MSL-LoadLib Documentation

Release 0.10.0

Measurement Standards Laboratory of New Zealand

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CONTENTS

This package loads a shared library in Python. It is basically just a thin wrapper around `ctypes` (for libraries that use the `__cdecl` or `__stdcall` calling convention), Python for .NET (for libraries that use Microsoft's .NET Framework, `CLR`), Py4J (for Java `.jar` or `.class` files) and comtypes (for libraries that use the Component Object Model).

However, the primary advantage is that it is possible to communicate with a 32-bit shared library in 64-bit Python. For various reasons, mainly to do with the differences in pointer sizes, it is not possible to load a 32-bit shared library (e.g., .dll, .so, .dylib files) in a 64-bit process, and vice versa. This package contains a *`Server32`* class that hosts a 32-bit library and a *`Client64`* class that sends a request to the server to communicate with the 32-bit library as a form of inter-process communication.

CHAPTER

ONE

CONTENTS

1.1 Install

To install MSL-LoadLib run

```
pip install msl-loadlib
```

Alternatively, using the MSL Package Manager run

```
msl install loadlib
```

1.1.1 Dependencies

- Python 2.7, 3.5+

Optional dependencies:

- Python for .NET
- Py4J
- comtypes

You can install MSL-LoadLib and Python for .NET using,

```
pip install msl-loadlib[clr]
```

MSL-LoadLib and Py4J,

```
pip install msl-loadlib[java]
```

MSL-LoadLib and comtypes,

```
pip install msl-loadlib[com]
```

or MSL-LoadLib and all optional dependencies

```
pip install msl-loadlib[all]
```

1.1.2 Compatibility

- The *start_server32* module has been built into a frozen Python executable for Windows and Linux and works with the Python versions listed above. The 32-bit server is running on a Python 3 interpreter and therefore all modules that run on the server must use Python 3 syntax.
- You can create a new 32-bit server. See *Re-freezing the 32-bit server* for more details.

1.1.3 Prerequisites

Windows

64-bit Windows already comes with WoW64 to run 32-bit software and therefore no prerequisites are required to load `__cdecl` or `__stdcall` libraries. However, the library might have its own dependencies, such as a particular Visual C++ Redistributable, that may need to be installed.

If you need to load a Microsoft .NET library then you must install Python for .NET

```
pip install pythonnet
```

If you need to load a Java library (i.e., a `.jar` or `.class` file) then you must install Py4J,

```
pip install py4j
```

a Java Runtime Environment, and ensure that the `java` executable is available on the PATH variable. For example, the following should return the version of Java that is installed

```
C:\Users\username>java --version
java 19 2022-09-20
Java(TM) SE Runtime Environment (build 19+36-2238)
Java HotSpot(TM) 64-Bit Server VM (build 19+36-2238, mixed mode, sharing)
```

If you need to load a Component Object Model library then you must install comtypes

```
pip install comtypes
```

Tip: When loading a shared library it is vital that all dependencies of the library are also on the computer and that the directory that the dependencies are located in is available on the PATH variable. A helpful utility to determine the dependencies of a shared library on Windows is Dependencies (which is a modern Dependency Walker). Microsoft also provides the DUMPBIN tool. For finding the dependencies of a .NET library the Dependency Walker for .NET can also be helpful.

Linux

Before using MSL-LoadLib on Linux, the following packages are required.

Install the packages that are required to load 32-bit and 64-bit C/C++ and FORTRAN libraries

> **Attention:** The following packages are required to run the examples that are included with MSL-LoadLib when it is installed. The dependencies for the C/C++ or FORTRAN library that you want to load may be different.

```
sudo apt install g++ gfortran libgfortran5 zlib1g:i386 libstdc++6:i386␣
↪libgfortran5:i386
```

The following ensures that the ss command is available

```
sudo apt install iproute2
```

If you need to load a Microsoft .NET library then you must install Mono (see here for instructions) and Python for .NET

```
pip3 install pythonnet
```

> **Attention:** If your version of Python is < 3.7, wheels for pythonnet are not available on PyPI and you must build Python for .NET from source. First, install the build dependencies,
>
> ```
> sudo apt install libglib2.0-dev clang python3-pip python3-dev
> pip3 install pycparser
> ```
>
> and then install Python for .NET
>
> ```
> pip3 install pythonnet
> ```
>
> If you have problems installing Python for .NET then the best place to find help is on the issues page of Python for .NET's repository.

Important: As of version 0.10.0 of MSL-LoadLib, pythonnet is no longer available on the 32-bit server for Linux. Mono can load both 32-bit and 64-bit libraries and therefore a 32-bit .NET library can be loaded directly via *LoadLibrary* on 64-bit Linux.

If you need to load a Java library (i.e., a `.jar` or `.class` file) then you must install Py4J,

```
pip3 install py4j
```

and a Java Runtime Environment

```
sudo apt install default-jre
```

Tip: When loading a shared library it is vital that all dependencies of the library are also on the computer and that the directory that the dependency is located in is available on the PATH variable. A helpful utility

to determine the dependencies of a shared library on Unix is ldd.

macOS

The 32-bit server has not been created for macOS; however, the *LoadLibrary* class can be used to load a library that uses the `__cdecl` calling convention that is the same bitness as the Python interpreter, a .NET library or a Java library.

The following assumes that you are using Homebrew as your package manager.

It is recommended to update Homebrew before installing packages

```
brew update
```

To load a C/C++ or FORTRAN library install gcc (which includes gfortran)

```
brew install gcc
```

If you need to load a Microsoft .NET library then you must install Mono,

```
brew install mono
```

and Python for .NET

```
pip3 install pythonnet
```

Attention: If your version of Python is < 3.7, wheels for pythonnet are not available on PyPI and you must build Python for .NET from source. First, install the build dependencies,

```
brew install pkg-config glib
pip3 install pycparser
```

and then install Python for .NET

```
pip3 install pythonnet
```

If you have problems installing Python for .NET then the best place to find help is on the issues page of Python for .NET's repository.

If you need to load a Java library (i.e., a `.jar` or `.class` file) then you must install Py4J,

```
pip3 install py4j
```

and a Java Runtime Environment

```
brew cask install java
```

1.2 Load a library

If you are loading a 64-bit library in 64-bit Python (or a 32-bit library in 32-bit Python) then you can directly load the library using *LoadLibrary*.

Important: If you want to load a 32-bit library in 64-bit Python then inter-process communication is used to communicate with the 32-bit library. See *Access a 32-bit library in 64-bit Python* for more details.

All of the shared libraries in the following examples are included with the MSL-LoadLib package. The *C++* and *FORTRAN* libraries have been compiled in 32- and 64-bit Windows and Linux and in 64-bit macOS. The *.NET* library was complied in 32- and 64-bit using Microsoft Visual Studio 2017. The kernel32 library is a 32-bit library and it is only valid on Windows (since it uses the `__stdcall` calling convention). The *LabVIEW* library was built using 32- and 64-bit LabVIEW on Windows. The *Java* libraries are platform and bitness independent since they run in the JVM.

Tip: If the file extension is not specified then a default extension, `.dll` (Windows), `.so` (Linux) or `.dylib` (macOS) is used.

1.2.1 C++

Load a 64-bit C++ library in 64-bit Python (view the *C++ source code*). *To load the 32-bit version in 32-bit Python use* `'/cpp_lib32'`.

```
>>> from msl.loadlib import LoadLibrary
>>> from msl.examples.loadlib import EXAMPLES_DIR
>>> cpp = LoadLibrary(EXAMPLES_DIR + '/cpp_lib64')
```

Call the `add` function to calculate the sum of two integers

```
>>> cpp.lib.add(1, 2)
3
```

1.2.2 FORTRAN

Load a 64-bit FORTRAN library in 64-bit Python (view the *FORTRAN source code*). *To load the 32-bit version in 32-bit Python use* `'/fortran_lib32'`.

```
>>> from msl.loadlib import LoadLibrary
>>> from msl.examples.loadlib import EXAMPLES_DIR
>>> fortran = LoadLibrary(EXAMPLES_DIR + '/fortran_lib64')
```

Call the `factorial` function. With a FORTRAN library you must pass values by reference using `ctypes`, and, since the returned value is not of type `ctypes.c_int` we must configure `ctypes` for a value of type `ctypes.c_double` to be returned

```
>>> from ctypes import byref, c_int, c_double
>>> fortran.lib.factorial.restype = c_double
>>> fortran.lib.factorial(byref(c_int(37)))
1.3763753091226343e+43
```

1.2.3 Microsoft .NET Framework

Load a 64-bit C# library (a .NET Framework) in 64-bit Python (view the *C# source code*). Include the `'net'` argument to indicate that the `.dll` file is for the .NET Framework. *To load the 32-bit version in 32-bit Python use* `'/dotnet_lib32.dll'`.

Tip: `'clr'` is an alias for `'net'` and can also be used as the *libtype*

```
>>> from msl.loadlib import LoadLibrary
>>> from msl.examples.loadlib import EXAMPLES_DIR
>>> net = LoadLibrary(EXAMPLES_DIR + '/dotnet_lib64.dll', 'net')
```

The *dotnet_lib64* library contains a reference to the `DotNetMSL` module (which is a C# namespace), the `StaticClass` class, the `StringManipulation` class and the System namespace

Create an instance of the `BasicMath` class in the `DotNetMSL` namespace and call the `multiply_doubles` method

```
>>> bm = net.lib.DotNetMSL.BasicMath()
>>> bm.multiply_doubles(2.3, 5.6)
12.879999...
```

Create an instance of the `ArrayManipulation` class in the `DotNetMSL` namespace and call the `scalar_multiply` method

```
>>> am = net.lib.DotNetMSL.ArrayManipulation()
>>> values = am.scalar_multiply(2., [1., 2., 3., 4., 5.])
>>> values
<System.Double[] object at ...>
>>> [val for val in values]
[2.0, 4.0, 6.0, 8.0, 10.0]
```

Use the `reverse_string` method in the `StringManipulation` class to reverse a string

```
>>> net.lib.StringManipulation().reverse_string('abcdefghijklmnopqrstuvwxyz')
'zyxwvutsrqponmlkjihgfedcba'
```

Use the static `add_multiple` method in the `StaticClass` class to add five integers

```
>>> net.lib.StaticClass.add_multiple(1, 2, 3, 4, 5)
15
```

One can create objects from the System namespace,

```
  >>> System = net.lib.System

for example, to create a 32-bit signed integer,
```

```
>>> System.Int32(9)
<System.Int32 object at ...>
```

or, a one-dimensional Array of the specified Type

```
>>> array = System.Array[int](list(range(10)))
>>> array
<System.Int32[] object at ...>
>>> list(array)
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
>>> array[0] = -1
>>> list(array)
[-1, 1, 2, 3, 4, 5, 6, 7, 8, 9]
```

1.2.4 Java

Since Java byte code is executed in a JVM it doesn't matter whether it was built with a 32- or 64-bit Java Development Kit. The Python interpreter does not load the Java byte code but communicates with the JVM through a local network socket that is created by Py4J.

Load a Java archive (view the *.jar source code*)

```
>>> from msl.loadlib import LoadLibrary
>>> from msl.examples.loadlib import EXAMPLES_DIR
>>> jar = LoadLibrary(EXAMPLES_DIR + '/java_lib.jar')
>>> jar
<LoadLibrary libtype=JVMView path=...java_lib.jar>
>>> jar.gateway
<py4j.java_gateway.JavaGateway object at ...>
```

The Java archive contains a `nz.msl.examples` package with two classes, `MathUtils` and `Matrix`

```
>>> MathUtils = jar.lib.nz.msl.examples.MathUtils
>>> Matrix = jar.lib.nz.msl.examples.Matrix
```

Calculate the square root of a number using the `MathUtils` class

```
>>> MathUtils.sqrt(32.4)
5.692099788303...
```

Solve a linear system of equations, Ax=b

```
>>> A = jar.gateway.new_array(jar.lib.Double, 3, 3)
>>> coeff = [[3, 2, -1], [7, -2, 4], [-1, 5, 1]]
>>> for i in range(3):
...     for j in range(3):
```

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```
...         A[i][j] = float(coeff[i][j])
...
>>> b = jar.gateway.new_array(jar.lib.Double, 3)
>>> b[0] = 4.0
>>> b[1] = 15.0
>>> b[2] = 12.0
>>> x = Matrix.solve(Matrix(A), Matrix(b))
>>> print(x.toString())
+1.000000e+00
+2.000000e+00
+3.000000e+00
```

Verify that x is the solution

```
>>> for i in range(3):
...     x_i = 0.0
...     for j in range(3):
...         x_i += coeff[i][j] * x.getValue(j,0)
...     assert abs(x_i - b[i]) < 1e-12
...
```

Shutdown the connection to the JVM when you are finished

```
>>> jar.gateway.shutdown()
```

Load Java byte code (view the *.class source code*)

```
>>> cls = LoadLibrary(EXAMPLES_DIR + '/Trig.class')
>>> cls
<LoadLibrary libtype=JVMView path=...Trig.class>
>>> cls.lib
<py4j.java_gateway.JVMView object at ...>
```

The Java library contains a `Trig` class, which calculates various trigonometric quantities

```
>>> Trig = cls.lib.Trig
>>> Trig
<py4j.java_gateway.JavaClass object at ...>
>>> Trig.cos(1.2)
0.3623577544766...
>>> Trig.asin(0.6)
0.6435011087932...
>>> Trig.tanh(1.3)
0.8617231593133...
```

Once again, shutdown the connection to the JVM when you are finished

```
>>> cls.gateway.shutdown()
```

1.2.5 COM

To load a Component Object Model (COM library) you pass in the library's Program ID. To view the COM libraries that are available on your computer you can run the *get_com_info()* function.

> **Attention:** This example is only valid on Windows.

Here we load the FileSystemObject and include the `'com'` argument to indicate that it is a COM library

```
>>> from msl.loadlib import LoadLibrary
>>> com = LoadLibrary('Scripting.FileSystemObject', 'com')
>>> com
<LoadLibrary libtype=POINTER(IFileSystem3) path=Scripting.FileSystemObject>
```

We can then use the library to create, edit and close a text file by using the CreateTextFile method

```
>>> fp = com.lib.CreateTextFile('a_new_file.txt')
>>> fp.Write('This is a test.')
0
>>> fp.Close()
0
```

Verify that the file exists and that the text is correct

```
>>> com.lib.FileExists('a_new_file.txt')
True
>>> file = com.lib.OpenTextFile('a_new_file.txt')
>>> file.ReadAll()
'This is a test.'
>>> file.Close()
0
```

1.2.6 Windows __stdcall

Load a 32-bit Windows `__stdcall` library in 32-bit Python, see kernel32. Include the `'windll'` argument to specify that the calling convention is `__stdcall`.

```
>>> from msl.loadlib import LoadLibrary
>>> kernel = LoadLibrary(r'C:\Windows\SysWOW64\kernel32.dll', 'windll')
>>> kernel
<LoadLibrary libtype=WinDLL path=C:\Windows\SysWOW64\kernel32.dll>
>>> kernel.lib
<WinDLL 'C:\Windows\SysWOW64\kernel32.dll', handle ... at ...>
>>> from ctypes import pointer
>>> from msl.examples.loadlib.kernel32 import SystemTime
>>> st = SystemTime()
>>> time = kernel.lib.GetLocalTime(pointer(st))
```

Now that we have a SYSTEMTIME structure we can access its attributes

```
>>> from datetime import datetime
>>> today = datetime.today()
>>> st.wYear == today.year
True
>>> st.wMonth == today.month
True
>>> st.wDay == today.day
True
```

See *here* for an example on how to communicate with kernel32 from 64-bit Python.

1.2.7 LabVIEW

Load a 64-bit LabVIEW library in 64-bit Python (view the *LabVIEW source code*). *To load the 32-bit version in 32-bit Python use* `'/labview_lib32.dll'`. *Also, an appropriate LabVIEW Run-Time Engine must be installed. The LabVIEW example is only valid on Windows.*

Note: A LabVIEW library can be built into a DLL using the `__cdecl` or `__stdcall` calling convention. Make sure that you specify the appropriate *libtype* when instantiating the *LoadLibrary* class.

