Mixing Python and Java

How Python and Java can communicate and work together

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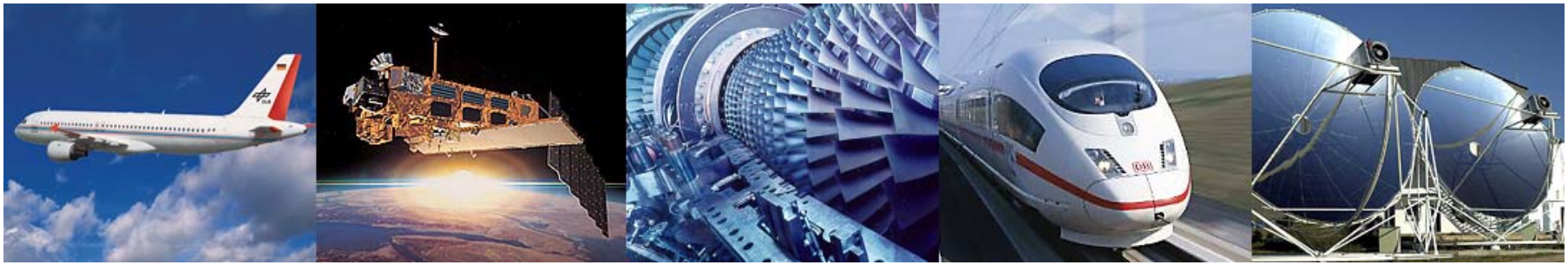


- Research Institution
- Space Agency
- Project Management Agency

Locations and employees

6000 employees across
29 research institutes and
facilities at

- 13 sites.

Offices in Brussels,
Paris and Washington.

Research Areas

- Aeronautics
- Space
- Transport
- Energy
- Space Agency
- Project Management Agency

Is it all about

Jython

?

Mixing Python and Java?
Outline

Accessing Python from Java

- Jython
- JEPP

Accessing Java from Python

- JPype
- JCC

Inter-process communication

- CORBA
- SOAP
- Other remote object libraries

Java
Why People are Using Java?

- Widely used in many different application domains
  - industry/business, research, academia
- Available on many different platforms
- Good performance
  - good Garbage Collector (and no GIL)
- Many, many libraries
  - E.g., for data base access, XML processing, PDF generation, security, or user interfaces
- Availability of good documentation for all aspects of Java programming
- Very good development tools
  - Eclipse, NetBeans, IntelliJ IDEA, …

Python
Why People are Using Python?

Python in Research and Industry

- Scientists and engineers don’t want to write software but just solve their problems
- If they have to write code, it must be as easy as possible

Reasons for Python?

- Very easy to learn and easy to use
  (= *steep learning curve*)
- Allows rapid development
  (= *short development time*)
- <u>Inherent great maintainability</u>

“Python has the cleanest, most-scientist- or engineer friendly syntax and semantics.

-Paul F. Dubois

Paul F. Dubois. Ten good practices in scientific programming. Comp. In Sci. Eng., Jan/Feb 1999, pp.7-11

Why Mixing Java and Python?
Embedded scripting and more…

- Many mature Java applications and frameworks exists
  - Lots of commercial and Open Source software systems and libraries
  - For example, The Eclipse Universe, Apache-Software, Portal-Frameworks, Workflows systems, …

- Common use cases
  - Add embedded (Python) scripting to Java applications
  - Use Java libraries from Python code

Why Mixing Java and Python?

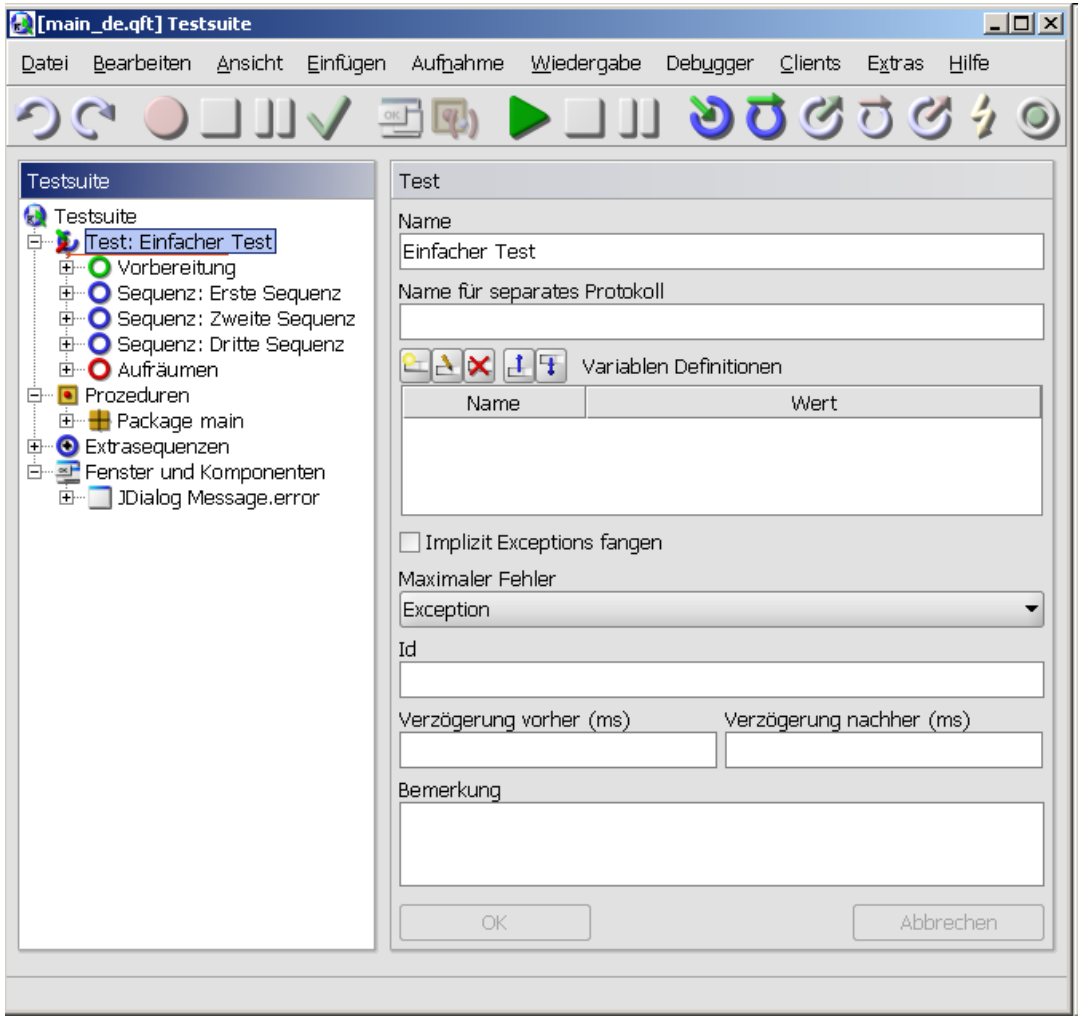
Integration of Python code into Java applications…

