::event::WindowEvent p0);
};

void WindowListener::windowClosing(java::awt::event::WindowEvent p0)
{
    exit(0);
}

class Grid11 : public java::awt::FrameJNIProxy {
    java::awt::GridLayoutJNIProxy gl;
    java::awt::LabelJNIProxy l0;
    java::awt::LabelJNIProxy l1;
    java::awt::LabelJNIProxy l2;
    java::awt::LabelJNIProxy l3;
    WindowListener l;
public:
    Grid11(LPTSTR title):java::awt::FrameJNIProxy(title),
        gl(1, 1),
        l0("1*1", java::awt::LabelJNIProxy::CENTER),
        l1("2*2", java::awt::LabelJNIProxy::CENTER),
        l2("3*3", java::awt::LabelJNIProxy::CENTER),
        l3("4*4", java::awt::LabelJNIProxy::CENTER)
    {
        setLayout(gl);
        l0.setBackground(java::awt::ColorJNIProxy::get_blue());
        l1.setBackground(java::awt::ColorJNIProxy::get_red());
        l2.setBackground(java::awt::ColorJNIProxy::get_blue());
        l3.setBackground(java::awt::ColorJNIProxy::get_red());
        add((java::awt::Component)l0);
        add((java::awt::Component)l1);
        add((java::awt::Component)l2);
        add((java::awt::Component)l3);
        addWindowListener(l);
    }
};

int main(int argc, char* argv[])
{
```

```

JVM::load();

Grid11 frame("Grid11 Test");
frame.setBounds(100, 100, 200, 200);
frame.show();

    // Main Primitive Loop
while(true){
    Sleep(50);
};
return 0;
}

```

6.3 HelloWorld

Shows Frame with Label component.

Java classes wrapped:

java.awt.Frame

java.awt.Label

Implemented interfaces:

java.awt.event.WindowListener

The main code:

```

#include "stdafx.h"
#include "defproxies.h"

// Implement WindowListener interface
class WindowListener: public
CPP_Java_Bridge::java::awt::event::WindowListenerJNIImpl {
public:
    void windowClosing(CPP_Java_Bridge::java::awt::event::WindowEvent p0);
};

void WindowListener::windowClosing(java::awt::event::WindowEvent p0)
{
    exit(0);
}

class Hello : public java::awt::FrameJNIProxy {
    // A label, in C++, can not call constructor at here, call it
    // at the enclosing class's ctor-initializer.
    java::awt::LabelJNIProxy hello;
    WindowListener l;
public:
    Hello()
        : java::awt::FrameJNIProxy("Hello"),
        hello("Hello, world!", java::awt::LabelJNIProxy::CENTER) { // construct
the label
        // add the label into the frame.
        add((java::awt::Component)hello);
        addWindowListener(l);
    }
};

```

```

int main(int argc, char* argv[])
{
    JVM::load();

    Hello hello;
    hello.pack();
    hello.show();

    // Main Primitive Loop
    while(true){
        Sleep(50);
    };    return 0;
}

```

6.4 EmbeddedAWTFrame

Demonstrates embedding of AWT components into MFC Application. Here the method *javax.swing.SwingUtilities.invokeLater(...)* used only for illustration purposes.

Java classes wrapped:

java.awt.Button
java.awt.Color
java.awt.Panel
javax.swing.SwingUtilities
sun.awt.windows.WEmbeddedFrame

Implemented interfaces:

java.lang.Runnable

In the code generated with MS Visual Studio to embed java code we did

- Added loading JVM before the dialog starts: in EmbeddedAWTFrame.cpp added *jni_helpers::JVM::load()*; to “InitInstance()” function
- Created Runnable class with the class generated *CPP_Java_Bridge::java::lang::RunnableJNIImpl* to implement the method *run()*
- In the method *OnShowWindow()* the java code is embedded into C++ Dialog