```
>>> from msl.loadlib import LoadLibrary
>>> from msl.examples.loadlib import EXAMPLES_DIR
>>> labview = LoadLibrary(EXAMPLES_DIR + '/labview_lib64.dll')
>>> labview
<LoadLibrary libtype=CDLL path=...labview_lib64.dll>
>>> labview.lib
<CDLL '...labview_lib64.dll', handle ... at ...>
```

Create some data to calculate the mean, variance and standard deviation of

```
>>> data = [1, 2, 3, 4, 5, 6, 7, 8, 9]
```

Convert *data* to a `ctypes` array and allocate memory for the returned values

```
>>> from ctypes import c_double, byref
>>> x = (c_double * len(data))(*data)
>>> mean, variance, std = c_double(), c_double(), c_double()
```

Calculate the sample standard deviation (i.e., the third argument is set to 0) and variance

```
>>> ret = labview.lib.stdev(x, len(data), 0, byref(mean), byref(variance),␣
↪byref(std))
>>> mean.value
5.0
>>> variance.value
7.5
>>> std.value
2.7386127875258306
```

Calculate the population standard deviation (i.e., the third argument is set to 1) and variance

```
>>> ret = labview.lib.stdev(x, len(data), 1, byref(mean), byref(variance),␣
↪byref(std))
>>> mean.value
5.0
>>> variance.value
6.666666666666667
>>> std.value
2.581988897471611
```

1.3 Access a 32-bit library in 64-bit Python

This section of the documentation shows examples for how a module running within a 64-bit Python interpreter can communicate with a 32-bit shared library by using inter-process communication. The method that is used to allow a 32-bit and a 64-bit process to exchange information is by use of a file. The `pickle` module is used to (de)serialize Python objects.

The following table summarizes the example modules that are available.

Modules that end in *32* contain a class that is a subclass of *`Server32`*. This subclass is a wrapper around a 32-bit library and is hosted on a 32-bit server.

Modules that end in *64* contain a class that is a subclass of *`Client64`*. This subclass sends a request to the corresponding *`Server32`* subclass to communicate with the 32-bit library.

`echo32`	An example of a 32-bit *echo* server.
`echo64`	An example of a 64-bit *echo* client.
`cpp32`	A wrapper around a 32-bit C++ library, *cpp_lib32*.
`cpp64`	Communicates with *cpp_lib32* via the *`Cpp32`* class.
`fortran32`	A wrapper around a 32-bit FORTRAN library, *fortran_lib32*.
`fortran64`	Communicates with *fortran_lib32* via the *`Fortran32`* class.
`dotnet32`	A wrapper around a 32-bit .NET library, *dotnet_lib32*.
`dotnet64`	Communicates with a 32-bit .NET library via the *`DotNet32`* class.
`kernel32`	A wrapper around the 32-bit Windows kernel32.dll library.
`kernel64`	Communicates with kernel32.dll via the *`Kernel32`* class.
`labview32`	A wrapper around a 32-bit LabVIEW library, *labview_lib32*.
`labview64`	Communicates with *labview_lib32* via the *`Labview32`* class.

The following illustrates a minimal usage example. The *my_lib.dll* file is a 32-bit C++ library that cannot

be loaded from a module that is running within a 64-bit Python interpreter. This library gets loaded by the *MyServer* class which is running within a 32-bit process. *MyServer* hosts the library at a specified host address and port number. Any class that is a subclass of *Server32 must* provide two arguments in its constructor: `host` and `port`. Including keyword arguments in the constructor is optional.

```
# my_server.py

from msl.loadlib import Server32

class MyServer(Server32):
    """Wrapper around a 32-bit C++ library 'my_lib.dll' that has an 'add' and
↪'version' function."""

    def __init__(self, host, port, **kwargs):
        # Load the 'my_lib' shared-library file using ctypes.CDLL
        super(MyServer, self).__init__('my_lib.dll', 'cdll', host, port)

        # The Server32 class has a 'lib' property that is a reference to the␣
↪ctypes.CDLL object

        # Call the version function from the library
        self.version = self.lib.version()

    def add(self, a, b):
        # The shared library's 'add' function takes two integers as inputs and␣
↪returns the sum
        return self.lib.add(a, b)
```

MyClient is a subclass of *Client64* which sends a request to *MyServer* to call the `add` function in the shared library and to get the value of `version`. *MyServer* processes the request and sends the response back to *MyClient*.

```
# my_client.py

from msl.loadlib import Client64

class MyClient(Client64):
    """Call a function in 'my_lib.dll' via the 'MyServer' wrapper."""

    def __init__(self):
        # Specify the name of the Python module to execute on the 32-bit␣
↪server (i.e., 'my_server')
        super(MyClient, self).__init__(module32='my_server')

    def add(self, a, b):
        # The Client64 class has a 'request32' method to send a request to the␣
↪32-bit server
        # Send the 'a' and 'b' arguments to the 'add' method in MyServer
        return self.request32('add', a, b)

    def version(self):
```

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```
        # Get the version
        return self.request32('version')
```

The *MyClient* class would then be used as follows

```
>>> from my_client import MyClient
>>> c = MyClient()
>>> c.add(1, 2)
3
>>> c.version()
1
```

Keyword arguments, *kwargs*, that the *Server32* subclass requires can be passed to the server from the client (see, *Client64*). However, the data types for the values of the *kwargs* are not preserved (since they are ultimately parsed from the command line). Therefore, all data types for the values of the *kwargs* will be of type `str` at the constructor of the *Server32* subclass. These *kwargs* are the only arguments where the data type is not preserved for the client-server protocol. See the "Echo" example which shows that data types are preserved between client-server method calls.

The following examples are provided for communicating with different libraries that were compiled in different programming languages or using different calling conventions:

1.3.1 An *Echo* Example

This example illustrates that Python data types are preserved when they are passed from the *Echo64* client to the *Echo32* server and back. The *Echo32* server just returns a `tuple` of the `(args, kwargs)` that it received back to the *Echo64* client.

Create an *Echo64* object

```
>>> from msl.examples.loadlib import Echo64
>>> echo = Echo64()
```

send a boolean as an argument, see *send_data()*

```
>>> echo.send_data(True)
((True,), {})
```

send a boolean as a keyword argument

```
>>> echo.send_data(boolean=True)
((), {'boolean': True})
```

send multiple data types as arguments and as keyword arguments

```
>>> echo.send_data(1.2, {'my_list':[1, 2, 3]}, 0.2j, range(10), x=True, y=
↪'hello world!')
((1.2, {'my_list': [1, 2, 3]}, 0.2j, range(0, 10)), {'x': True, 'y': 'hello␣
↪world!'})
```

Shutdown the 32-bit server when you are done

```
>>> stdout, stderr = echo.shutdown_server32()
```

1.3.2 Load a 32-bit C++ library in 64-bit Python

This example shows how to access a 32-bit C++ library from 64-bit Python. *Cpp32* is the 32-bit server and *Cpp64* is the 64-bit client. The source code of the C++ program is available *here*.

Note: If you have issues running the example please make sure that you have the *prerequisites* installed for your operating system.

Important: By default `ctypes` expects that a `ctypes.c_int` data type is returned from the library call. If the returned value from the library is not a `ctypes.c_int` then you must redefine the ctypes restype value to be the appropriate data type. The *Cpp32* class shows various examples of redefining the restype value.

Create a *Cpp64* client to communicate with the 32-bit *cpp_lib32* library from 64-bit Python

```
>>> from msl.examples.loadlib import Cpp64
>>> cpp = Cpp64()
```

Add two integers, see *add()*

```
>>> cpp.add(3, 14)
17
```

Subtract two C++ floating-point numbers, see *subtract()*

```
>>> cpp.subtract(43.2, 3.2)
40.0
```

Add or subtract two C++ double-precision numbers, see *add_or_subtract()*

```
>>> cpp.add_or_subtract(1.0, 2.0, True)
3.0
>>> cpp.add_or_subtract(1.0, 2.0, False)
-1.0
```

Arrays

Multiply a 1D array by a number, see *scalar_multiply()*

Attention: The *scalar_multiply()* function takes a pointer to an array as an input argument, see *cpp_lib.h*. One cannot pass pointers from *Client64* to *Server32* because a 64-bit process cannot share the same memory space as a 32-bit process. All 32-bit pointers must be created (using `ctypes`) in the class that is a subclass of *Server32* and only the **value** that is stored at that address can be returned to *Client64* for use in the 64-bit program.

```
>>> a = [float(val) for val in range(10)]
>>> cpp.scalar_multiply(2.0, a)
[0.0, 2.0, 4.0, 6.0, 8.0, 10.0, 12.0, 14.0, 16.0, 18.0]
```

If you have a `numpy.ndarray` in 64-bit Python then you cannot pass the ndarray object to *Server32* because the 32-bit server would need to load the ndarray in a 32-bit version of numpy (which is not included by default in the 32-bit server, but could be – see *Re-freezing the 32-bit server* for more details). To simplify the procedure you could convert the ndarray to a `list` using the `numpy.ndarray.tolist()` method

```
>>> import numpy as np
>>> a = np.arange(9.)
>>> cpp.scalar_multiply(3.1, a.tolist())
[0.0, 3.1, 6.2, 9.3, 12.4, 15.5, 18.6, 21.7, 24.8]
```

or you could use the builtin `array.array` class

```
>>> from array import array
>>> b = array('d', a.tobytes())
>>> cpp.scalar_multiply(3.1, b)
[0.0, 3.1, 6.2, 9.3, 12.4, 15.5, 18.6, 21.7, 24.8]
```

If you want the returned value from *scalar_multiply* to be a numpy ndarray then use

```
>>> np.array(cpp.scalar_multiply(3.1, b))
array([ 0. ,  3.1,  6.2,  9.3, 12.4, 15.5, 18.6, 21.7, 24.8])
```

Strings

In this example the memory for the reversed string is allocated in Python, see *reverse_string_v1()*

```
>>> cpp.reverse_string_v1('hello world!')
'!dlrow olleh'
```

In this example the memory for the reversed string is allocated in C++, see *reverse_string_v2()*

```
>>> cpp.reverse_string_v2('uncertainty')
'ytniatrecnu'
```

Structs

It is possible to `pickle` a `ctypes.Structure` and pass the *struct* object between *Cpp64* and *Cpp32* provided that the *struct* is a **fixed size** in memory (i.e., the *struct* does not contain any pointers). If the *struct* contains pointers then you must create the *struct* within *Cpp32* and you can only pass the **values** of the *struct* back to *Cpp64*.

Attention: The following will only work if *Cpp64* is run using Python 3 because *Cpp32* is running on Python 3 and there are issues with `ctypes` and `pickle` when mixing Python 2 (client) and Python 3 (server).

The *cpp_lib32* library contains the following structs

```
struct Point {
    double x;
    double y;
};

struct FourPoints {
    Point points[4];
};

struct NPoints {
    int n;
    Point *points;
};
```

The *distance_4_points()* method uses the *FourPoints* struct to calculate the total distance connecting 4 *Point* structs. Since the *FourPoints* struct is a **fixed size** it can be created in 64-bit Python, *pickled* and then *unpickled* in *Cpp32*

```
>>> from msl.examples.loadlib import FourPoints
>>> fp = FourPoints((0, 0), (0, 1), (1, 1), (1, 0))
>>> cpp.distance_4_points(fp)
4.0
```

The *Cpp32.circumference* method uses the *NPoints* struct to calculate the circumference of a circle using *n* *Point* structs. Since the *NPoints* struct is **not a fixed size** it must be created in the *Cpp32.circumference* method. The *Cpp64.circumference* method takes the values of the *radius* and *n* as input arguments to pass to the *Cpp32.circumference* method.

```
>>> for i in range(16):
...     print(cpp.circumference(0.5, 2**i))
...
0.0
2.0
2.828427124746...
3.061467458920...
3.121445152258...
3.136548490545...
3.140331156954...
3.141277250932...
3.141513801144...
3.141572940367...
3.141587725277...
3.141591421511...
3.141592345569...
```

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```
3.141592576584...
3.141592634337...
3.141592648775...
```

Shutdown the 32-bit server when you are done communicating with the 32-bit library

```
>>> stdout, stderr = cpp.shutdown_server32()
```

1.3.3 Load a 32-bit FORTRAN library in 64-bit Python

This example shows how to access a 32-bit FORTRAN library from 64-bit Python. *Fortran32* is the 32-bit server and *Fortran64* is the 64-bit client. The source code of the FORTRAN program is available *here*.

Note: If you have issues running the example please make sure that you have the *prerequisites* installed for your operating system.

Important: By default `ctypes` expects that a `ctypes.c_int` data type is returned from the library call. If the returned value from the library is not a `ctypes.c_int` then you must redefine the ctypes restype value to be the appropriate data type. The *Fortran32* class shows various examples of redefining the restype value.

Create a *Fortran64* client to communicate with the 32-bit *fortran_lib32* library

```
>>> from msl.examples.loadlib import Fortran64
>>> f = Fortran64()
```

Add two `int8` values, see *sum_8bit()*

```
>>> f.sum_8bit(-50, 110)
60
```

Add two `int16` values, see *sum_16bit()*

```
>>> f.sum_16bit(2**15-1, -1)
32766
```

Add two `int32` values, see *sum_32bit()*

```
>>> f.sum_32bit(123456788, 1)
123456789
```

Add two `int64` values, see *sum_64bit()*

```
>>> f.sum_64bit(-2**63, 1)
-9223372036854775807...
```

Multiply two `float32` values, see *multiply_float32()*

```
>>> f.multiply_float32(1e30, 2e3)
1.99999998899...e+33
```

Multiply two `float64` values, see *multiply_float64()*

```
>>> f.multiply_float64(1e30, 2e3)
2.00000000000...e+33
```

Check if a value is positive, see *is_positive()*

```
>>> f.is_positive(1e-100)
True
>>> f.is_positive(-1e-100)
False
```

Add or subtract two integers, see *add_or_subtract()*

```
>>> f.add_or_subtract(1000, 2000, True)
3000
>>> f.add_or_subtract(1000, 2000, False)
-1000
```

Calculate the n'th factorial, see *factorial()*

```
>>> f.factorial(0)
1.0
>>> f.factorial(127)
3.012660018457658e+213
```

Calculate the standard deviation of an list of values, see *standard_deviation()*

```
>>> f.standard_deviation([float(val) for val in range(1,10)])
2.73861278752583...
```

Compute the Bessel function of the first kind of order 0, see *besselJ0()*

```
>>> f.besselJ0(8.6)
0.0146229912787412...
```

Reverse a string, see *reverse_string()*

```
>>> f.reverse_string('hello world!')
'!dlrow olleh'
```

Add two 1D arrays, see *add_1D_arrays()*

```
>>> a = [float(val) for val in range(1, 10)]
>>> b = [0.5*val for val in range(1, 10)]
>>> a
[1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0]
>>> b
[0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5]
```

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```
>>> f.add_1D_arrays(a, b)
[1.5, 3.0, 4.5, 6.0, 7.5, 9.0, 10.5, 12.0, 13.5]
```

Multiply two matrices, see *matrix_multiply()*

```
>>> m1 = [[1, 2, 3], [4, 5, 6]]
>>> m2 = [[1, 2], [3, 4], [5, 6]]
>>> f.matrix_multiply(m1, m2)
[[22.0, 28.0], [49.0, 64.0]]
```

Shutdown the 32-bit server when you are done communicating with the 32-bit library

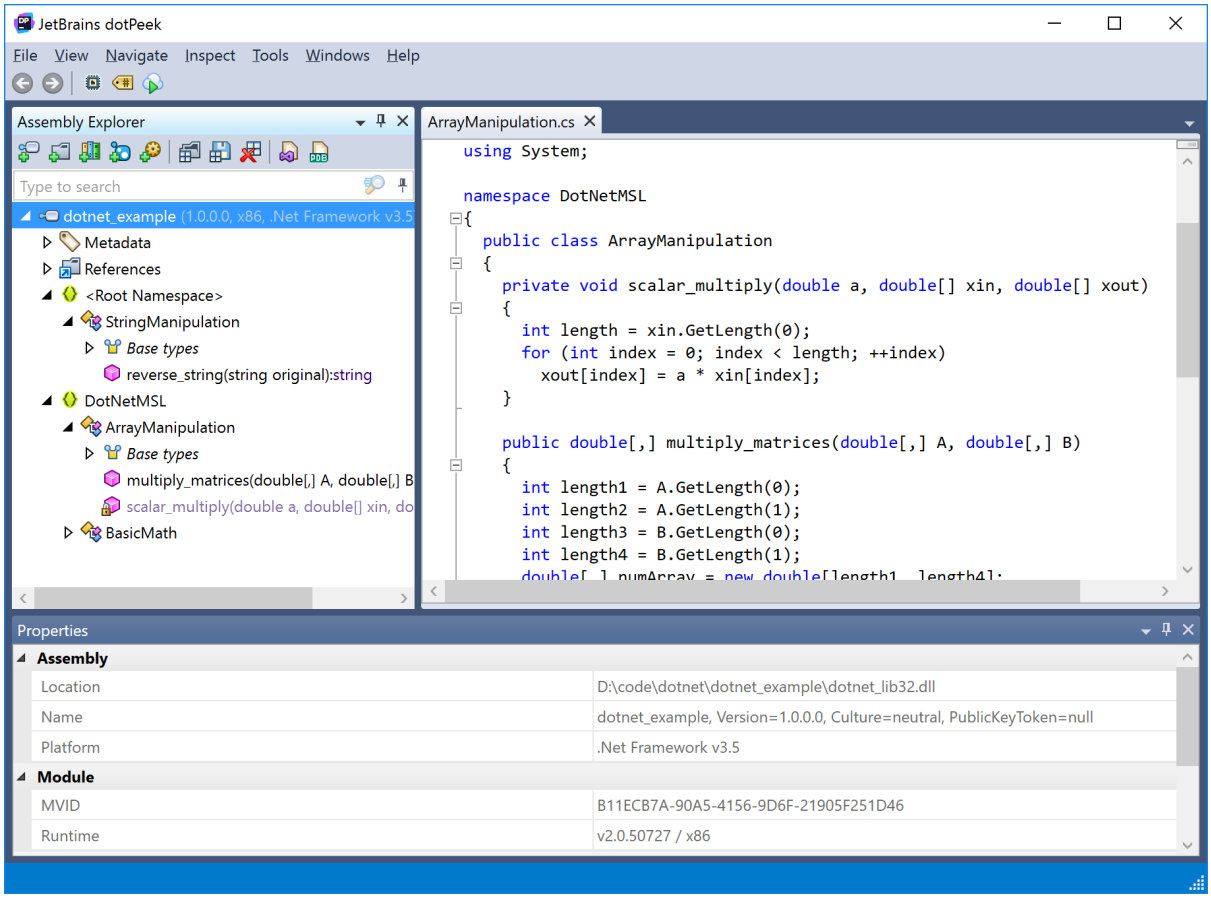
```
>>> stdout, stderr = f.shutdown_server32()
```

1.3.4 Load a 32-bit .NET library in 64-bit Python

This example shows how to access a 32-bit .NET library from 64-bit Python. *DotNet32* is the 32-bit server and *DotNet64* is the 64-bit client. The source code of the C# program is available *here*.