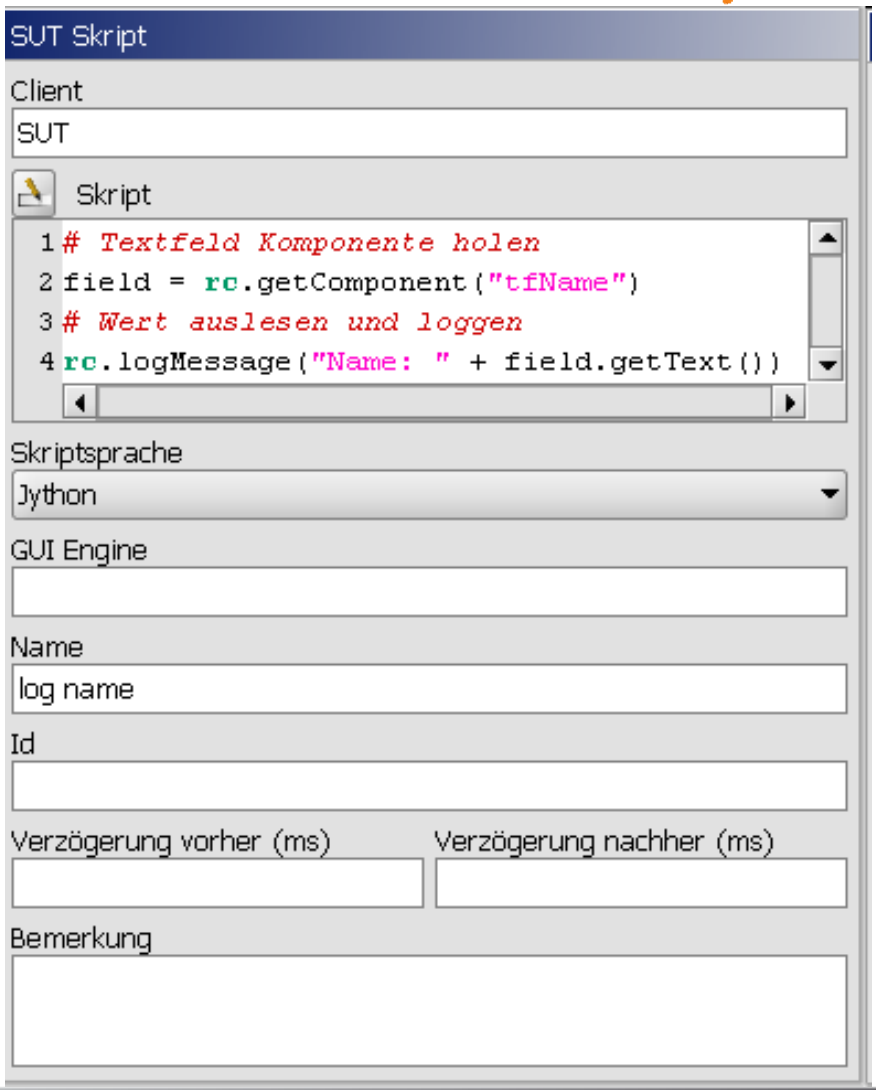
- Existing code or libraries exist either for Java or Python only
  - Effort to re-implement the functionalities could be very high
  - If the library is very well tested, it could be an enormous effort to reach a comparable level of quality

- Common use cases
  - Just use an existing library from the “other” language
  - Especially, use Python code (or C/Fortran/*WHATEVER* code with Python wrappers) from Java
  - Its harder to wrap C codes in Java than in Python (see CTypes)