Note: If you have issues running the example please make sure that you have the *prerequisites* installed for your operating system.

Tip: The JetBrains dotPeek program can be used to decompile a .NET assembly into the equivalent source code. For example, *peeking* inside the *dotnet_lib32.dll* library, that the *DotNet32* class is a wrapper around, gives



Create a *DotNet64* client to communicate with the 32-bit *dotnet_lib32.dll* library

```
>>> from msl.examples.loadlib import DotNet64
>>> dn = DotNet64()
```

Get the names of the classes in the .NET library module, see *get_class_names()*

```
>>> dn.get_class_names()
['StringManipulation', 'StaticClass', 'DotNetMSL.BasicMath', 'DotNetMSL.
↪ArrayManipulation']
```

Add two integers, see *add_integers()*

```
>>> dn.add_integers(8, 2)
10
```

Divide two C# floating-point numbers, see *divide_floats()*

```
>>> dn.divide_floats(3., 2.)
1.5
```

Multiple two C# double-precision numbers, see *multiply_doubles()*

```
>>> dn.multiply_doubles(872.24, 525.525)
458383.926
```

Add or subtract two C# double-precision numbers, see *add_or_subtract()*

```
>>> dn.add_or_subtract(99., 9., True)
108.0
>>> dn.add_or_subtract(99., 9., False)
90.0
```

Multiply a 1D array by a number, see *scalar_multiply()*

```
>>> a = [float(val) for val in range(10)]
>>> a
[0.0, 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0]
>>> dn.scalar_multiply(2.0, a)
[0.0, 2.0, 4.0, 6.0, 8.0, 10.0, 12.0, 14.0, 16.0, 18.0]
```

Multiply two matrices, see *multiply_matrices()*

```
>>> m1 = [[1., 2., 3.], [4., 5., 6.]]
>>> m2 = [[1., 2.], [3., 4.], [5., 6.]]
>>> dn.multiply_matrices(m1, m2)
[[22.0, 28.0], [49.0, 64.0]]
```

Reverse a string, see *reverse_string()*

```
>>> dn.reverse_string('New Zealand')
'dnalaeZ weN'
```

Call the static methods in the `StaticClass` class

```
>>> dn.add_multiple(1, 2, 3, 4, 5)
15
>>> dn.concatenate('the ', 'experiment ', 'worked ', False, 'temporarily')
'the experiment worked '
>>> dn.concatenate('the ', 'experiment ', 'worked ', True, 'temporarily')
'the experiment worked temporarily'
```

Shutdown the 32-bit server when you are done communicating with the 32-bit library

```
>>> stdout, stderr = dn.shutdown_server32()
```

1.3.5 Load a 32-bit __stdcall library in 64-bit Python

This example shows how to access the 32-bit Windows kernel32 library from 64-bit Python. *Kernel32* is the 32-bit server and *Kernel64* is the 64-bit client.

Create a *Kernel64* client to communicate with the 32-bit kernel32 library

```
>>> from msl.examples.loadlib import Kernel64
>>> k = Kernel64()
>>> k.lib32_path
'C:\\Windows\\SysWOW64\\kernel32.dll'
```

Call the library to get the current date and time, see *get_local_time()*

```
>>> k.get_local_time()
datetime.datetime(2021, 1, 21, 15, 29, 8, 482000)
```

Shutdown the 32-bit server when you are done communicating with the 32-bit library

```
>>> stdout, stderr = k.shutdown_server32()
```

1.3.6 Load a 32-bit LabVIEW library in 64-bit Python

This example shows how to access a 32-bit LabVIEW library from 64-bit Python. *Labview32* is the 32-bit server and *Labview64* is the 64-bit client. The source code of the LabVIEW program is available *here*.

Attention: This example requires that a 32-bit LabVIEW Run-Time Engine is installed and that the operating system is Windows.

Create a *Labview64* client to communicate with the 32-bit *labview_lib32* library

```
>>> from msl.examples.loadlib import Labview64
>>> labview = Labview64()
```

Calculate the mean and the *sample* variance and standard deviation of some data, see *stdev()*

```
>>> data = [1, 2, 3, 4, 5, 6, 7, 8, 9]
>>> labview.stdev(data)
(5.0, 7.5, 2.7386127875258306)
```

Calculate the mean and the *population* variance and standard deviation of data

```
>>> labview.stdev(data, 1)
(5.0, 6.666666666666667, 2.581988897471611)
```

Shutdown the 32-bit server when you are done communicating with the 32-bit library

```
>>> stdout, stderr = labview.shutdown_server32()
```

Tip: If you find yourself repeatedly implementing each method in your *Client64* subclass in the following way (i.e., you are essentially duplicating the code for each method)

```
from msl.loadlib import Client64

class LinearAlgebra(Client64):

    def __init__(self):
        super(LinearAlgebra, self).__init__(module32='linear_algebra_32.py')

    def solve(self, matrix, vector):
```

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```
        return self.request32('solve', matrix, vector)

    def eigenvalues(self, matrix):
        return self.request32('eigenvalues', matrix)

    def stdev(self, data, as_population=True)
        return self.request32('stdev', data, as_population=as_population)

    def determinant(self, matrix):
        return self.request32('determinant', matrix)

    def cross_product(self, vector1, vector2):
        return self.request32('cross_product', vector1, vector2)
```

Then you can simplify the implementation by defining your *Client64* subclass as

```
from msl.loadlib import Client64

class LinearAlgebra(Client64):

    def __init__(self):
        super(LinearAlgebra, self).__init__(module32='linear_algebra_32.py')

    def __getattr__(self, name):
        def send(*args, **kwargs):
            return self.request32(name, *args, **kwargs)
        return send
```

and you will get the same behaviour. If you call a method that does not exist on the *Server32* subclass or if you specify the wrong number of arguments or keyword arguments then a *Server32Error* will be raised.

There are situations where you may want to explicitly write some (or all) of the methods in the *Client64* subclass in addition to (or instead of) implementing the `__getattr__` method, e.g.,

- you are writing an API for others to use and you want features like autocomplete or docstrings to be available in the IDE that the person using your API is using
- you want the *Client64* subclass to do error checking on the `*args`, `**kwargs` and/or on the result from the *Server32* subclass (this allows you to have control over the type of Exception that is raised because if the *Server32* subclass raises an exception then it is a *Server32Error*)
- you want to modify the returned object from a particular *Server32* method, for example, a `list` is returned but you want the corresponding *Client64* method to return a `numpy.ndarray`

1.4 MSL-LoadLib API Documentation

The root package is

msl.loadlib	Load a shared library.

which has the following class for directly loading a shared library,

LoadLibrary(path[, libtype])	Load a shared library.

the following client-server classes for communicating with a 32-bit library from 64-bit Python,

Client64(module32[, host, port, timeout, ...])	Base class for communicating with a 32-bit library from 64-bit Python.
Server32(path, libtype, host, port, *args, ...)	Base class for loading a 32-bit library in 32-bit Python.

a function to create a frozen 32-bit server

freeze_server32	Creates a 32-bit server to use for inter-process communication.

some general helper functions

utils	Common functions used by the **MSL-LoadLib** package.

and a module for interacting with ActiveX libraries

activex	Helper module for loading an ActiveX library.

1.4.1 Package Structure

msl.loadlib package

Load a shared library.

The following constants are provided in the **MSL-LoadLib** package.

msl.loadlib.version_info = version_info(major=0, minor=10, micro=0, releaselevel='final')

Contains the version information as a (major, minor, micro, releaselevel) tuple.

Type
namedtuple

msl.loadlib.**IS_WINDOWS = False**

Whether the operating system is Windows.

Type
bool

msl.loadlib.**IS_LINUX = True**

Whether the operating system is Linux.

Type
bool

msl.loadlib.**IS_MAC = False**

Whether the operating system is macOS.

Type
bool

msl.loadlib.**IS_PYTHON_64BIT = True**

Whether the Python interpreter is 64-bits.

Type
bool

msl.loadlib.**IS_PYTHON2 = False**

Whether Python 2.x is being used.

Type
bool

msl.loadlib.**IS_PYTHON3 = True**

Whether Python 3.x is being used.

Type
bool

msl.loadlib.activex module

Helper module for loading an ActiveX library.

The module also defines all the Window Styles and Extended Window Styles constants.

class msl.loadlib.activex.**Forms**

Bases: object

Form

alias of object

class msl.loadlib.activex.**Application**

Bases: object

Create the main application window to display ActiveX controls.

Creating an application requires pythonnet to be installed.

See Form for more details.

Examples

```
>>> from msl.loadlib.activex import Application
>>> app = Application()
>>> app.create_panel()
<System.Windows.Forms.Panel object at ...>
```

handle_events(*source*, *sink=None*, *interface=None*)

Handle events from an ActiveX object.

Parameters

- **source** – The ActiveX object that emits events.
- **sink** – The object that handles the events. The *sink* must define methods with the same names as the ActiveX event names. If not specified then uses the calling application instance as the *sink*.
- **interface** – The interface to use.

Returns

The connection object.

static create_panel()

Create a new Panel.

static load(*activex_id*, *parent=None*, *x=0*, *y=0*, *width=0*, *height=0*, *style=0*, *ex_style=0*)

Load an ActiveX library.

Additional information about the keyword arguments are described by the CreateWindowExA object.

Loading an ActiveX library requires comtypes to be installed.

Parameters

- **activex_id** (str) – The ProgID or CLSID of the ActiveX object.
- **parent** – The parent or owner window of the window being created. The parent is typically an object from the System.Windows.Forms namespace that has a `Handle` property.
- **x** (int, optional) – The initial horizontal position of the window.
- **y** (int, optional) – The initial vertical position of the window.
- **width** (int, optional) – The width of the window.
- **height** (int, optional) – The height of the window.
- **style** (int, optional) – The style of the window being created. This argument can be a combination of the Window Styles constants, e.g., `style = WS_CHILD | WS_VISIBLE`.
- **ex_style** (int, optional) – The extended window style of the window being created. This argument can be a combination of the Extended Window Styles constants, e.g., `ex_style = WS_EX_APPWINDOW | WS_EX_CONTEXTHELP`.

Returns
The interface pointer to the ActiveX library.

Raises
`OSError` – If the library cannot be loaded.

msl.loadlib.client64 module

Contains the base class for communicating with a 32-bit library from 64-bit Python.

The *Server32* class is used in combination with the *Client64* class to communicate with a 32-bit shared library from 64-bit Python.

class msl.loadlib.client64.**Client64**(*module32*, *host='127.0.0.1'*, *port=None*, *timeout=10.0*, *quiet=None*, *append_sys_path=None*, *append_environ_path=None*, *rpc_timeout=None*, *protocol=None*, *server32_dir=None*, ***kwargs*)

Bases: `object`

Base class for communicating with a 32-bit library from 64-bit Python.

Starts a 32-bit server, *Server32*, to host a Python class that is a wrapper around a 32-bit library. *Client64* runs within a 64-bit Python interpreter, and it sends a request to the server which calls the 32-bit library to execute the request. The server then provides a response back to the client.

Changed in version 0.6: Added the *rpc_timeout* argument.

Changed in version 0.8: Added the *protocol* argument and the default *quiet* value became `None`.

Changed in version 0.10: Added the *server32_dir* argument.

Parameters

- **module32** (`str`) – The name of the Python module that is to be imported by the 32-bit server.
- **host** (`str`, optional) – The address of the 32-bit server. Default is `'127.0.0.1'`.
- **port** (`int`, optional) – The port to open on the 32-bit server. Default is `None`, which means to automatically find a port that is available.
- **timeout** (`float`, optional) – The maximum number of seconds to wait to establish a connection to the 32-bit server. Default is 10 seconds.
- **quiet** (`bool`, optional) – This keyword argument is no longer used and will be removed in a future release.
- **append_sys_path** (`str` or `list` of `str`, optional) – Append path(s) to the 32-bit server's `sys.path` variable. The value of `sys.path` from the 64-bit process is automatically included, i.e., `sys.path(32bit) = sys.path(64bit) + append_sys_path`.
- **append_environ_path** (`str` or `list` of `str`, optional) – Append path(s) to the 32-bit server's `os.environ['PATH']` variable. This can be useful if the library that is being loaded requires additional libraries that must be available on `PATH`.

- **rpc_timeout** (float, optional) – The maximum number of seconds to wait for a response from the 32-bit server. The RPC timeout value is used for *all* requests from the server. If you want different requests to have different timeout values then you will need to implement custom timeout handling for each method on the server. Default is None, which means to use the default timeout value used by the socket module (which is to *wait forever*).
- **protocol** (int, optional) – The pickle protocol to use. If not specified then determines the value to use based on the version of Python that the *Client64* is running in.
- **server32_dir** (str, optional) – The directory where the frozen 32-bit server is located.
- ****kwargs** – All additional keyword arguments are passed to the *Server32* subclass. The data type of each value is not preserved. It will be a string at the constructor of the *Server32* subclass.

Note: If *module32* is not located in the current working directory then you must either specify the full path to *module32* **or** you can specify the folder where *module32* is located by passing a value to the *append_sys_path* parameter. Using the *append_sys_path* option also allows for any other modules that *module32* may depend on to also be included in sys.path so that those modules can be imported when *module32* is imported.

Raises

- *ConnectionTimeoutError* – If the connection to the 32-bit server cannot be established.
- OSError – If the frozen executable cannot be found.
- TypeError – If the data type of *append_sys_path* or *append_environ_path* is invalid.

property host

The address of the host for the *connection*.

Type
str

property port

The port number of the *connection*.

Type
int

property connection

The reference to the connection to the 32-bit server.

Type
HTTPConnection

property lib32_path

The path to the 32-bit library.

Returns

str – The path to the 32-bit shared-library file.

request32(*name*, **args*, ***kwargs*)

Send a request to the 32-bit server.

Parameters

- **name** (str) – The name of an attribute of the *Server32* subclass. The name can be a method, property or any attribute.
- ***args** – The arguments that the method in the *Server32* subclass requires.
- ****kwargs** – The keyword arguments that the method in the *Server32* subclass requires.

Returns

Whatever is returned by the method of the *Server32* subclass.

Raises

- ***Server32Error*** – If there was an error processing the request on the 32-bit server.
- ***ResponseTimeoutError*** – If a timeout occurs while waiting for the response from the 32-bit server.

shutdown_server32(*kill_timeout=10*)

Shutdown the 32-bit server.

This method shuts down the 32-bit server, closes the client connection, and deletes the temporary file that is used to save the serialized pickle'd data.

Changed in version 0.6: Added the *kill_timeout* argument.

Changed in version 0.8: Returns the (stdout, stderr) streams from the 32-bit server.

Parameters

kill_timeout (float, optional) – If the 32-bit server is still running after *kill_timeout* seconds then the server will be killed using brute force. A warning will be issued if the server is killed in this manner.

Returns

tuple – The (stdout, stderr) streams from the 32-bit server. Limit the total number of characters that are written to either stdout or stderr on the 32-bit server to be < 4096. This will avoid potential blocking when reading the stdout and stderr PIPE buffers.

Note: This method gets called automatically when the reference count to the *Client64* object reaches 0 – see __del__().

---

msl.loadlib.exceptions module

Exception classes.

exception msl.loadlib.exceptions.**ConnectionTimeoutError**(**args*, ***kwargs*)

Bases: OSError

Raised when the connection to the 32-bit server cannot be established.

exception msl.loadlib.exceptions.**Server32Error**(*value*, *name=None*, *traceback=None*)

Bases: HTTPException

Raised when an exception occurs on the 32-bit server.

New in version 0.5.

Parameters

- **value** (str) – The error message.
- **name** (str, optional) – The name of the exception.
- **traceback** (str, optional) – The exception traceback.

property name

The name of the exception from the 32-bit server.

Type
str

property traceback

The exception traceback from the 32-bit server.

Type
str

property value

The error message from the 32-bit server.

Type
str

exception msl.loadlib.exceptions.**ResponseTimeoutError**

Bases: OSError

Raised when a timeout occurs while waiting for a response from the 32-bit server.

New in version 0.6.

msl.loadlib.freeze_server32 module

Creates a 32-bit server to use for inter-process communication.

This module must be run from a 32-bit Python interpreter with PyInstaller installed.

If you want to re-freeze the 32-bit server, for example, if you want a 32-bit version of numpy to be available on the server, then run the following with a 32-bit Python interpreter that has the packages that you want to be available on the server installed