Example

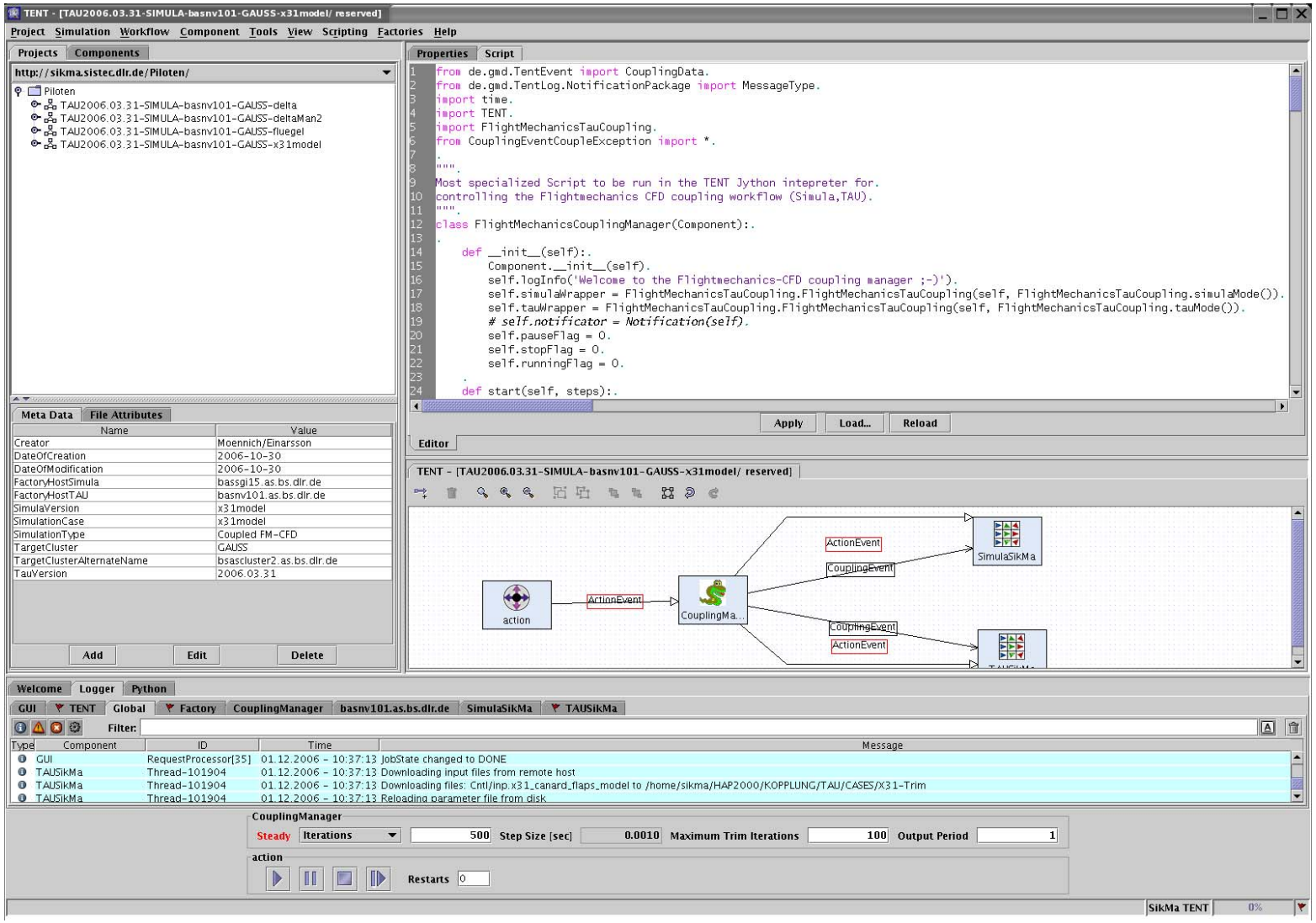
QF-Test – Automated GUI Testing





Example

TENT – Software Integration and Workflow Management



Use Cases for Python Scripting (1)

Steering and controlling the program by user defined scripts

- Applications are complex parameter variations or steering multidisciplinary coupled simulations

Automation of repeating tasks

- In most cases, this is called “macro” recording and replaying

Extending user interfaces

- For example, with additional customized dialogs and other extensions
- In Java, this requires scripts which use the Java GUI libraries (AWT, Swing, or SWT)

Integration of additional legacy tools

- Important and widely used for integration and workflow systems
- End users can integrate external codes without changing the Java program itself

Use Cases for Python Scripting (2)

Interactive experimentation and debugging of the Java program

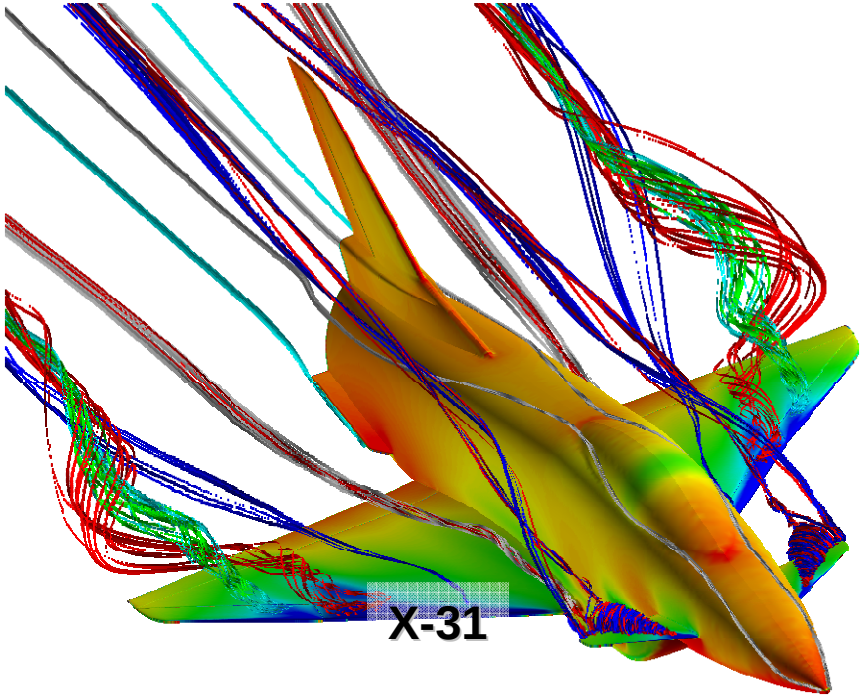
- Can be easily done with an embedded interactive interpreter
- Allows end users and software developers to debug and analyze the Java program during runtime