```
>>> from msl.loadlib import freeze_server32
>>> freeze_server32.main()
```

msl.loadlib.freeze_server32.**main**(*spec=None*, *requires_pythonnet=True*, *requires_comtypes=True*, *dest=None*)

Creates a 32-bit Python server.

Uses PyInstaller to create a frozen 32-bit Python executable. This executable starts a 32-bit server, *Server32*, which hosts a Python module that can load a 32-bit library.

Changed in version 0.5: Added the *requires_pythonnet* and *requires_comtypes* arguments.

Changed in version 0.10: Added the *dest* argument.

Parameters

- **spec** (str, optional) – The path to a PyInstaller .spec file to use to create the frozen 32-bit server.
- **requires_pythonnet** (bool, optional) – Whether Python for .NET must be available on the frozen 32-bit server. This argument is ignored for a non-Windows operating system.
- **requires_comtypes** (bool, optional) – Whether comtypes must be available on the frozen 32-bit server. This argument is ignored for a non-Windows operating system.
- **dest** (str, optional) – The destination directory to save the server to.

msl.loadlib.load_library module

Load a shared library.

class msl.loadlib.load_library.**LoadLibrary**(*path*, *libtype=None*, ***kwargs*)

Bases: object

Load a shared library.

For example, a C/C++, FORTRAN, C#, Java, Delphi, LabVIEW, ActiveX, ... library.

Changed in version 0.4: Added support for Java archives.

Changed in version 0.5: Added support for COM libraries.

Changed in version 0.9: Added support for ActiveX libraries.

Parameters

- **path** (str) – The path to the shared library.

  The search order for finding the shared library is:

  1. assume that a full or a relative (to the current working directory) path is specified,
  2. use ctypes.util.find_library() to find the shared library file,
  3. search sys.path, then
  4. search os.environ['PATH'] to find the shared library.

If loading a COM library then *path* is either the *ProgID*, e.g. `"InternetExplorer.Application"`, or the *CLSID*, e.g. `"{2F7860A2-1473-4D75-827D-6C4E27600CAC}"`.

- **libtype** (str, optional) – The library type. The following values are currently supported:
  - `'cdll'` – for a library that uses the __cdecl calling convention
  - `'windll'` or `'oledll'` – for a __stdcall calling convention
  - `'net'` or `'clr'` – for Microsoft's .NET Framework (Common Language Runtime)
  - `'java'` – for a Java archive, `.jar`, or Java byte code, `.class`, file
  - `'com'` – for a COM library
  - `'activex'` – for an ActiveX library

  Default is `'cdll'`.

  Tip: Since the `.jar` or `.class` extension uniquely defines a Java library, the *libtype* will be automatically set to `'java'` if *path* ends with `.jar` or `.class`.

- ****kwargs** – All additional keyword arguments are passed to the object that loads the library.

  If *libtype* is
  - `'cdll'` then CDLL
  - `'windll'` then WinDLL
  - `'oledll'` then OleDLL
  - `'net'` or `'clr'` then all keyword arguments are ignored
  - `'java'` then JavaGateway
  - `'com'` then comtypes.CreateObject
  - `'activex'` then *Application.load*

Raises

- OSError – If the shared library cannot be loaded.
- ValueError – If the value of *libtype* is not supported.

LIBTYPES = ['cdll', 'windll', 'oledll', 'net', 'clr', 'java', 'com', 'activex']

The library types that are supported.

cleanup()

Clean up references to the library.

New in version 0.10.0.

property assembly

Returns a reference to the .NET Runtime Assembly object if the shared library is a .NET Framework otherwise returns `None`.

Tip: The JetBrains dotPeek program can be used to reliably decompile any .NET Assembly into the equivalent source code.

---

property gateway

Returns the `JavaGateway` object, only if the shared library is a Java archive, otherwise returns `None`.

property lib

Returns the reference to the loaded library object.

For example, if *libtype* is

- `'cdll'` then a `CDLL` object
- `'windll'` then a `WinDLL` object
- `'oledll'` then a `OleDLL` object
- `'net'` or `'clr'` then a *`DotNet`* object
- `'java'` then a `JVMView` object
- `'com'` or `'activex'` then an interface pointer to the COM object

property path

The path to the shared library file.

Type
`str`

class msl.loadlib.load_library.**DotNet**(*dot_net_dict*, *path*)

Bases: `object`

Contains the namespace modules, classes and System.Type objects of a .NET Assembly.

Do not instantiate this class directly.

msl.loadlib.server32 module

Contains the base class for loading a 32-bit shared library in 32-bit Python.

The *`Server32`* class is used in combination with the *`Client64`* class to communicate with a 32-bit shared library from 64-bit Python.

class msl.loadlib.server32.**Server32**(*path*, *libtype*, *host*, *port*, **args*, ***kwargs*)

Bases: `HTTPServer`

Base class for loading a 32-bit library in 32-bit Python.

All modules that are to be run on the 32-bit server must contain a class that is inherited from this class and the module can import **any** of the standard python modules **except** for `distutils`, `ensurepip`, `tkinter` and `turtle`.

All modules that are run on the 32-bit server must be able to run on the Python interpreter that the server is running on, see *version()* for how to determine the version of the Python interpreter.

Parameters

- **path** (str) – The path to the 32-bit library. See *LoadLibrary* for more details.
- **libtype** (str) – The library type. See *LoadLibrary* for more details.

  Note: Since Java byte code is executed on the JVM it does not make sense to use *Server32* for a Java `.jar` or `.class` file.

- **host** (str) – The IP address of the server.
- **port** (int) – The port to run the server on.
- ***args** – All additional arguments are currently ignored.
- ****kwargs** – All keyword arguments are passed to *LoadLibrary*.

property assembly

Returns a reference to the .NET Runtime Assembly object if the shared library is a .NET Framework otherwise returns None.

Tip: The JetBrains dotPeek program can be used to reliably decompile any .NET Assembly into the equivalent source code.

property lib

Returns the reference to the 32-bit, loaded-library object.

For example, if *libtype* is

- `'cdll'` then a CDLL object
- `'windll'` then a WinDLL object
- `'oledll'` then a OleDLL object
- `'net'` or `'clr'` then a *DotNet* object
- `'com'` or `'activex'` then an interface pointer to the COM object

property path

The path to the shared library file.

Type
str

static version()

Gets the version of the Python interpreter that the 32-bit server is running on.

Returns
str – The result of executing `'Python ' + sys.version` on the 32-bit server.

Examples

```
>>> from msl.loadlib import Server32
>>> Server32.version()
'Python 3.11.4 ...'
```

Note: This method takes about 1 second to finish because the 32-bit server needs to start in order to determine the version of the Python interpreter.

---

static interactive_console()

Start an interactive console.

This method starts an interactive console, in a new terminal, with the Python interpreter on the 32-bit server.

Examples

```
>>> from msl.loadlib import Server32
>>> Server32.interactive_console()
```

property quiet

This attribute is no longer used, it will be removed in a future release.

Returns `True`.

static remove_site_packages_64bit()

Remove the site-packages directory from the 64-bit process.

By default, the site-packages directory of the 64-bit process is included in `sys.path` of the 32-bit process. Having the 64-bit site-packages directory available can sometimes cause issues. For example, comtypes imports numpy so if numpy is installed in the 64-bit process then comtypes will import the 64-bit version of numpy in the 32-bit process. Depending on the version of Python and/or numpy this can cause the 32-bit server to crash.

New in version 0.9.

Examples

```
import sys
from msl.loadlib import Server32

class FileSystem(Server32):

    def __init__(self, host, port, **kwargs):

        # remove the site-packages directory that was passed from 64-
↪bit Python
        # before calling the super() function to load the COM library
        path = Server32.remove_site_packages_64bit()
```

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```
        super(FileSystem, self).__init__('Scripting.FileSystemObject
↪', 'com', host, port)

        # optional: add the site-packages directory back into sys.
↪path
        sys.path.append(path)
```

Returns

`str` – The path of the site-packages directory that was removed. Can be an empty string if the directory was not found in `sys.path`.

static is_interpreter()

Check if code is running on the 32-bit server.

If the same module is executed by both *Client64* and *Server32* then there may be only parts of the code that should be executed by the correct bitness of the Python interpreter.

New in version 0.9.

Returns

`bool` – Whether the code is running on the 32-bit server.

Examples

```
import sys
from msl.loadlib import Server32

if Server32.is_interpreter():
    # this only gets executed on the 32-bit server
    assert sys.maxsize < 2**32
```

static examples_dir()

Get the directory where the example libraries are located.

New in version 0.9.

Returns

`str` – The directory where the example libraries are located.

shutdown_handler()

Proxy function that is called immediately prior to the server shutting down.

The intended use case is for the server to do any necessary cleanup, such as stopping locally started threads or closing file handles before it shuts down.

New in version 0.6.

msl.loadlib.start_server32 module

This module is built in to a 32-bit executable by running *freeze_server32*.

The executable is used to host a 32-bit library, *Server32*, so that a module running in a 64-bit Python interpreter, *Client64*, can communicate with the library. This client-server exchange of information is a form of inter-process communication.

msl.loadlib.start_server32.**main**()

Starts a 32-bit server (which is a subclass of *Server32*).

Parses the command-line arguments to run a Python module on a 32-bit server to host a 32-bit library. To see the list of command-line arguments that are allowed, run the executable with the `--help` flag (or click here to view the source code of the `argparse.ArgumentParser` implementation).

msl.loadlib.utils module

Common functions used by the **MSL-LoadLib** package.

msl.loadlib.utils.**is_pythonnet_installed**()

Checks if Python for .NET is installed.

Returns

`bool` – Whether Python for .NET is installed.

Note: For help getting Python for .NET installed on a non-Windows operating system look at the *prerequisites*, the Mono project and the Python for .NET documentation.

---

msl.loadlib.utils.**is_py4j_installed**()

Checks if Py4J is installed.

New in version 0.4.

Returns

`bool` – Whether Py4J is installed.

msl.loadlib.utils.**is_comtypes_installed**()

Checks if comtypes is installed.

New in version 0.5.

Returns

`bool` – Whether comtypes is installed.

msl.loadlib.utils.**check_dot_net_config**(*py_exe_path*)

Check if the **useLegacyV2RuntimeActivationPolicy** property is enabled.

By default, Python for .NET works with .NET 4.0+ and therefore it cannot automatically load a shared library that was compiled with .NET <4.0. This method ensures that the **useLegacyV2RuntimeActivationPolicy** property exists in the **<python-executable>.config** file and that it is enabled.

This link provides an overview explaining why the **useLegacyV2RuntimeActivationPolicy** property is required.

The **<python-executable>.config** file should look like

```
<?xml version="1.0" encoding="utf-8" ?>
<configuration>
    <startup useLegacyV2RuntimeActivationPolicy="true">
        <supportedRuntime version="v4.0" />
        <supportedRuntime version="v2.0.50727" />
    </startup>
</configuration>
```

Parameters
py_exe_path (str) – The path to a Python executable.

Returns

- int –

  One of the following values:

  - -1 – if there was a problem
  - 0 – if the .NET property was already enabled, or
  - 1 – if the property was created successfully.

- str – A message describing the outcome.

msl.loadlib.utils.**is_port_in_use**(*port*)

Checks whether the TCP port is in use.

Changed in version 0.10.0: Only check TCP ports (instead of both TCP and UDP ports). Uses the `ss` command instead of `netstat` on Linux.

Changed in version 0.7.0: Renamed from *port_in_use* and added support for macOS.

Parameters
port (int) – The port number to test.

Returns
bool – Whether the TCP port is in use.

msl.loadlib.utils.**get_available_port**()

int: Returns a port number that is available.

msl.loadlib.utils.**wait_for_server**(*host*, *port*, *timeout*)

Wait for the 32-bit server to start.

Parameters

- **host** (str) – The host address of the server, e.g., `'127.0.0.1'`.
- **port** (int) – The port number of the server.
- **timeout** (float) – The maximum number of seconds to wait to establish a connection to the server.

Raises
ConnectionTimeoutError – If a timeout occurred.

msl.loadlib.utils.**get_com_info**(**additional_keys*)

Reads the registry for the COM libraries that are available.

This function is only supported on Windows.

New in version 0.5.

Parameters

***additional_keys** (str, optional) – The Program ID (ProgID) key is returned automatically. You can include additional keys (e.g., Version, InprocHandler32, ToolboxBitmap32, VersionIndependentProgID, ...) if you also want this additional information to be returned for each Class ID.

Returns

dict – The keys are the Class ID's and each value is a dict of the information that was requested.

Examples

```
>>> from msl.loadlib import utils
>>> info = utils.get_com_info()
>>> info = utils.get_com_info('Version', 'ToolboxBitmap32')
```

msl.loadlib.utils.**generate_com_wrapper**(*lib*, *out_dir=None*)

Generate a Python wrapper module around a COM library.

For more information see Accessing type libraries.

New in version 0.9.

Parameters

- **lib** – Can be any of the following
  - a *LoadLibrary* object
  - the *ProgID* or *CLSID* of a registered COM library as a str
  - a COM pointer instance
  - an ITypeLib COM pointer instance
  - a path to a library file (.tlb, .exe or .dll) as a str
  - a tuple or list specifying the GUID of a library, a major and a minor version number, plus optionally an LCID number, e.g., (guid, major, minor, lcid=0)
  - an object with _reg_libid_ and _reg_version_ attributes
- **out_dir** (str, optional) – The output directory to save the wrapper to. If not specified then saves it to the ../site-packages/comtypes/gen directory.

Returns

The wrapper module that was generated.

1.4.2 Example modules for communicating with a 32-bit library from 64-bit Python

msl.examples.loadlib package

Example modules showing how to load a 32-bit shared library in 64-bit Python.

Modules that end in **32** contain a class that is a subclass of *Server32*. This subclass is a wrapper around a 32-bit library and is hosted on a 32-bit server.

Modules that end in **64** contain a class that is a subclass of *Client64*. This subclass sends a request to the corresponding *Server32* subclass to communicate with the 32-bit library.

msl.examples.loadlib.cpp32 module

A wrapper around a 32-bit C++ library, *cpp_lib32*.

Example of a server that loads a 32-bit shared library, *cpp_lib*, in a 32-bit Python interpreter to host the library. The corresponding *cpp64* module can be executed by a 64-bit Python interpreter and the *Cpp64* class can send a request to the *Cpp32* class which calls the 32-bit library to execute the request and then return the response from the library.

class msl.examples.loadlib.cpp32.**Cpp32**(*host*, *port*, ***kwargs*)

Bases: *Server32*

A wrapper around the 32-bit C++ library, *cpp_lib32*.

This class demonstrates how to send/receive various data types to/from a 32-bit C++ library via ctypes.

Parameters

- **host** (str) – The IP address of the server.
- **port** (int) – The port to open on the server.

Note: Any class that is a subclass of *Server32* **MUST** provide two arguments in its constructor: *host* and *port* (in that order) and ***kwargs*. Otherwise the server32 executable, see *start_server32*, cannot create an instance of the *Server32* subclass.

---

add(*a*, *b*)

Add two integers.

The corresponding C++ code is

```
int add(int a, int b) {
    return a + b;
}
```

See the corresponding 64-bit *add()* method.

Parameters

- **a** (int) – The first integer.
- **b** (int) – The second integer.

Returns

int – The sum of *a* and *b*.

subtract(*a*, *b*)

Subtract two floating-point numbers *('float' refers to the C++ data type)*.

The corresponding C++ code is

```
float subtract(float a, float b) {
    return a - b;
}
```

See the corresponding 64-bit *subtract()* method.

Parameters

- **a** (float) – The first floating-point number.
- **b** (float) – The second floating-point number.

Returns

float – The difference between *a* and *b*.

add_or_subtract(*a*, *b*, *do_addition*)

Add or subtract two double-precision numbers *('double' refers to the C++ data type)*.

The corresponding C++ code is

```
double add_or_subtract(double a, double b, bool do_addition) {
    if (do_addition) {
        return a + b;
    } else {
        return a - b;
    }
}
```

See the corresponding 64-bit *add_or_subtract()* method.

Parameters

- **a** (float) – The first double-precision number.
- **b** (float) – The second double-precision number.
- **do_addition** (bool) – Whether to **add** the numbers.

Returns

float – Either *a* + *b* if *do_addition* is True else *a* - *b*.

scalar_multiply(*a*, *xin*)

Multiply each element in an array by a number.

The corresponding C++ code is

```
void scalar_multiply(double a, double* xin, int n, double* xout) {
    for (int i = 0; i < n; i++) {
        xout[i] = a * xin[i];
    }
}
```

See the corresponding 64-bit *scalar_multiply()* method.

Parameters

- **a** (float) – The scalar value.
- **xin** (list of float) – The array to modify.

Returns

list of float – A new array with each element in *xin* multiplied by *a*.

reverse_string_v1(*original*)

Reverse a string (version 1).

In this method Python allocates the memory for the reversed string and passes the string to C++.

The corresponding C++ code is

```
void reverse_string_v1(const char* original, int n, char* reversed) {
    for (int i = 0; i < n; i++) {
        reversed[i] = original[n-i-1];
    }
}
```

See the corresponding 64-bit *reverse_string_v1()* method.

Parameters

original (str) – The original string.

Returns

str – The string reversed.

reverse_string_v2(*original*)

Reverse a string (version 2).

In this method C++ allocates the memory for the reversed string and passes the string to Python.

The corresponding C++ code is

```
char* reverse_string_v2(char* original, int n) {
    char* reversed = new char[n];
    for (int i = 0; i < n; i++) {
        reversed[i] = original[n - i - 1];
    }
    return reversed;
}
```

See the corresponding 64-bit *reverse_string_v2()* method.

Parameters

original (str) – The original string.

Returns

str – The string reversed.

distance_4_points(*four_points*)

Calculates the total distance connecting 4 *Point*'s.

The corresponding C++ code is

```
double distance_4_points(FourPoints p) {
    double d = distance(p.points[0], p.points[3]);
    for (int i = 1; i < 4; i++) {
        d += distance(p.points[i], p.points[i-1]);
    }
    return d;
}
```

See the corresponding 64-bit *distance_4_points()* method.

Parameters

four_points (*FourPoints*) – The points to use to calculate the total distance.

Returns

float – The total distance connecting the 4 *Point*'s.

circumference(*radius*, *n*)

Estimates the circumference of a circle.

This method calls the `distance_n_points` function in *cpp_lib32*.

See the corresponding 64-bit *circumference()* method.