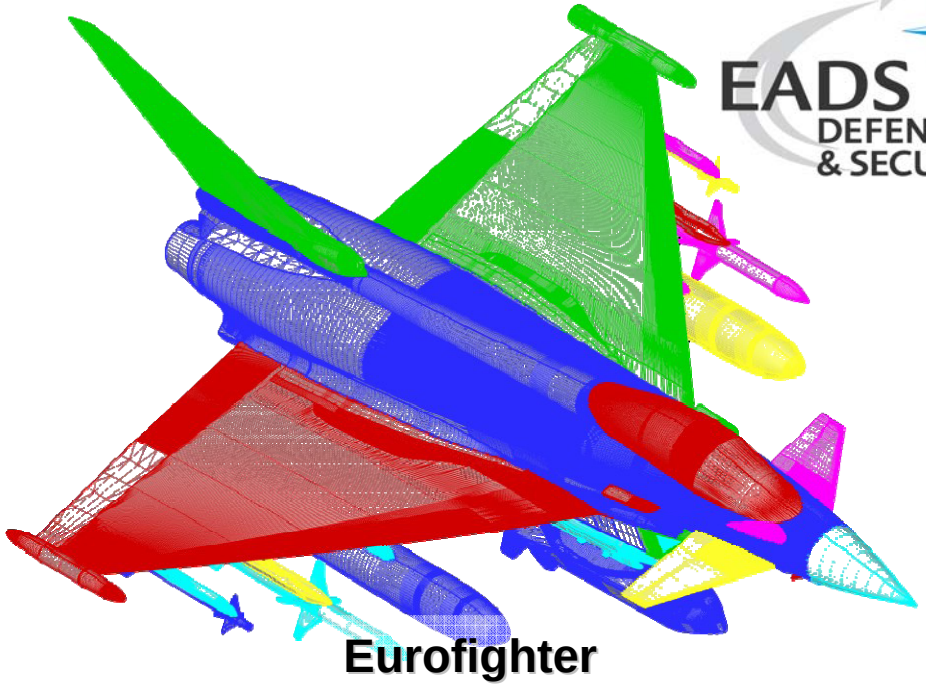
Creating automated tests for quality assurance

- Recording user actions during runtime of the Java program as a Python script (“Journaling")
- Editing and generalizing the recorded script
- Replaying the script manually or automatically

Example: Codes with Python Interfaces

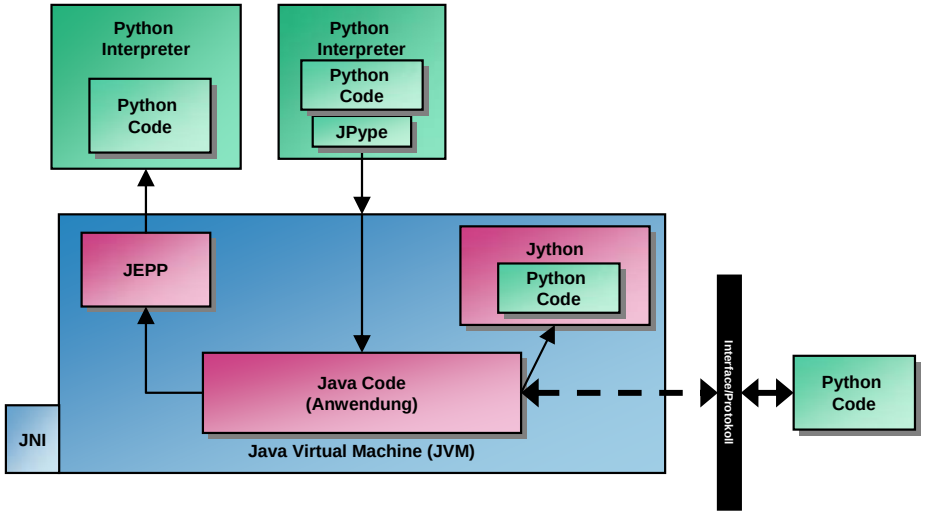
Numerical Simulation Software in C++ or Fortran





- Examples for high-definition CFD-Solver with Python interfaces
  - DLR **TAU-Code** (**`http://www.dlr.de/as`**)
  - ONERA **elsA-Code** (**`http://elsa.onera.fr`**)
- Integration into Java workflow systems with the following techniques…

Tools for Python-Java-Integration



Accessing Python from Java

Use cases

- The application should have embedded scripting functionality.
- The application should use an external code written in Python.
- The application should use an external code written in Python or other languages such as C, C++, Fortran.

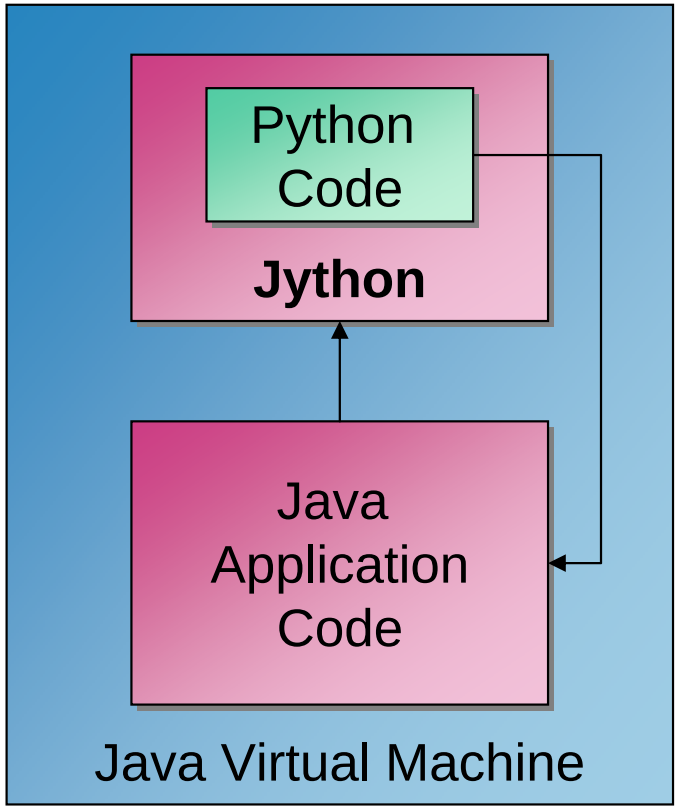
Tools

- Jython
- JEPP

Jython

- Complete re-implementation of the Python interpreter in Java
- Python code runs in the Java VM
- Website: **`http://www.jython.org`**
- Latest version: Jython 2.5
- For details & questions, catch
  - Tobias Ivarsson
  - Frank Wierzbicki

  and others here at EuroPython ☺



Jython

Code Example 1: Java code

- Execute Python code

```
import org.python.util.PythonInterpreter ;
import org.python.core.*;
class TestClass {
  public static void main(String[] args) {
    try {
      org.python.util.PythonInterpreter python =
        new org.python.util.PythonInterpreter ();
      python.execfile("python_script.py");
    } catch (Exception e) {
    System.out.println(“Some error!");
  }
}
```

Jython

Code Example 2: Python code

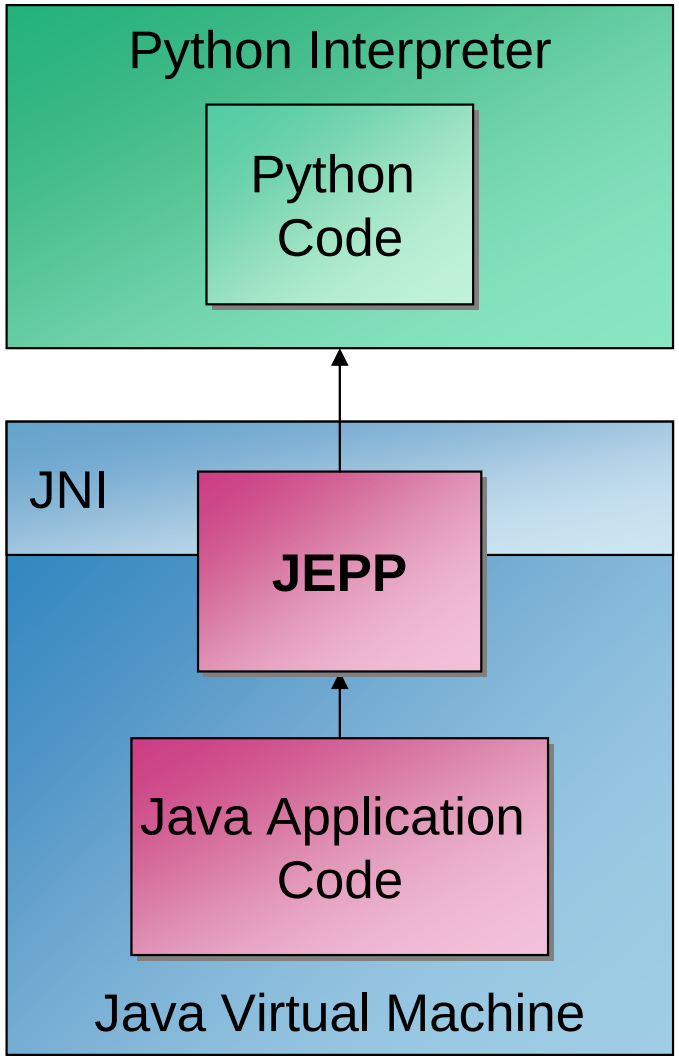
- Use Swing

```
from javax.swing import *

frame = JFrame("Hello Jython")
label = JLabel("Hello Jython!", JLabel.CENTER)
frame.add(label)
frame.setDefaultCloseOperation(
                                JFrame.EXIT_ON_CLOSE)
frame.setSize(200, 100)
frame.show()
```

JEPP

Java Embedded Python

- Embeds CPython interpreter via Java Native Interface (JNI) in Java
- Python code runs in CPython
- Website: **`http://jepp.sourceforge.net/`**



JEPP
Code Example

- Execute (“evaluate”) Python statements

```
Jep jep = new Jep(false, SCRIPT_PATH, cl);
jep.eval("print 'hello'");
jep.close();
```

- Execute a Python script file

```
Jep jep = new Jep(false, SCRIPT_PATH, cl);
jep.runScript(SCRIPT_PATH + file);
jep.close();
```

Accessing Java from Python

Use cases

- The application should use an external Java application.
- The application should use a Java library.

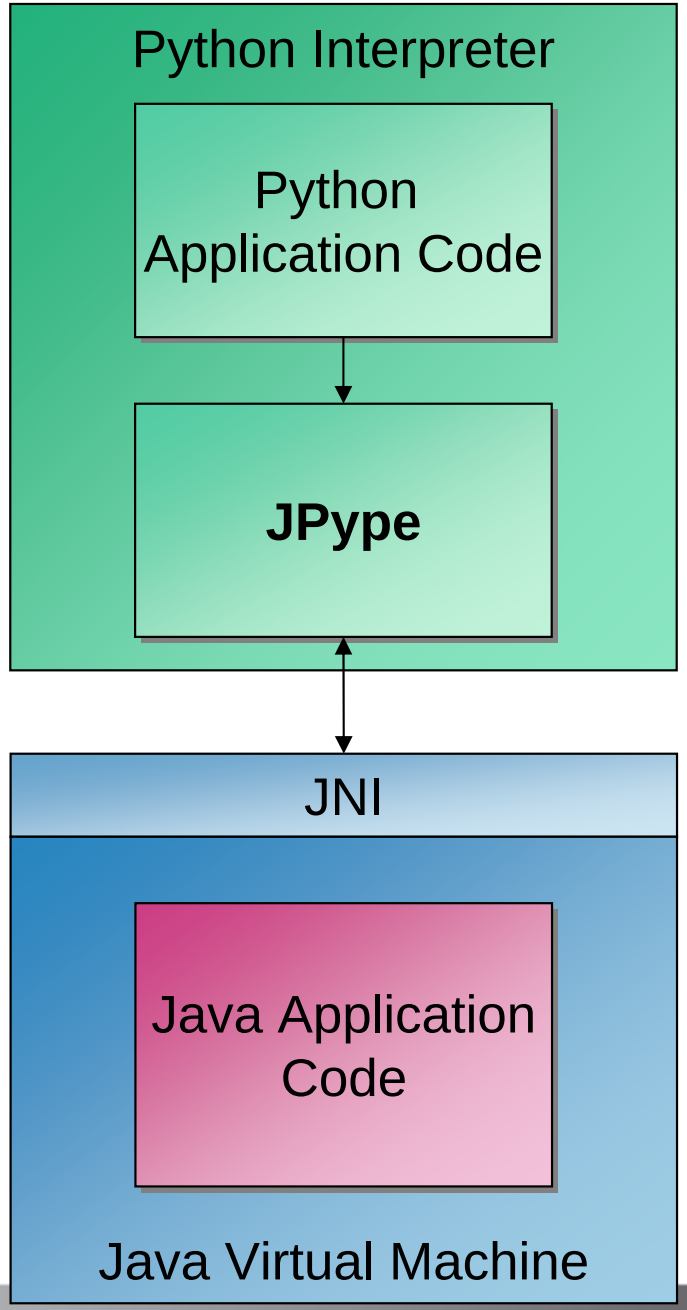
Tools

- JPype
- JCC

JPype
Java to Python Integration

- Interface on native level of both (Java & Python) Virtual Machines/Interpreters
- Starts a Java Virtual Machine