The corresponding C++ code uses the *NPoints* struct as the input parameter to sum the distance between adjacent points on the circle.

```
double distance_n_points(NPoints p) {
    if (p.n < 2) {
        return 0.0;
    }
    double d = distance(p.points[0], p.points[p.n-1]);
    for (int i = 1; i < p.n; i++) {
        d += distance(p.points[i], p.points[i-1]);
    }
    return d;
}
```

Parameters

- **radius** (float) – The radius of the circle.
- **n** (int) – The number of points to use to estimate the circumference.

Returns

float – The estimated circumference of the circle.

class msl.examples.loadlib.cpp32.**Point**

Bases: Structure

C++ struct that is a fixed size in memory.

This object can be pickle'd.

```
struct Point {
    double x;
    double y;
};
```

x

Structure/Union member

y

Structure/Union member

class msl.examples.loadlib.cpp32.**FourPoints**(*point1*, *point2*, *point3*, *point4*)

Bases: Structure

C++ struct that is a fixed size in memory.

This object can be pickle'd.

```
struct FourPoints {
    Point points[4];
};
```

Parameters

- **point1** (tuple of int) – The first point as an (x, y) ordered pair.
- **point2** (tuple of int) – The second point as an (x, y) ordered pair.
- **point3** (tuple of int) – The third point as an (x, y) ordered pair.
- **point4** (tuple of int) – The fourth point as an (x, y) ordered pair.

points

Structure/Union member

class msl.examples.loadlib.cpp32.**NPoints**

Bases: Structure

C++ struct that is **not** a fixed size in memory.

This object cannot be pickle'd because it contains a pointer. A 32-bit process and a 64-bit process cannot share a pointer.

```
struct NPoints {
    int n;
    Point *points;
};
```

n

Structure/Union member

points

Structure/Union member

msl.examples.loadlib.cpp64 module

Communicates with *cpp_lib32* via the *Cpp32* class.

Example of a module that can be executed within a 64-bit Python interpreter which can communicate with a 32-bit library, *cpp_lib32*, that is hosted by a 32-bit Python server, *cpp32*. A 64-bit process cannot load a 32-bit library and therefore inter-process communication is used to interact with a 32-bit library from a 64-bit process.

Cpp64 is the 64-bit client and *Cpp32* is the 32-bit server for inter-process communication.

class msl.examples.loadlib.cpp64.**Cpp64**

Bases: *Client64*

Communicates with a 32-bit C++ library, *cpp_lib32*.

This class demonstrates how to communicate with a 32-bit C++ library if an instance of this class is created within a 64-bit Python interpreter.

Base class for communicating with a 32-bit library from 64-bit Python.

Starts a 32-bit server, *Server32*, to host a Python class that is a wrapper around a 32-bit library. *Client64* runs within a 64-bit Python interpreter, and it sends a request to the server which calls the 32-bit library to execute the request. The server then provides a response back to the client.

Changed in version 0.6: Added the *rpc_timeout* argument.

Changed in version 0.8: Added the *protocol* argument and the default *quiet* value became `None`.

Changed in version 0.10: Added the *server32_dir* argument.

Parameters

- **module32** (`str`) – The name of the Python module that is to be imported by the 32-bit server.
- **host** (`str`, optional) – The address of the 32-bit server. Default is `'127.0.0.1'`.
- **port** (`int`, optional) – The port to open on the 32-bit server. Default is `None`, which means to automatically find a port that is available.
- **timeout** (`float`, optional) – The maximum number of seconds to wait to establish a connection to the 32-bit server. Default is 10 seconds.
- **quiet** (`bool`, optional) – This keyword argument is no longer used and will be removed in a future release.
- **append_sys_path** (`str` or `list` of `str`, optional) – Append path(s) to the 32-bit server's `sys.path` variable. The value of `sys.path` from the 64-bit process is automatically included, i.e., `sys.path(32bit) = sys.path(64bit) + append_sys_path`.
- **append_environ_path** (`str` or `list` of `str`, optional) – Append path(s) to the 32-bit server's `os.environ['PATH']` variable. This can be useful if the library that is being loaded requires additional libraries that must be available on `PATH`.
- **rpc_timeout** (`float`, optional) – The maximum number of seconds to wait for a response from the 32-bit server. The RPC timeout value is used for *all*

requests from the server. If you want different requests to have different timeout values then you will need to implement custom timeout handling for each method on the server. Default is None, which means to use the default timeout value used by the socket module (which is to *wait forever*).

- **protocol** (int, optional) – The pickle protocol to use. If not specified then determines the value to use based on the version of Python that the *Client64* is running in.
- **server32_dir** (str, optional) – The directory where the frozen 32-bit server is located.
- ****kwargs** – All additional keyword arguments are passed to the *Server32* subclass. The data type of each value is not preserved. It will be a string at the constructor of the *Server32* subclass.

Note: If *module32* is not located in the current working directory then you must either specify the full path to *module32* **or** you can specify the folder where *module32* is located by passing a value to the *append_sys_path* parameter. Using the *append_sys_path* option also allows for any other modules that *module32* may depend on to also be included in sys.path so that those modules can be imported when *module32* is imported.

Raises

- *ConnectionTimeoutError* – If the connection to the 32-bit server cannot be established.
- OSError – If the frozen executable cannot be found.
- TypeError – If the data type of *append_sys_path* or *append_environ_path* is invalid.

add(*a*, *b*)

Add two integers.

See the corresponding 32-bit *add()* method.

Parameters

- **a** (int) – The first integer.
- **b** (int) – The second integer.

Returns

int – The sum of *a* and *b*.

subtract(*a*, *b*)

Subtract two floating-point numbers *('float' refers to the C++ data type)*.

See the corresponding 32-bit *subtract()* method.

Parameters

- **a** (float) – The first floating-point number.
- **b** (float) – The second floating-point number.

Returns
float – The difference between *a* and *b*.

add_or_subtract(*a*, *b*, *do_addition*)

Add or subtract two floating-point numbers *('double' refers to the C++ data type)*.

See the corresponding 32-bit *add_or_subtract()* method.

Parameters

- **a** (float) – The first floating-point number.
- **b** (float) – The second floating-point number.
- **do_addition** (bool) – Whether to **add** the numbers.

Returns
float – Either *a* + *b* if *do_addition* is True else *a* - *b*.

scalar_multiply(*a*, *xin*)

Multiply each element in an array by a number.

See the corresponding 32-bit *scalar_multiply()* method.

Parameters

- **a** (float) – The scalar value.
- **xin** (list of float) – The array to modify.

Returns
list of float – A new array with each element in *xin* multiplied by *a*.

reverse_string_v1(*original*)

Reverse a string (version 1).

In this method Python allocates the memory for the reversed string and passes the string to C++.

See the corresponding 32-bit *reverse_string_v1()* method.

Parameters
original (str) – The original string.

Returns
str – The string reversed.

reverse_string_v2(*original*)

Reverse a string (version 2).

In this method C++ allocates the memory for the reversed string and passes the string to Python.

See the corresponding 32-bit *reverse_string_v2()* method.

Parameters
original (str) – The original string.

Returns
str – The string reversed.

distance_4_points(*points*)

Calculates the total distance connecting 4 *Point*'s.

See the corresponding 32-bit *distance_4_points()* method.

> **Attention:** This method does not work with if *Cpp64* is running in Python 2. You would have to create the *FourPoints* object in the 32-bit version of *distance_4_points()* because there are issues using the `pickle` module between different major version numbers of Python for `ctypes` objects.

Parameters

points (*FourPoints*) – Since *points* is a struct that is a fixed size we can pass the `ctypes.Structure` object directly from 64-bit Python to the 32-bit Python. The `ctypes` module on the 32-bit server can load the `pickle`'d `ctypes.Structure`.

Returns

`float` – The total distance connecting the 4 *Point*'s.

circumference(*radius*, *n*)

Estimates the circumference of a circle.

This method calls the `distance_n_points` function in *cpp_lib32*.

See the corresponding 32-bit *circumference()* method.

Parameters

- **radius** (`float`) – The radius of the circle.
- **n** (`int`) – The number of points to use to estimate the circumference.

Returns

`float` – The estimated circumference of the circle.

msl.examples.loadlib.dotnet32 module

A wrapper around a 32-bit .NET library, *dotnet_lib32*.

Example of a server that loads a 32-bit .NET library, *dotnet_lib32.dll* in a 32-bit Python interpreter to host the library. The corresponding *dotnet64* module can be executed by a 64-bit Python interpreter and the *DotNet64* class can send a request to the *DotNet32* class which calls the 32-bit library to execute the request and then return the response from the library.

class msl.examples.loadlib.dotnet32.**DotNet32**(*host*, *port*, ***kwargs*)

Bases: *Server32*

Example of a class that is a wrapper around a 32-bit .NET Framework library, *dotnet_lib32.dll*. Python for .NET can handle many native Python data types as input arguments.

Parameters

- **host** (`str`) – The IP address of the server.
- **port** (`int`) – The port to open on the server.

Note: Any class that is a subclass of *Server32* **MUST** provide two arguments in its constructor: *host* and *port* (in that order) and ***kwargs*. Otherwise the `server32` executable, see *start_server32*, cannot create an instance of the *Server32* subclass.

get_class_names()

Returns the class names in the library.

See the corresponding 64-bit *get_class_names()* method.

Returns

`list` of `str` – The names of the classes that are available in *dotnet_lib32.dll*.

add_integers(*a*, *b*)

Add two integers.

The corresponding C# code is

```
public int add_integers(int a, int b)
{
    return a + b;
}
```

See the corresponding 64-bit *add_integers()* method.

Parameters

- **a** (`int`) – The first integer.
- **b** (`int`) – The second integer.

Returns

`int` – The sum of *a* and *b*.

divide_floats(*a*, *b*)

Divide two C# floating-point numbers.

The corresponding C# code is

```
public float divide_floats(float a, float b)
{
    return a / b;
}
```

See the corresponding 64-bit *divide_floats()* method.

Parameters

- **a** (`float`) – The first number.
- **b** (`float`) – The second number.

Returns

`float` – The quotient of *a* / *b*.

multiply_doubles(*a*, *b*)

Multiply two C# double-precision numbers.

The corresponding C# code is

```
public double multiply_doubles(double a, double b)
{
    return a * b;
}
```

See the corresponding 64-bit *multiply_doubles()* method.

Parameters

- **a** (float) – The first number.
- **b** (float) – The second number.

Returns

float – The product of *a* * *b*.

add_or_subtract(*a*, *b*, *do_addition*)

Add or subtract two C# double-precision numbers.

The corresponding C# code is

```
public double add_or_subtract(double a, double b, bool do_addition)
{
    if (do_addition)
    {
        return a + b;
    }
    else
    {
        return a - b;
    }
}
```

See the corresponding 64-bit *add_or_subtract()* method.

Parameters

- **a** (float) – The first double-precision number.
- **b** (float) – The second double-precision number.
- **do_addition** (bool) – Whether to **add** the numbers.

Returns

float – Either *a* + *b* if *do_addition* is True else *a* - *b*.

scalar_multiply(*a*, *xin*)

Multiply each element in an array by a number.

The corresponding C# code is

```
public double[] scalar_multiply(double a, double[] xin)
{
    int n = xin.GetLength(0);
    double[] xout = new double[n];
    for (int i = 0; i < n; i++)
```

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```
    {
        xout[i] = a * xin[i];
    }
    return xout;
}
```

See the corresponding 64-bit *scalar_multiply()* method.

Parameters

- **a** (float) – The scalar value.
- **xin** (list of float) – The array to modify.

Returns

list of float – A new array with each element in *xin* multiplied by *a*.

multiply_matrices(*a1*, *a2*)

Multiply two matrices.

The corresponding C# code is

```
public double[,] multiply_matrices(double[,] A, double[,] B)
{
    int rA = A.GetLength(0);
    int cA = A.GetLength(1);
    int rB = B.GetLength(0);
    int cB = B.GetLength(1);
    double temp = 0;
    double[,] C = new double[rA, cB];
    if (cA != rB)
    {
        Console.WriteLine("matrices can't be multiplied!");
        return new double[0, 0];
    }
    else
    {
        for (int i = 0; i < rA; i++)
        {
            for (int j = 0; j < cB; j++)
            {
                temp = 0;
                for (int k = 0; k < cA; k++)
                {
                    temp += A[i, k] * B[k, j];
                }
                C[i, j] = temp;
            }
        }
        return C;
    }
}
```

See the corresponding 64-bit *multiply_matrices()* method.

Parameters

- **a1** (list of list of float) – The first matrix.
- **a2** (list of list of float) – The second matrix.

Returns

list of list of float – The result of *a1 * a2*.

reverse_string(*original*)

Reverse a string.

The corresponding C# code is

```
public string reverse_string(string original)
{
    char[] charArray = original.ToCharArray();
    Array.Reverse(charArray);
    return new string(charArray);
}
```

See the corresponding 64-bit *reverse_string()* method.

Parameters

original (str) – The original string.

Returns

str – The string reversed.

add_multiple(*a*, *b*, *c*, *d*, *e*)

Add multiple integers. *Calls a static method in a static class.*

The corresponding C# code is

```
public static int add_multiple(int a, int b, int c, int d, int e)
{
    return a + b + c + d + e;
}
```

See the corresponding 64-bit *add_multiple()* method.

Parameters

- **a** (int) – An integer.
- **b** (int) – An integer.
- **c** (int) – An integer.
- **d** (int) – An integer.
- **e** (int) – An integer.

Returns

int – The sum of the input arguments.

concatenate(*a*, *b*, *c*, *d*, *e*)

Concatenate strings. *Calls a static method in a static class.*

The corresponding C# code is

```
public static string concatenate(string a, string b, string c, bool
↪d, string e)
{
    string res = a + b + c;
    if (d)
    {
        res += e;
    }
    return res;