- Website:
  `http://jpype.sourceforge.net`



JPype
Code Example (1)

- Hello World

```
from jpype import *
# Start JVM
startJVM (path to jvm.dll, "-ea")
# Print "Hello World"
java.lang.System.out.println("Hello World")
# Shutdown JVM
shutdownJVM()
```

JPype
Code Example (2)

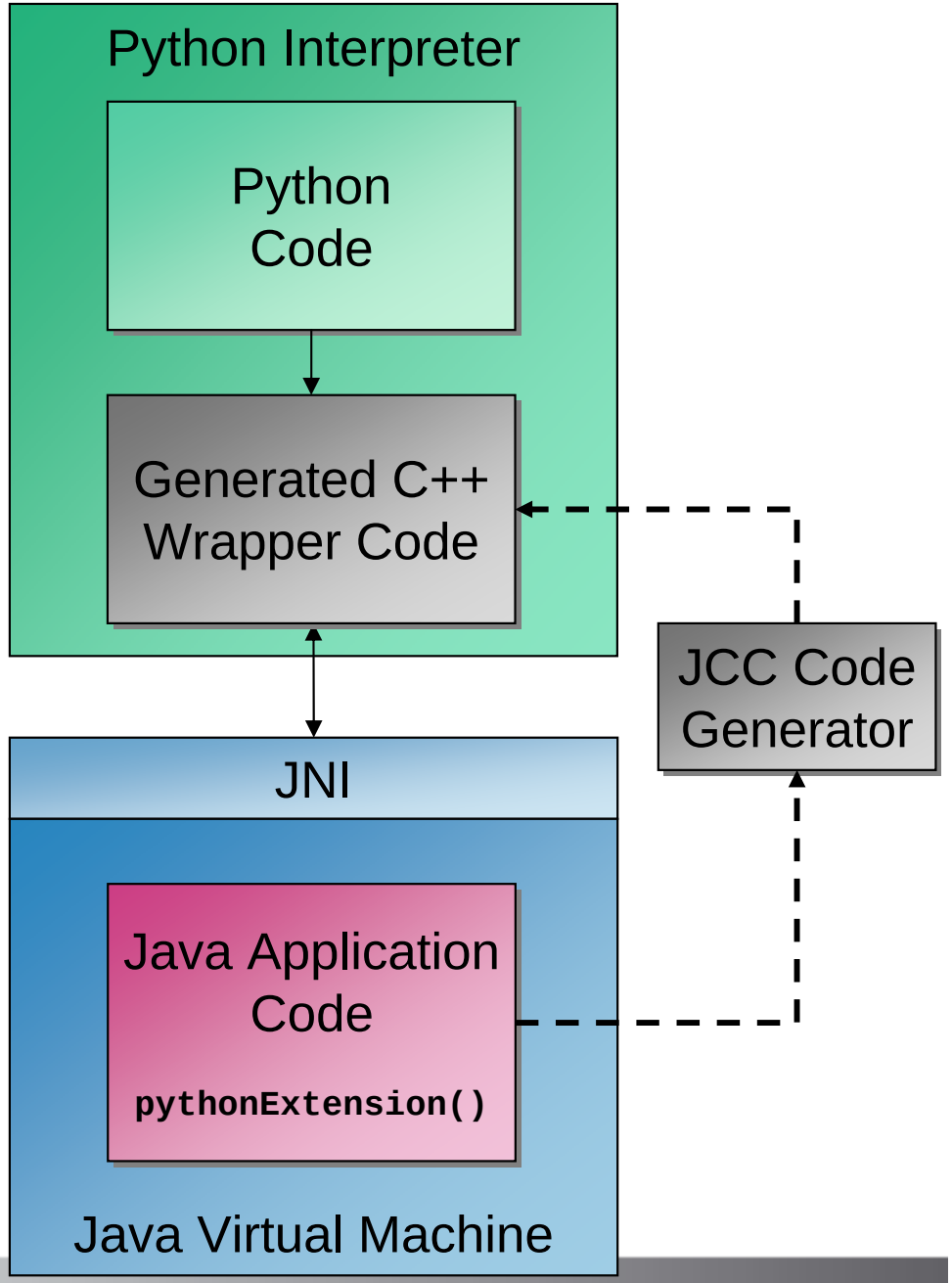
- Call Java methods from Python

```
import jpype
# Start JVM
jpype.startJVM(path to jvm.dll, "-ea")
# Create reference to java package
javaPackage = jpype.JPackage("JavaPackageName")
# Create reference to java class
javaClass = javaPackage.JavaClassName
# Create instance of java class
javaObject = javaClass()
# Call java methods
javaObject.JavaMethodName()
# Shutdown JVM
jpype.shutdownJVM()
```

JCC
PyLucene's Code Generator

- C++ code generator for calling Java from C++/Python
- C++ object interface for wrapping a Java library via JNI
  - Generates complete CPython extension
- Supported on Mac OS X, Linux, Solaris and Windows, requires C++ compiler

- Website: **`http://lucene.apache.org/pylucene/jcc`**
  - Part of PyLucene



JCC
Code Example

- Requirement: VM initialization

```
import jcc
# Start JVM
jcc.initVM(maxheap='2000m', …)
```