}
```

See the corresponding 64-bit *concatenate()* method.

Parameters

- **a** (str) – A string.
- **b** (str) – A string.
- **c** (str) – A string.
- **d** (bool) – Whether to include *e* in the concatenation.
- **e** (str) – A string.

Returns

str – The strings concatenated together.

msl.examples.loadlib.dotnet64 module

Communicates with a 32-bit .NET library via the *DotNet32* class.

Example of a module that can be executed within a 64-bit Python interpreter which can communicate with a 32-bit .NET library, *dotnet_lib32.dll* that is hosted by a 32-bit Python server, *dotnet32*. A 64-bit process cannot load a 32-bit library and therefore inter-process communication is used to interact with a 32-bit library from a 64-bit process.

DotNet64 is the 64-bit client and *DotNet32* is the 32-bit server for inter-process communication.

class msl.examples.loadlib.dotnet64.**DotNet64**

Bases: *Client64*

Communicates with the 32-bit C# *dotnet_lib32.dll* library.

This class demonstrates how to communicate with a 32-bit .NET library if an instance of this class is created within a 64-bit Python interpreter.

Base class for communicating with a 32-bit library from 64-bit Python.

Starts a 32-bit server, *Server32*, to host a Python class that is a wrapper around a 32-bit library. *Client64* runs within a 64-bit Python interpreter, and it sends a request to the server which calls the 32-bit library to execute the request. The server then provides a response back to the client.

Changed in version 0.6: Added the *rpc_timeout* argument.

Changed in version 0.8: Added the *protocol* argument and the default *quiet* value became `None`.

Changed in version 0.10: Added the *server32_dir* argument.

Parameters

- **module32** (`str`) – The name of the Python module that is to be imported by the 32-bit server.
- **host** (`str`, optional) – The address of the 32-bit server. Default is `'127.0.0.1'`.
- **port** (`int`, optional) – The port to open on the 32-bit server. Default is `None`, which means to automatically find a port that is available.
- **timeout** (`float`, optional) – The maximum number of seconds to wait to establish a connection to the 32-bit server. Default is 10 seconds.
- **quiet** (`bool`, optional) – This keyword argument is no longer used and will be removed in a future release.
- **append_sys_path** (`str` or `list` of `str`, optional) – Append path(s) to the 32-bit server's `sys.path` variable. The value of `sys.path` from the 64-bit process is automatically included, i.e., `sys.path(32bit) = sys.path(64bit) + append_sys_path`.
- **append_environ_path** (`str` or `list` of `str`, optional) – Append path(s) to the 32-bit server's `os.environ['PATH']` variable. This can be useful if the library that is being loaded requires additional libraries that must be available on `PATH`.
- **rpc_timeout** (`float`, optional) – The maximum number of seconds to wait for a response from the 32-bit server. The RPC timeout value is used for *all* requests from the server. If you want different requests to have different timeout values then you will need to implement custom timeout handling for each method on the server. Default is `None`, which means to use the default timeout value used by the `socket` module (which is to *wait forever*).
- **protocol** (`int`, optional) – The `pickle` protocol to use. If not specified then determines the value to use based on the version of Python that the *Client64* is running in.
- **server32_dir** (`str`, optional) – The directory where the frozen 32-bit server is located.
- ****kwargs** – All additional keyword arguments are passed to the *Server32* subclass. The data type of each value is not preserved. It will be a string at the constructor of the *Server32* subclass.

Note: If *module32* is not located in the current working directory then you must either specify the full path to *module32* **or** you can specify the folder where *module32* is located by passing a value to the *append_sys_path* parameter. Using the *append_sys_path* option also allows for any other modules that *module32* may depend on to also be included in `sys.path` so that those modules can be imported when *module32* is imported.

Raises

- *ConnectionTimeoutError* – If the connection to the 32-bit server cannot be established.
- OSError – If the frozen executable cannot be found.
- TypeError – If the data type of *append_sys_path* or *append_environ_path* is invalid.

get_class_names()

Return the class names in the library.

See the corresponding 32-bit *get_class_names()* method.

Returns

list of str – The names of the classes that are available in *dotnet_lib32.dll*.

add_integers(*a*, *b*)

Add two integers.

See the corresponding 32-bit *add_integers()* method.

Parameters

- **a** (int) – The first integer.
- **b** (int) – The second integer.

Returns

int – The sum of *a* and *b*.

divide_floats(*a*, *b*)

Divide two C# floating-point numbers.

See the corresponding 32-bit *divide_floats()* method.

Parameters

- **a** (float) – The first number.
- **b** (float) – The second number.

Returns

float – The quotient of *a* / *b*.

multiply_doubles(*a*, *b*)

Multiply two C# double-precision numbers.

See the corresponding 32-bit *multiply_doubles()* method.

Parameters

- **a** (float) – The first number.
- **b** (float) – The second number.

Returns

float – The product of *a* * *b*.

add_or_subtract(*a*, *b*, *do_addition*)

Add or subtract two C# double-precision numbers.

See the corresponding 32-bit *add_or_subtract()* method.

Parameters

- **a** (float) – The first double-precision number.
- **b** (float) – The second double-precision number.
- **do_addition** (bool) – Whether to **add** the numbers.

Returns

float – Either *a* + *b* if *do_addition* is True else *a* - *b*.

scalar_multiply(*a*, *xin*)

Multiply each element in an array by a number.

See the corresponding 32-bit *scalar_multiply()* method.

Parameters

- **a** (float) – The scalar value.
- **xin** (list of float) – The array to modify.

Returns

list of float – A new array with each element in *xin* multiplied by *a*.

multiply_matrices(*a1*, *a2*)

Multiply two matrices.

See the corresponding 32-bit *multiply_matrices()* method.

Parameters

- **a1** (list of list of float) – The first matrix.
- **a2** (list of list of float) – The second matrix.

Returns

list of list of float – The result of *a1* * *a2*.

reverse_string(*original*)

Reverse a string.

See the corresponding 32-bit *reverse_string()* method.

Parameters

original (str) – The original string.

Returns

str – The string reversed.

add_multiple(*a*, *b*, *c*, *d*, *e*)

Add multiple integers. *Calls a static method in a static class.*

See the corresponding 32-bit *add_multiple()* method.

Parameters

- **a** (int) – An integer.

- **b** (int) – An integer.
- **c** (int) – An integer.
- **d** (int) – An integer.
- **e** (int) – An integer.

Returns

int – The sum of the input arguments.

concatenate(*a*, *b*, *c*, *d*, *e*)

Concatenate strings. *Calls a static method in a static class.*

See the corresponding 32-bit *concatenate()* method.

Parameters

- **a** (str) – A string.
- **b** (str) – A string.
- **c** (str) – A string.
- **d** (bool) – Whether to include *e* in the concatenation.
- **e** (str) – A string.

Returns

str – The strings concatenated together.

msl.examples.loadlib.echo32 module

An example of a 32-bit *echo* server.

Example of a server that is executed by a 32-bit Python interpreter that receives requests from the corresponding *echo64* module which can be run by a 64-bit Python interpreter.

Echo32 is the 32-bit server class and *Echo64* is the 64-bit client class. These *echo* classes do not actually communicate with a shared library. The point of these *echo* classes is to show that a Python data type in a 64-bit process appears as the same data type in the 32-bit process and vice versa.

class msl.examples.loadlib.echo32.**Echo32**(*host*, *port*, ***kwargs*)

Bases: *Server32*

Example of a server class that illustrates that Python data types are preserved when they are sent from the *Echo64* client to the server.

Parameters

- **host** (str) – The IP address of the server.
- **port** (int) – The port to open on the server.

Note: Any class that is a subclass of *Server32* **MUST** provide two arguments in its constructor: *host* and *port* (in that order) and ***kwargs*. Otherwise the `server32` executable, see *start_server32*, cannot create an instance of the *Server32* subclass.

---

received_data(**args*, ***kwargs*)

Process a request from the *send_data()* method from the 64-bit client.

Parameters

- ***args** – The arguments.
- ****kwargs** – The keyword arguments.

Returns

tuple – The *args* and *kwargs* that were received.

msl.examples.loadlib.echo64 module

An example of a 64-bit *echo* client.

Example of a client that can be executed by a 64-bit Python interpreter that sends requests to the corresponding *echo32* module which is executed by a 32-bit Python interpreter.

Echo32 is the 32-bit server class and *Echo64* is the 64-bit client class. These *echo* classes do not actually communicate with a shared library. The point of these *echo* classes is to show that a Python data type in a 64-bit process appears as the same data type in the 32-bit process and vice versa.

class msl.examples.loadlib.echo64.**Echo64**

Bases: *Client64*

Example of a client class that illustrates that Python data types are preserved when they are sent to the *Echo32* server and back again.

send_data(**args*, ***kwargs*)

Send a request to execute the *received_data()* method on the 32-bit server.

Parameters

- ***args** – The arguments that the *received_data()* method requires.
- ****kwargs** – The keyword arguments that the *received_data()* method requires.

Returns

tuple – The *args* and *kwargs* that were returned from *received_data()*.

msl.examples.loadlib.fortran32 module

A wrapper around a 32-bit FORTRAN library, *fortran_lib32*.

Example of a server that loads a 32-bit FORTRAN library, *fortran_lib32*, in a 32-bit Python interpreter to host the library. The corresponding *fortran64* module can be executed by a 64-bit Python interpreter and the *Fortran64* class can send a request to the *Fortran32* class which calls the 32-bit library to execute the request and then return the response from the library.

class msl.examples.loadlib.fortran32.**Fortran32**(*host*, *port*, ***kwargs*)

Bases: *Server32*

A wrapper around a 32-bit FORTRAN library, *fortran_lib32*.

This class demonstrates how to send/receive various data types to/from a 32-bit FORTRAN library via `ctypes`. For a summary of the FORTRAN data types see here.

Parameters

- **host** (`str`) – The IP address of the server.
- **port** (`int`) – The port to open on the server.

Note: Any class that is a subclass of *Server32* **MUST** provide two arguments in its constructor: *host* and *port* (in that order) and ***kwargs*. Otherwise the `server32` executable, see *start_server32*, cannot create an instance of the *Server32* subclass.

---

sum_8bit(*a*, *b*)

Add two 8-bit signed integers.

Python only has one `int` data type to represent integer values. The *sum_8bit()* method converts the data types of *a* and *b* to be `ctypes.c_int8`.

The corresponding FORTRAN code is

```
function sum_8bit(a, b) result(value)
    !DEC$ ATTRIBUTES DLLEXPORT, ALIAS:'sum_8bit' :: sum_8bit
    implicit none
    integer(1) :: a, b, value
    value = a + b
end function sum_8bit
```

See the corresponding 64-bit *sum_8bit()* method.

Parameters

- **a** (`int`) – The first 8-bit signed integer.
- **b** (`int`) – The second 8-bit signed integer.

Returns

`int` – The sum of *a* and *b*.

sum_16bit(*a*, *b*)

Add two 16-bit signed integers

Python only has one `int` data type to represent integer values. The *sum_16bit()* method converts the data types of *a* and *b* to be `ctypes.c_int16`.

The corresponding FORTRAN code is

```
function sum_16bit(a, b) result(value)
    !DEC$ ATTRIBUTES DLLEXPORT, ALIAS:'sum_16bit' :: sum_16bit
    implicit none
    integer(2) :: a, b, value
    value = a + b
end function sum_16bit
```

See the corresponding 64-bit *sum_16bit()* method.

Parameters

- **a** (int) – The first 16-bit signed integer.
- **b** (int) – The second 16-bit signed integer.

Returns
int – The sum of *a* and *b*.

sum_32bit(*a*, *b*)

Add two 32-bit signed integers.

Python only has one int data type to represent integer values. The *sum_32bit()* method converts the data types of *a* and *b* to be ctypes.c_int32.

The corresponding FORTRAN code is

```
function sum_32bit(a, b) result(value)
    !DEC$ ATTRIBUTES DLLEXPORT, ALIAS:'sum_32bit' :: sum_32bit
    implicit none
    integer(4) :: a, b, value
    value = a + b
end function sum_32bit
```

See the corresponding 64-bit *sum_32bit()* method.

Parameters

- **a** (int) – The first 32-bit signed integer.
- **b** (int) – The second 32-bit signed integer.

Returns
int – The sum of *a* and *b*.

sum_64bit(*a*, *b*)

Add two 64-bit signed integers.

Python only has one int data type to represent integer values. The *sum_64bit()* method converts the data types of *a* and *b* to be ctypes.c_int64.

The corresponding FORTRAN code is

```
function sum_64bit(a, b) result(value)
    !DEC$ ATTRIBUTES DLLEXPORT, ALIAS:'sum_64bit' :: sum_64bit
    implicit none
    integer(8) :: a, b, value
    value = a + b
end function sum_64bit
```

See the corresponding 64-bit *sum_64bit()* method.

Parameters

- **a** (int) – The first 64-bit signed integer.
- **b** (int) – The second 64-bit signed integer.

Returns
int – The sum of *a* and *b*.

multiply_float32(*a*, *b*)

Multiply two FORTRAN floating-point numbers.

The corresponding FORTRAN code is

```
function multiply_float32(a, b) result(value)
    !DEC$ ATTRIBUTES DLLEXPORT, ALIAS:'multiply_float32' :: multiply_
↪float32
    implicit none
    real(4) :: a, b, value
    value = a * b
end function multiply_float32
```

See the corresponding 64-bit *multiply_float32()* method.

Parameters

- **a** (float) – The first floating-point number.
- **b** (float) – The second floating-point number.

Returns

float – The product of *a* and *b*.

multiply_float64(*a*, *b*)

Multiply two FORTRAN double-precision numbers.

The corresponding FORTRAN code is

```
function multiply_float64(a, b) result(value)
    !DEC$ ATTRIBUTES DLLEXPORT, ALIAS:'multiply_float64' :: multiply_
↪float64
    implicit none
    real(8) :: a, b, value
    value = a * b
end function multiply_float64
```

See the corresponding 64-bit *multiply_float64()* method.

Parameters

- **a** (float) – The first double-precision number.
- **b** (float) – The second double-precision number.

Returns

float – The product of *a* and *b*.

is_positive(*a*)

Returns whether the value of the input argument is > 0.

The corresponding FORTRAN code is

```
function is_positive(a) result(value)
    !DEC$ ATTRIBUTES DLLEXPORT, ALIAS:'is_positive' :: is_positive
    implicit none
    logical :: value
```

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```
    real(8) :: a
    value = a > 0.d0
end function is_positive
```

See the corresponding 64-bit *is_positive()* method.

Parameters
a (float) – A double-precision number.

Returns
bool – Whether the value of *a* is > 0.

add_or_subtract(*a*, *b*, *do_addition*)

Add or subtract two integers.

The corresponding FORTRAN code is

```
function add_or_subtract(a, b, do_addition) result(value)
    !DEC$ ATTRIBUTES DLLEXPORT, ALIAS:'add_or_subtract' :: add_or_
↪subtract
    implicit none
    logical :: do_addition
    integer(4) :: a, b, value
    if (do_addition) then
        value = a + b
    else
        value = a - b
    endif
end function add_or_subtract
```

See the corresponding 64-bit *add_or_subtract()* method.

Parameters

- **a** (int) – The first integer.
- **b** (int) – The second integer.
- **do_addition** (bool) – Whether to **add** the numbers.

Returns
int – Either *a* + *b* if *do_addition* is True else *a* - *b*.

factorial(*n*)

Compute the n'th factorial.

The corresponding FORTRAN code is

```
function factorial(n) result(value)
    !DEC$ ATTRIBUTES DLLEXPORT, ALIAS:'factorial' :: factorial
    implicit none
    integer(1) :: n
    integer(4) :: i
    double precision value
    if (n < 0) then
```

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```
        value = 0.d0
        print *, "Cannot compute the factorial of a negative number",
↪ n
    else
        value = 1.d0
        do i = 2, n
            value = value * i
        enddo
    endif
end function factorial
```

See the corresponding 64-bit *factorial()* method.

Parameters
n (int) – The integer to computer the factorial of. The maximum allowed value is 127.

Returns
float – The factorial of *n*.

standard_deviation(*data*)

Compute the standard deviation.

The corresponding FORTRAN code is

```
function standard_deviation(a, n) result(var)
    !DEC$ ATTRIBUTES DLLEXPORT, ALIAS:'standard_deviation' :: standard_
↪deviation
    integer :: n ! the length of the array
    double precision :: var, a(n)
    var = SUM(a)/SIZE(a) ! SUM is a built-in fortran function
    var = SQRT(SUM((a-var)**2)/(SIZE(a)-1.0))
end function standard_deviation
```

See the corresponding 64-bit *standard_deviation()* method.

Parameters
data (list of float) – The data to compute the standard deviation of.

Returns
float – The standard deviation of *data*.

besselJ0(*x*)

Compute the Bessel function of the first kind of order 0 of x.

The corresponding FORTRAN code is

```
function besselj0(x) result(val)
    !DEC$ ATTRIBUTES DLLEXPORT, ALIAS:'besselj0' :: besselj0
    double precision :: x, val
    val = BESSEL_J0(x)
end function besselJ0
```

See the corresponding 64-bit *besselJ0()* method.

Parameters
x (float) – The value to compute BESSEL_J0 of.

Returns
float – The value of BESSEL_J0(x).

reverse_string(*original*)

Reverse a string.

The corresponding FORTRAN code is

```
subroutine reverse_string(original, n, reversed)
    !DEC$ ATTRIBUTES DLLEXPORT, ALIAS:'reverse_string' :: reverse_
↪string
    !DEC$ ATTRIBUTES REFERENCE :: original, reversed
    implicit none
    integer :: i, n
    character(len=n) :: original, reversed
    do i = 1, n
        reversed(i:i) = original(n-i+1:n-i+1)
    end do
end subroutine reverse_string
```

See the corresponding 64-bit *reverse_string()* method.

Parameters
original (str) – The original string.

Returns
str – The string reversed.

add_1D_arrays(*a1*, *a2*)

Perform an element-wise addition of two 1D double-precision arrays.

The corresponding FORTRAN code is

```
subroutine add_1d_arrays(a, in1, in2, n)
    !DEC$ ATTRIBUTES DLLEXPORT, ALIAS:'add_1d_arrays' :: add_1d_arrays
    implicit none
    integer(4) :: n ! the length of the input arrays
    double precision :: in1(n), in2(n) ! the arrays to add (element-
↪wise)
    double precision :: a(n) ! the array that will contain the␣
↪element-wise sum
    a(:) = in1(:) + in2(:)
end subroutine add_1D_arrays
```

See the corresponding 64-bit *add_1D_arrays()* method.

Parameters

- **a1** (list of float) – The first array.
- **a2** (list of float) – The second array.

Returns
list of float – The element-wise addition of *a1* + *a2*.

matrix_multiply(*a1*, *a2*)

Multiply two matrices.

The corresponding FORTRAN code is