JCC Code Example

Using PyLucene: Search Lucene Index

- Search for „Query“ in directory „index“

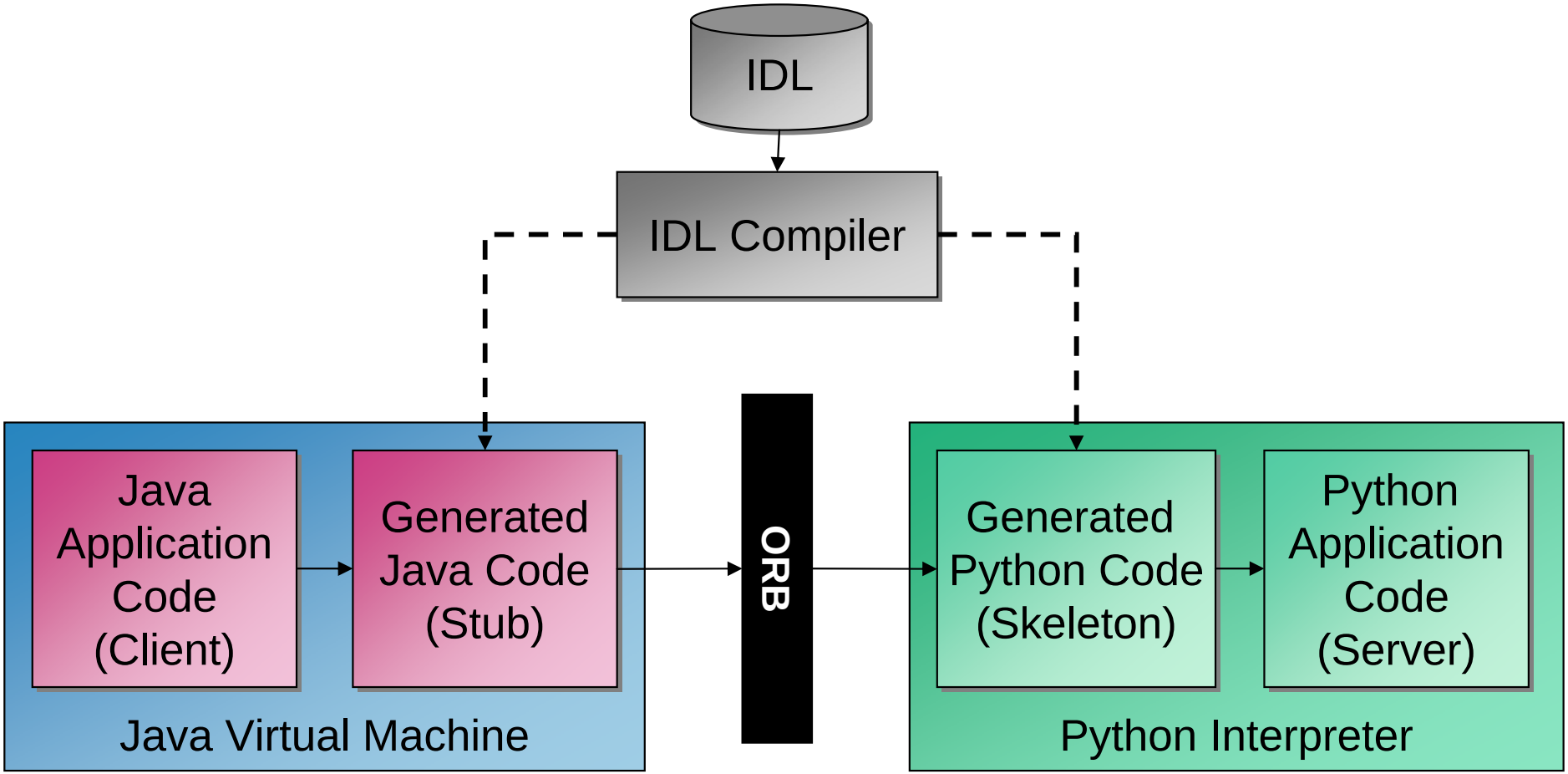
```
from lucene import QueryParser, IndexSearcher, StandardAnalyzer,
    FSDirectory, Hit, VERSION, initVM, CLASSPATH

initVM(CLASSPATH)
directory = FSDirectory.getDirectory(“index”, False)
searcher = IndexSearcher(directory)
analyzer = StandardAnalyzer()
command = raw_input("Query:")
query = QueryParser("contents", analyzer).parse(command)
hits = searcher.search(query)
for hit in hits:
    doc = Hit.cast_(hit).getDocument()
    print 'path:', doc.get("path"), 'name:', doc.get("name")
searcher.close()
```

Inter-Process Communication

- Inter-process communication (IPC) is data exchange between different processes on one or more computers connected by a network
- Typical IPC techniques are
  - remote procedure calls (RPC)
  - message passing.
- The most common APIs are
  - Object Request Broker (ORB) or
  - Web Services protocols based on XML.
- A drawback is the need for additional services, such as a directory service for registration and location of remote objects
  - Naming Service for CORBA
  - Universal Description, Discovery and Integration (UDDI) for Web Services

Object Request Broker (ORBs)

CORBA



CORBA Implementations for Python

Fnorb

- Pure Python implementation that works with CPython and Jython.
- It is a light-weight CORBA implementation and interoperable with the standard Java ORB.
- The development of Fnorb has ended.

omniORB

- An ORB implementation for C++ and Python that can be used from CPython.
- The Python ORB (omniORBpy) uses the C++ implementation of omniORB.
- omniORB is actively developed with regular releases.
- Website: **`http://omniorb.sourceforge.net`**

CORBA Example
Interface

- Hello World interface in Interface Definition Language (IDL)

```
module HelloWorld {

    const string Message = "Hello CORBA World!";

    interface Hello {
      string hello_world();
    };
};
```

CORBA Example

Python Server (Fnorb): Implementation of Interface

```
# Standard/built-in modules.
import sys
# Fnorb modules.
from Fnorb.orb import BOA, CORBA
# Stubs and skeletons generated by 'fnidl'.
import HelloWorld, HelloWorld_skel

class HelloWorldServer(HelloWorld_skel.Hello_skel):
    """ Implementation of the 'Hello' interface. """

    def hello_world(self):
        print HelloWorld.Message
    return HelloWorld.Message
```

CORBA Example

Python Server (Fnorb): Main Function

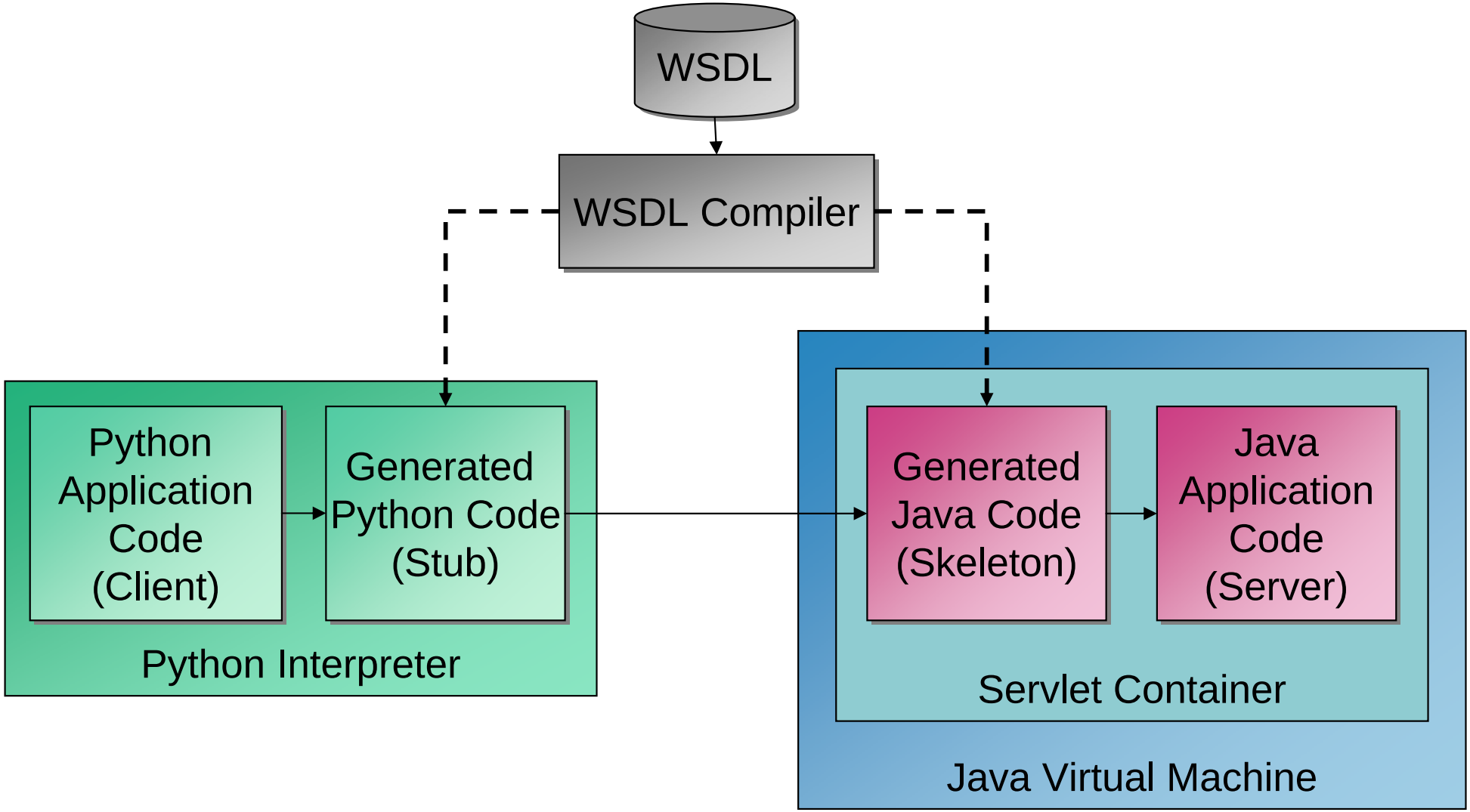
```
def main(argv):
  # Initialise ORB and BOA
  orb = CORBA.ORB_init(argv, CORBA.ORB_ID)
  boa = BOA.BOA_init(argv, BOA.BOA_ID)
  # Create object reference
  obj = boa.create('fred', HelloWorldServer._FNORB_ID)
  # Create an instance of the implementation class.
  impl = HelloWorldServer()
  # Activate the implementation
  boa.obj_is_ready(obj, impl)
  # Write the stringified object reference to a file
  open('Server.ref', 'w').write(orb.object_to_string(obj))
  boa._fnorb_mainloop() # Start the event loop
  return 0
```

CORBA Example

Java Client

```
public class Client {
  public static void main ( String args[] ) {
    java.util.Properties props = System.getProperties();
    try {
      org.omg.CORBA.ORB orb = org.omg.CORBA.ORB.init(args,props);
      org.omg.CORBA.Object obj = null;
      java.io.BufferedReader in = new java.io.BufferedReader(
                                  new java.io.FileReader(“Server.ref"));
      String ref = in.readLine();
      obj = orb.string_to_object(ref);
      Hello hello = HelloHelper.narrow(obj);

      hello.hello_world();

      orb.destroy();
    } catch (Exception e) { e.printStackTrace(); }
}
```

Web Services: SOAP



Web Services for Python

Zolera SOAP Infrastructure (ZSI)

- For Python the only remaining SOAP toolkit of considerable quality is the Zolera SOAP Infrastructure (ZSI)

Other Remote Object Libraries

Python Remote Objects (Pyro)

- Pyro is similar to Java's Remote Method Invocation (RMI).
- It is simple, very portable, and works with Jython.
- Brings its own Naming Service for locating remote objects.
- Pyro is actively developed with regular new releases.

Simple Python Interface to Remote Objects (SPIRO)

- SPIRO implements an ORB and is developed as a bridge between CPython and Jython.
- The development has ended.

Conclusions

I ♥ Jython

… but there are alternatives which makes sense for certain use cases!

Questions?

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