```
subroutine matrix_multiply(a, a1, r1, c1, a2, r2, c2)
    !DEC$ ATTRIBUTES DLLEXPORT, ALIAS:'matrix_multiply' :: matrix_
↪multiply
    implicit none
    integer(4) :: r1, c1, r2, c2 ! the dimensions of the input arrays
    double precision :: a1(r1,c1), a2(r2,c2) ! the arrays to multiply
    double precision :: a(r1,c2) ! resultant array
    a = MATMUL(a1, a2)
end subroutine matrix_multiply
```

Note: FORTRAN stores multi-dimensional arrays in column-major order, as opposed to row-major order for C (Python) arrays. Therefore, the input matrices need to be transposed before sending the matrices to FORTRAN and also the result needs to be transposed before returning the result.

See the corresponding 64-bit *matrix_multiply()* method.

Parameters

- **a1** (list of list of float) – The first matrix.
- **a2** (list of list of float) – The second matrix.

Returns

list of list of float – The result of *a1* * *a2*.

msl.examples.loadlib.fortran64 module

Communicates with *fortran_lib32* via the *Fortran32* class.

Example of a module that can be executed within a 64-bit Python interpreter which can communicate with a 32-bit library, *fortran_lib32*, that is hosted by a 32-bit Python server, *fortran32*. A 64-bit process cannot load a 32-bit library and therefore inter-process communication is used to interact with a 32-bit library from a 64-bit process.

Fortran64 is the 64-bit client and *Fortran32* is the 32-bit server for inter-process communication.

class msl.examples.loadlib.fortran64.**Fortran64**

Bases: *Client64*

Communicates with the 32-bit FORTRAN *fortran_lib32* library.

This class demonstrates how to communicate with a 32-bit FORTRAN library if an instance of this class is created within a 64-bit Python interpreter.

Base class for communicating with a 32-bit library from 64-bit Python.

Starts a 32-bit server, *Server32*, to host a Python class that is a wrapper around a 32-bit library. *Client64* runs within a 64-bit Python interpreter, and it sends a request to the server which calls the 32-bit library to execute the request. The server then provides a response back to the client.

Changed in version 0.6: Added the *rpc_timeout* argument.

Changed in version 0.8: Added the *protocol* argument and the default *quiet* value became `None`.

Changed in version 0.10: Added the *server32_dir* argument.

Parameters

- **module32** (`str`) – The name of the Python module that is to be imported by the 32-bit server.
- **host** (`str`, optional) – The address of the 32-bit server. Default is `'127.0.0.1'`.
- **port** (`int`, optional) – The port to open on the 32-bit server. Default is `None`, which means to automatically find a port that is available.
- **timeout** (`float`, optional) – The maximum number of seconds to wait to establish a connection to the 32-bit server. Default is 10 seconds.
- **quiet** (`bool`, optional) – This keyword argument is no longer used and will be removed in a future release.
- **append_sys_path** (`str` or `list` of `str`, optional) – Append path(s) to the 32-bit server's `sys.path` variable. The value of `sys.path` from the 64-bit process is automatically included, i.e., `sys.path(32bit) = sys.path(64bit) + append_sys_path`.
- **append_environ_path** (`str` or `list` of `str`, optional) – Append path(s) to the 32-bit server's `os.environ['PATH']` variable. This can be useful if the library that is being loaded requires additional libraries that must be available on `PATH`.
- **rpc_timeout** (`float`, optional) – The maximum number of seconds to wait for a response from the 32-bit server. The RPC timeout value is used for *all* requests from the server. If you want different requests to have different timeout values then you will need to implement custom timeout handling for each method on the server. Default is `None`, which means to use the default timeout value used by the `socket` module (which is to *wait forever*).
- **protocol** (`int`, optional) – The `pickle` protocol to use. If not specified then determines the value to use based on the version of Python that the *Client64* is running in.
- **server32_dir** (`str`, optional) – The directory where the frozen 32-bit server is located.
- ****kwargs** – All additional keyword arguments are passed to the *Server32* subclass. The data type of each value is not preserved. It will be a string at the constructor of the *Server32* subclass.

Note: If *module32* is not located in the current working directory then you must either specify the full path to *module32* **or** you can specify the folder where *module32* is located by passing a value to the *append_sys_path* parameter. Using the *append_sys_path* option also allows for any other

modules that *module32* may depend on to also be included in `sys.path` so that those modules can be imported when *module32* is imported.

Raises

- *ConnectionTimeoutError* – If the connection to the 32-bit server cannot be established.
- `OSError` – If the frozen executable cannot be found.
- `TypeError` – If the data type of *append_sys_path* or *append_environ_path* is invalid.

sum_8bit(*a*, *b*)

Send a request to add two 8-bit signed integers.

See the corresponding 32-bit *sum_8bit()* method.

Parameters

- **a** (`int`) – The first 8-bit signed integer.
- **b** (`int`) – The second 8-bit signed integer.

Returns

`int` – The sum of *a* and *b*.

sum_16bit(*a*, *b*)

Send a request to add two 16-bit signed integers.

See the corresponding 32-bit *sum_16bit()* method.

Parameters

- **a** (`int`) – The first 16-bit signed integer.
- **b** (`int`) – The second 16-bit signed integer.

Returns

`int` – The sum of *a* and *b*.

sum_32bit(*a*, *b*)

Send a request to add two 32-bit signed integers.

See the corresponding 32-bit *sum_32bit()* method.

Parameters

- **a** (`int`) – The first 32-bit signed integer.
- **b** (`int`) – The second 32-bit signed integer.

Returns

`int` – The sum of *a* and *b*.

sum_64bit(*a*, *b*)

Send a request to add two 64-bit signed integers.

See the corresponding 32-bit *sum_64bit()* method.

Parameters

- **a** (int) – The first 64-bit signed integer.
- **b** (int) – The second 64-bit signed integer.

Returns
int – The sum of *a* and *b*.

multiply_float32(*a*, *b*)

Send a request to multiply two FORTRAN floating-point numbers.

See the corresponding 32-bit *multiply_float32()* method.

Parameters

- **a** (float) – The first floating-point number.
- **b** (float) – The second floating-point number.

Returns
float – The product of *a* and *b*.

multiply_float64(*a*, *b*)

Send a request to multiply two FORTRAN double-precision numbers.

See the corresponding 32-bit *multiply_float64()* method.

Parameters

- **a** (float) – The first double-precision number.
- **b** (float) – The second double-precision number.

Returns
float – The product of *a* and *b*.

is_positive(*a*)

Returns whether the value of the input argument is > 0.

See the corresponding 32-bit *is_positive()* method.

Parameters
a (float) – A double-precision number.

Returns
bool – Whether the value of *a* is > 0.

add_or_subtract(*a*, *b*, *do_addition*)

Add or subtract two integers.

See the corresponding 32-bit *add_or_subtract()* method.

Parameters

- **a** (int) – The first integer.
- **b** (int) – The second integer.
- **do_addition** (bool) – Whether to **add** the numbers.

Returns
int – Either *a* + *b* if *do_addition* is True else *a* - *b*.

factorial(*n*)

Compute the n'th factorial.

See the corresponding 32-bit *factorial()* method.

Parameters
n (int) – The integer to computer the factorial of. The maximum allowed value is 127.

Returns
float – The factorial of *n*.

standard_deviation(*data*)

Compute the standard deviation.

See the corresponding 32-bit *standard_deviation()* method.

Parameters
data (list of float) – The data to compute the standard deviation of.

Returns
float – The standard deviation of *data*.

besselJ0(*x*)

Compute the Bessel function of the first kind of order 0 of x.

See the corresponding 32-bit *besselJ0()* method.

Parameters
x (float) – The value to compute BESSEL_J0 of.

Returns
float – The value of BESSEL_J0(x).

reverse_string(*original*)

Reverse a string.

See the corresponding 32-bit *reverse_string()* method.

Parameters
original (str) – The original string.

Returns
str – The string reversed.

add_1D_arrays(*a1*, *a2*)

Perform an element-wise addition of two 1D double-precision arrays.

See the corresponding 32-bit *add_1D_arrays()* method.

Parameters

- **a1** (list of float) – The first array.
- **a2** (list of float) – The second array.

Returns
list of float – The element-wise addition of *a1* + *a2*.

matrix_multiply(*a1*, *a2*)

Multiply two matrices.

See the corresponding 32-bit *matrix_multiply()* method.

Parameters

- **a1** (list of list of float) – The first matrix.
- **a2** (list of list of float) – The second matrix.

Returns

list of list of float – The result of *a1 * a2*.

msl.examples.loadlib.kernel32 module

A wrapper around the 32-bit Windows kernel32.dll library.

Example of a server that loads a 32-bit Windows library, kernel32.dll, in a 32-bit Python interpreter to host the library. The corresponding *kernel64* module can be executed by a 64-bit Python interpreter and the *Kernel64* class can send a request to the *Kernel32* class which calls the 32-bit library to execute the request and then return the response from the library.

Kernel32 is the 32-bit server and *Kernel64* is the 64-bit client for inter-process communication.

Note: The kernel32.dll library is a standard Windows library and therefore this example is only valid on a Windows computer.

---

class msl.examples.loadlib.kernel32.**Kernel32**(*host*, *port*, ***kwargs*)

Bases: *Server32*

Example of a class that is a wrapper around the Windows 32-bit kernel32.dll library.

Parameters

- **host** (str) – The IP address of the server.
- **port** (int) – The port to open on the server.

Note: Any class that is a subclass of *Server32* **MUST** provide two arguments in its constructor: *host* and *port* (in that order) and ***kwargs*. Otherwise the server32 executable, see *start_server32*, cannot create an instance of the *Server32* subclass.

---

get_time()

Calls the kernel32.GetLocalTime function to get the current date and time.

See the corresponding 64-bit *get_local_time()* method.

Returns

datetime – The current date and time.

class msl.examples.loadlib.kernel32.**SystemTime**

Bases: Structure

Example of creating a ctypes.Structure.

See SYSTEMTIME for a description of the struct.

WORD

alias of c_ushort

wDay

Structure/Union member

wDayOfWeek

Structure/Union member

wHour

Structure/Union member

wMilliseconds

Structure/Union member

wMinute

Structure/Union member

wMonth

Structure/Union member

wSecond

Structure/Union member

wYear

Structure/Union member

msl.examples.loadlib.kernel64 module

Communicates with kernel32.dll via the *Kernel32* class.

Example of a module that can be executed by a 64-bit Python interpreter which can communicate with a Windows 32-bit library, kernel32.dll, that is hosted by the corresponding 32-bit Python server, *kernel32*.

Kernel64 is the 64-bit client and *Kernel32* is the 32-bit server for inter-process communication.

Note: The kernel32.dll library is a standard Windows library and therefore this example is only valid on a computer running Windows.

---

class msl.examples.loadlib.kernel64.**Kernel64**

Bases: *Client64*

Example of a class that can communicate with the 32-bit kernel32.dll library.

This class demonstrates how to communicate with a Windows 32-bit library if an instance of this class is created within a 64-bit Python interpreter.

Base class for communicating with a 32-bit library from 64-bit Python.

Starts a 32-bit server, *Server32*, to host a Python class that is a wrapper around a 32-bit library. *Client64* runs within a 64-bit Python interpreter, and it sends a request to the server which calls the 32-bit library to execute the request. The server then provides a response back to the client.

Changed in version 0.6: Added the *rpc_timeout* argument.

Changed in version 0.8: Added the *protocol* argument and the default *quiet* value became `None`.

Changed in version 0.10: Added the *server32_dir* argument.

Parameters

- **module32** (`str`) – The name of the Python module that is to be imported by the 32-bit server.
- **host** (`str`, optional) – The address of the 32-bit server. Default is `'127.0.0.1'`.
- **port** (`int`, optional) – The port to open on the 32-bit server. Default is `None`, which means to automatically find a port that is available.
- **timeout** (`float`, optional) – The maximum number of seconds to wait to establish a connection to the 32-bit server. Default is 10 seconds.
- **quiet** (`bool`, optional) – This keyword argument is no longer used and will be removed in a future release.
- **append_sys_path** (`str` or `list` of `str`, optional) – Append path(s) to the 32-bit server's `sys.path` variable. The value of `sys.path` from the 64-bit process is automatically included, i.e., `sys.path(32bit) = sys.path(64bit) + append_sys_path`.
- **append_environ_path** (`str` or `list` of `str`, optional) – Append path(s) to the 32-bit server's `os.environ['PATH']` variable. This can be useful if the library that is being loaded requires additional libraries that must be available on `PATH`.
- **rpc_timeout** (`float`, optional) – The maximum number of seconds to wait for a response from the 32-bit server. The RPC timeout value is used for *all* requests from the server. If you want different requests to have different timeout values then you will need to implement custom timeout handling for each method on the server. Default is `None`, which means to use the default timeout value used by the `socket` module (which is to *wait forever*).
- **protocol** (`int`, optional) – The `pickle` protocol to use. If not specified then determines the value to use based on the version of Python that the *Client64* is running in.
- **server32_dir** (`str`, optional) – The directory where the frozen 32-bit server is located.
- ****kwargs** – All additional keyword arguments are passed to the *Server32* subclass. The data type of each value is not preserved. It will be a string at the constructor of the *Server32* subclass.

Note: If *module32* is not located in the current working directory then you must either specify the full path to *module32* **or** you can specify the folder where *module32* is located by passing a value to the *append_sys_path* parameter. Using the *append_sys_path* option also allows for any other modules that *module32* may depend on to also be included in `sys.path` so that those modules can be imported when *module32* is imported.

Raises

- *ConnectionTimeoutError* – If the connection to the 32-bit server cannot be established.
- OSError – If the frozen executable cannot be found.
- TypeError – If the data type of *append_sys_path* or *append_environ_path* is invalid.

get_local_time()

Sends a request to the 32-bit server, *Kernel32*, to execute the kernel32.GetLocalTime function to get the current date and time.

See the corresponding 32-bit *get_time()* method.

Returns

datetime – The current date and time.

msl.examples.loadlib.labview32 module

A wrapper around a 32-bit LabVIEW library, *labview_lib32*.

Attention: This example requires that the appropriate LabVIEW Run-Time Engine is installed and that the operating system is Windows.

Example of a server that loads a 32-bit shared library, *labview_lib*, in a 32-bit Python interpreter to host the library. The corresponding *labview64* module can be executed by a 64-bit Python interpreter and the *Labview64* class can send a request to the *Labview32* class which calls the 32-bit library to execute the request and then return the response from the library.

class msl.examples.loadlib.labview32.**Labview32**(*host*, *port*, ***kwargs*)

Bases: *Server32*

A wrapper around the 32-bit LabVIEW library, *labview_lib32*.

Parameters

- **host** (str) – The IP address of the server.
- **port** (int) – The port to open on the server.

Note: Any class that is a subclass of *Server32* **MUST** provide two arguments in its constructor: *host* and *port* (in that order) and ***kwargs*. Otherwise the server32 executable, see *start_server32*, cannot create an instance of the *Server32* subclass.

stdev(*x*, *weighting=0*)

Calculates the mean, variance and standard deviation of the values in the input *x*.

See the corresponding 64-bit *stdev()* method.

Parameters

- **x** (list of float) – The data to calculate the mean, variance and standard deviation of.
- **weighting** (int, optional) – Whether to calculate the **sample**, weighting = 0, or the **population**, weighting = 1, standard deviation and variance.

Returns

- float – The mean.
- float – The variance.
- float – The standard deviation.

msl.examples.loadlib.labview64 module

Communicates with *labview_lib32* via the *Labview32* class.

Attention: This example requires that the appropriate LabVIEW Run-Time Engine is installed and that the operating system is Windows.

Example of a module that can be executed within a 64-bit Python interpreter which can communicate with a 32-bit library, *labview_lib32*, that is hosted by a 32-bit Python server, *labview32*. A 64-bit process cannot load a 32-bit library and therefore inter-process communication is used to interact with a 32-bit library from a 64-bit process.

Labview64 is the 64-bit client and *Labview32* is the 32-bit server for inter-process communication.

class msl.examples.loadlib.labview64.**Labview64**

Bases: *Client64*

Communicates with a 32-bit LabVIEW library, *labview_lib32*.

This class demonstrates how to communicate with a 32-bit LabVIEW library if an instance of this class is created within a 64-bit Python interpreter.

Base class for communicating with a 32-bit library from 64-bit Python.

Starts a 32-bit server, *Server32*, to host a Python class that is a wrapper around a 32-bit library. *Client64* runs within a 64-bit Python interpreter, and it sends a request to the server which calls the 32-bit library to execute the request. The server then provides a response back to the client.

Changed in version 0.6: Added the *rpc_timeout* argument.

Changed in version 0.8: Added the *protocol* argument and the default *quiet* value became None.

Changed in version 0.10: Added the *server32_dir* argument.

Parameters

- **module32** (str) – The name of the Python module that is to be imported by the 32-bit server.
- **host** (str, optional) – The address of the 32-bit server. Default is '127.0.0.1'.
- **port** (int, optional) – The port to open on the 32-bit server. Default is None, which means to automatically find a port that is available.

- **timeout** (float, optional) – The maximum number of seconds to wait to establish a connection to the 32-bit server. Default is 10 seconds.
- **quiet** (bool, optional) – This keyword argument is no longer used and will be removed in a future release.
- **append_sys_path** (str or list of str, optional) – Append path(s) to the 32-bit server's sys.path variable. The value of sys.path from the 64-bit process is automatically included, i.e., `sys.path(32bit) = sys.path(64bit) + append_sys_path`.
- **append_environ_path** (str or list of str, optional) – Append path(s) to the 32-bit server's os.environ['PATH'] variable. This can be useful if the library that is being loaded requires additional libraries that must be available on PATH.
- **rpc_timeout** (float, optional) – The maximum number of seconds to wait for a response from the 32-bit server. The RPC timeout value is used for *all* requests from the server. If you want different requests to have different timeout values then you will need to implement custom timeout handling for each method on the server. Default is None, which means to use the default timeout value used by the socket module (which is to *wait forever*).
- **protocol** (int, optional) – The pickle protocol to use. If not specified then determines the value to use based on the version of Python that the *Client64* is running in.
- **server32_dir** (str, optional) – The directory where the frozen 32-bit server is located.
- ****kwargs** – All additional keyword arguments are passed to the *Server32* subclass. The data type of each value is not preserved. It will be a string at the constructor of the *Server32* subclass.

Note: If *module32* is not located in the current working directory then you must either specify the full path to *module32* **or** you can specify the folder where *module32* is located by passing a value to the *append_sys_path* parameter. Using the *append_sys_path* option also allows for any other modules that *module32* may depend on to also be included in sys.path so that those modules can be imported when *module32* is imported.

Raises

- *ConnectionTimeoutError* – If the connection to the 32-bit server cannot be established.
- OSError – If the frozen executable cannot be found.
- TypeError – If the data type of *append_sys_path* or *append_environ_path* is invalid.

stdev(*x*, *weighting=0*)

Calculates the mean, variance and standard deviation of the values in the input *x*.

See the corresponding 32-bit *stdev()* method.

Parameters

- **x** (list of float) – The data to calculate the mean, variance and standard deviation of.
- **weighting** (int, optional) – Whether to calculate the **sample**, `weighting = 0`, or the **population**, `weighting = 1`, standard deviation and variance.

Returns

- float – The mean.
- float – The variance.
- float – The standard deviation.

1.5 Source code for the example libraries

The source code for the example shared libraries that are included with the **MSL-LoadLib** package can be found via the links below.

1.5.1 C++

Source code for the example C++ library.

cpp_lib.h

```
// cpp_lib.h
// Contains the declaration of exported functions.
//

#if defined(_MSC_VER)
    // Microsoft
    #define EXPORT __declspec(dllexport)
#elif defined(__GNUC__)
    // G++
    #define EXPORT __attribute__((visibility("default")))
#else
#   error "Unknown EXPORT semantics"
#endif

struct Point {
    double x;
    double y;
};

struct FourPoints {
    Point points[4];
};

struct NPoints {
    int n;
```

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```
    Point *points;
};

extern "C" {

    // a + b
    EXPORT int add(int a, int b);

    // a - b
    EXPORT float subtract(float a, float b);

    // IF do_addition IS TRUE THEN a + b ELSE a - b
    EXPORT double add_or_subtract(double a, double b, bool do_addition);

    // multiply each element in 'x' by 'a'
    EXPORT void scalar_multiply(double a, double* xin, int n, double* xout);

    // reverse a string
    EXPORT void reverse_string_v1(const char* original, int n, char*␣
↪reversed);

    // reverse a string and return it
    EXPORT char* reverse_string_v2(char* original, int n);

    // calculate the total distance connecting 4 Points
    EXPORT double distance_4_points(FourPoints p);

    // calculate the total distance connecting N Points
    EXPORT double distance_n_points(NPoints p);

}
```

cpp_lib.cpp

```
// cpp_lib.cpp
// Examples that show how to pass various data types between Python and a C++␣
↪library.
//
// Compiled using:
//   g++ cpp_lib.cpp -fPIC -shared -Bstatic -Wall -o cpp_lib64.so
//
#include <math.h>
#include "cpp_lib.h"

int add(int a, int b) {
    return a + b;
}
```

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```
float subtract(float a, float b) {
    return a - b;
}

double add_or_subtract(double a, double b, bool do_addition) {
    if (do_addition) {
        return a + b;
    } else {
        return a - b;
    }
}

void scalar_multiply(double a, double* xin, int n, double* xout) {
    for (int i = 0; i < n; i++) {
        xout[i] = a * xin[i];
    }
}

void reverse_string_v1(const char* original, int n, char* reversed) {
    for (int i = 0; i < n; i++) {
        reversed[i] = original[n-i-1];
    }
}

char* reverse_string_v2(char* original, int n) {
    char* reversed = new char[n];
    for (int i = 0; i < n; i++) {
        reversed[i] = original[n - i - 1];
    }
    return reversed;
}

// this function is not exported to the shared library
double distance(Point p1, Point p2) {
    double d = sqrt(pow(p1.x - p2.x, 2) + pow(p1.y - p2.y, 2));
    return d;
}

double distance_4_points(FourPoints p) {
    double d = distance(p.points[0], p.points[3]);
    for (int i = 1; i < 4; i++) {
        d += distance(p.points[i], p.points[i-1]);
    }
    return d;
}

double distance_n_points(NPoints p) {
    if (p.n < 2) {
        return 0.0;
```

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```
    }
    double d = distance(p.points[0], p.points[p.n-1]);
    for (int i = 1; i < p.n; i++) {
        d += distance(p.points[i], p.points[i-1]);
    }
    return d;
}
```

1.5.2 FORTRAN

Source code for the example FORTRAN library.

fortran_lib.f90

```
! fortran_lib.f90
!
! Basic examples of passing different data types to a FORTRAN function and␣
↪subroutine.
!
! Compiled in Windows using:
! gfortran -fno-underscoring -fPIC fortran_lib.f90 -static -shared -o fortran_
↪lib64.dll
!

! return the sum of two 8-bit signed integers
function sum_8bit(a, b) result(value)
    !DEC$ ATTRIBUTES DLLEXPORT, ALIAS:'sum_8bit' :: sum_8bit
    implicit none
    integer(1) :: a, b, value
    value = a + b
end function sum_8bit


! return the sum of two 16-bit signed integers
function sum_16bit(a, b) result(value)
    !DEC$ ATTRIBUTES DLLEXPORT, ALIAS:'sum_16bit' :: sum_16bit
    implicit none
    integer(2) :: a, b, value
    value = a + b
end function sum_16bit


! return the sum of two 32-bit signed integers
function sum_32bit(a, b) result(value)
    !DEC$ ATTRIBUTES DLLEXPORT, ALIAS:'sum_32bit' :: sum_32bit
    implicit none
    integer(4) :: a, b, value
```

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```
    value = a + b
end function sum_32bit


! return the sum of two 64-bit signed integers
function sum_64bit(a, b) result(value)
    !DEC$ ATTRIBUTES DLLEXPORT, ALIAS:'sum_64bit' :: sum_64bit
    implicit none
    integer(8) :: a, b, value
    value = a + b
end function sum_64bit


! return the product of two 32-bit floating point numbers
function multiply_float32(a, b) result(value)
    !DEC$ ATTRIBUTES DLLEXPORT, ALIAS:'multiply_float32' :: multiply_float32
    implicit none
    real(4) :: a, b, value
    value = a * b
end function multiply_float32


! return the product of two 64-bit floating point numbers
function multiply_float64(a, b) result(value)
    !DEC$ ATTRIBUTES DLLEXPORT, ALIAS:'multiply_float64' :: multiply_float64
    implicit none
    real(8) :: a, b, value
    value = a * b
end function multiply_float64


! return True if 'a' > 0 else False
function is_positive(a) result(value)
    !DEC$ ATTRIBUTES DLLEXPORT, ALIAS:'is_positive' :: is_positive
    implicit none
    logical :: value
    real(8) :: a
    value = a > 0.d0
end function is_positive


! if do_addition is True return a+b otherwise return a-b
function add_or_subtract(a, b, do_addition) result(value)
    !DEC$ ATTRIBUTES DLLEXPORT, ALIAS:'add_or_subtract' :: add_or_subtract
    implicit none
    logical :: do_addition
    integer(4) :: a, b, value
    if (do_addition) then
        value = a + b
```

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```
    else
        value = a - b
    endif
end function add_or_subtract


! compute the n'th factorial of a 8-bit signed integer, return a double-
↪precision number
function factorial(n) result(value)
    !DEC$ ATTRIBUTES DLLEXPORT, ALIAS:'factorial' :: factorial
    implicit none
    integer(1) :: n
    integer(4) :: i
    double precision value
    if (n < 0) then
        value = 0.d0
        print *, "Cannot compute the factorial of a negative number", n
    else
        value = 1.d0
        do i = 2, n
            value = value * i
        enddo
    endif
end function factorial


! calculate the standard deviation of an array.
function standard_deviation(a, n) result(var)
    !DEC$ ATTRIBUTES DLLEXPORT, ALIAS:'standard_deviation' :: standard_
↪deviation
    integer :: n ! the length of the array
    double precision :: var, a(n)
    var = SUM(a)/SIZE(a) ! SUM is a built-in fortran function
    var = SQRT(SUM((a-var)**2)/(SIZE(a)-1.0))
end function standard_deviation


! compute the Bessel function of the first kind of order 0 of x
function besselj0(x) result(val)
    !DEC$ ATTRIBUTES DLLEXPORT, ALIAS:'besselj0' :: besselj0
    double precision :: x, val
    val = BESSEL_J0(x)
end function besselJ0


! reverse a string, 'n' is the length of the original string
subroutine reverse_string(original, n, reversed)
    !DEC$ ATTRIBUTES DLLEXPORT, ALIAS:'reverse_string' :: reverse_string
    !DEC$ ATTRIBUTES REFERENCE :: original, reversed
```

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```
    implicit none
    integer :: i, n
    character(len=n) :: original, reversed
    do i = 1, n
        reversed(i:i) = original(n-i+1:n-i+1)
    end do
end subroutine reverse_string


! element-wise addition of two 1D double-precision arrays
subroutine add_1d_arrays(a, in1, in2, n)
    !DEC$ ATTRIBUTES DLLEXPORT, ALIAS:'add_1d_arrays' :: add_1d_arrays
    implicit none
    integer(4) :: n ! the length of the input arrays
    double precision :: in1(n), in2(n) ! the arrays to add (element-wise)
    double precision :: a(n) ! the array that will contain the element-wise␣
↪sum
    a(:) = in1(:) + in2(:)
    end subroutine add_1D_arrays


! multiply two 2D, double-precision arrays.
! NOTE: multi-dimensional arrays are column-major order in FORTRAN,
!       whereas C (Python) is row-major order.
subroutine matrix_multiply(a, a1, r1, c1, a2, r2, c2)
    !DEC$ ATTRIBUTES DLLEXPORT, ALIAS:'matrix_multiply' :: matrix_multiply
    implicit none
    integer(4) :: r1, c1, r2, c2 ! the dimensions of the input arrays
    double precision :: a1(r1,c1), a2(r2,c2) ! the arrays to multiply
    double precision :: a(r1,c2) ! resultant array
    a = MATMUL(a1, a2)
end subroutine matrix_multiply
```

1.5.3 Microsoft .NET Framework

Source code for the example C# library.

dotnet_lib.cs

```
// dotnet_lib.cs
// Examples that show how to pass various data types between Python and a C#␣
↪library.
//
using System;

// The DotNetMSL namespace contains two classes: BasicMath, ArrayManipulation
```

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```
namespace DotNetMSL
{
    // A class that is part of the DotNetMSL namespace
    public class BasicMath
    {

        public int add_integers(int a, int b)
        {
            return a + b;
        }

        public float divide_floats(float a, float b)
        {
            return a / b;
        }

        public double multiply_doubles(double a, double b)
        {
            return a * b;
        }

        public double add_or_subtract(double a, double b, bool do_addition)
        {
            if (do_addition)
            {
                return a + b;
            }
            else
            {
                return a - b;
            }
        }

    }

    // A class that is part of the DotNetMSL namespace
    public class ArrayManipulation
    {

        public double[] scalar_multiply(double a, double[] xin)
        {
            int n = xin.GetLength(0);
            double[] xout = new double[n];
            for (int i = 0; i < n; i++)
            {
                xout[i] = a * xin[i];
            }
            return xout;
        }
```

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```
        public double[,] multiply_matrices(double[,] A, double[,] B)
        {
            int rA = A.GetLength(0);
            int cA = A.GetLength(1);
            int rB = B.GetLength(0);
            int cB = B.GetLength(1);
            double temp = 0;
            double[,] C = new double[rA, cB];
            if (cA != rB)
            {
                Console.WriteLine("matrices can't be multiplied!");
                return new double[0, 0];
            }
            else
            {
                for (int i = 0; i < rA; i++)
                {
                    for (int j = 0; j < cB; j++)
                    {
                        temp = 0;
                        for (int k = 0; k < cA; k++)
                        {
                            temp += A[i, k] * B[k, j];
                        }
                        C[i, j] = temp;
                    }
                }
                return C;
            }
        }

    }
}

// A class that is not part of the DotNetMSL namespace
public class StringManipulation
{

    public string reverse_string(string original)
    {
        char[] charArray = original.ToCharArray();
        Array.Reverse(charArray);
        return new string(charArray);
    }

}

// A static class
```

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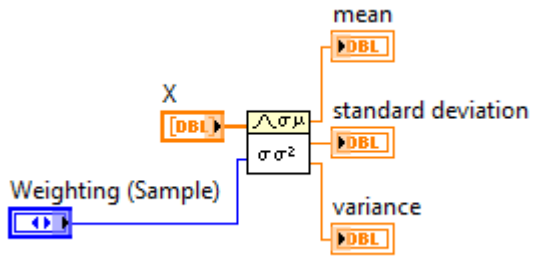
```
public static class StaticClass
{

    public static int add_multiple(int a, int b, int c, int d, int e)
    {
        return a + b + c + d + e;
    }

    public static string concatenate(string a, string b, string c, bool d,␣
↪string e)
    {
        string res = a + b + c;
        if (d)
        {
            res += e;
        }
        return res;

    }

}
```

1.5.4 LabVIEW

Source code for the example LabVIEW library.

labview_lib.vi



labview_lib.h

```
#include "extcode.h"
#pragma pack(push)
#pragma pack(1)

#ifdef __cplusplus
extern "C" {
#endif
```

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```
typedef uint16_t  Enum;
#define Enum_Sample 0
#define Enum_Population 1

/*!
 * stdev
 */
void __cdecl stdev(double X[], int32_t lenX, Enum WeightingSample,
        double *mean, double *variance, double *standardDeviation);

MgErr __cdecl LVDLLStatus(char *errStr, int errStrLen, void *module);

#ifdef __cplusplus
} // extern "C"
#endif

#pragma pack(pop)
```

1.5.5 Java

Source code for the example *.class* and *.jar* libraries.

Example `.class` file

The following file is compiled to `Trig.class` byte code.

Trig.java

```
/*
 * Compile with JDK 6 for maximal compatibility with Py4J
 *
 * javac Trig.java
 *
 */

public class Trig {

  /** Returns the trigonometric cosine of an angle. */
  static public double cos(double x) {
    return Math.cos(x);
  }

  /** Returns the hyperbolic cosine of a value. */
  static public double cosh(double x) {
    return Math.cosh(x);
  }
```

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```
  /** Returns the arc cosine of a value, [0.0, pi]. */
  static public double acos(double x) {
    return Math.acos(x);
  }

  /** Returns the trigonometric sine of an angle. */
  static public double sin(double x) {
    return Math.sin(x);
  }

  /** Returns the hyperbolic sine of a value. */
  static public double sinh(double x) {
    return Math.sinh(x);
  }

  /** Returns the arc sine of a value, [-pi/2, pi/2]. */
  static public double asin(double x) {
    return Math.asin(x);
  }

  /** Returns the trigonometric tangent of an angle. */
  static public double tan(double x) {
    return Math.tan(x);
  }

  /** Returns the hyperbolic tangent of a value. */
  static public double tanh(double x) {
    return Math.tanh(x);
  }

  /** Returns the arc tangent of a value; [-pi/2, pi/2]. */
  static public double atan(double x) {
    return Math.atan(x);
  }

  /**
   * Returns the angle theta from the conversion of rectangular coordinates
   * (x, y) to polar coordinates (r, theta).
   */
  static public double atan2(double y, double x) {
    return Math.atan2(y, x);
  }

}
```

Example `.jar` file

The following classes are included in the `nz.msl.examples` package in `java_lib.jar`.

MathUtils.java

```
package nz.msl.examples;

public class MathUtils {

  /** Generate a random number between [0, 1) */
  static public double random() {
    return Math.random();
  }

  /** Calculate the square root of {@code x} */
  static public double sqrt(double x) {
    return Math.sqrt(x);
  }

}
```

Matrix.java

```
package nz.msl.examples;

import java.util.Random;


public class Matrix {

  /** The matrix, M */
  private double[][] m;

  /** Lower-triangular matrix representation, M=LU, in LU Decomposition */
  private Matrix L;

  /** Upper-triangular matrix representation, M=LU, in LU Decomposition */
  private Matrix U;

  /** A NxM orthogonal matrix representation, M=QR, in QR Decomposition */
  private Matrix Q;

  /** Upper-triangular matrix representation, M=QR, in QR Decomposition */
  private Matrix R;

  /** When calculating the inverse we calculate the LU matrices once */
  static private boolean calculatingInverse = false;
```

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```
/*
 *
 * Define the constructors.
 *
 *
 */

/** Create a Matrix that is a copy of another Matrix. */
public Matrix(Matrix m) {
  this.m = new double[m.getNumberOfRows()][m.getNumberOfColumns()];
  for (int i=0; i<m.getNumberOfRows(); i++)
    for (int j=0; j<m.getNumberOfColumns(); j++)
      this.m[i][j] = m.getValue(i,j);
}

/** Create a {@code n} x {@code n} identity Matrix */
public Matrix(int n) {
  m = new double[n][n];
  for (int i=0; i<n; i++)
    m[i][i] = 1.0;
}

/** Create a {@code rows} x {@code cols} Matrix filled with zeros. */
public Matrix(int rows, int cols) {
  m = new double[rows][cols];
}

/** Create a {@code rows} x {@code cols} Matrix filled with a value. */
public Matrix(int rows, int cols, double value) {
  m = new double[rows][cols];
  for (int i=0; i<rows; i++)
    for (int j=0; j<cols; j++)
      m[i][j] = value;
}

/**
 * Create a {@code rows} x {@code cols} Matrix that is filled with
 * uniformly-distributed random values that are within the range
 * {@code min} to {@code max}.
 */
public Matrix(int rows, int cols, double min, double max) {
  Random rand = new Random();
  m = new double[rows][cols];
  for (int i=0; i<rows; i++)
    for (int j=0; j<cols; j++)
      m[i][j] = (max-min)*rand.nextDouble()+min;
}
```

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```
/** Create a Matrix from {@code m}. */
public Matrix(Double[][] m) {
  this.m = new double[m.length][m[0].length];
  for (int i=0; i<m.length; i++)
    for (int j=0; j<m[0].length; j++)
      this.m[i][j] = m[i][j];
}

/** Create a Matrix from a vector. */
public Matrix(Double[] vector) {
  m = new double[1][vector.length];
  for (int i=0; i<vector.length; i++)
    m[0][i] = vector[i];
}

/*
 *
 * The public static methods.
 *
 *
 */

/** Returns the product of two Matrices as a new Matrix, C=AB. */
public static Matrix multiply(Matrix a, Matrix b) {
  if (a.getNumberOfColumns() != b.getNumberOfRows()) {
    throw new IllegalArgumentException(
        String.format("ERROR! Cannot multiply a %dx%d matrix "
          + "with a %dx%d matrix",
          a.getNumberOfRows(), a.getNumberOfColumns(),
          b.getNumberOfRows(), b.getNumberOfColumns()));
  } else {
    Matrix c = new Matrix(a.getNumberOfRows(), b.getNumberOfColumns());
    double sum = 0.0;
    for (int i = 0; i < a.getNumberOfRows() ; i++) {
      for (int j = 0; j < b.getNumberOfColumns(); j++) {
               for (int k = 0 ; k < b.getNumberOfRows() ; k++) {
                  sum += a.getValue(i,k)*b.getValue(k,j);
               }
               c.setValue(i, j, sum);
               sum = 0.0;
            }
         }
    return c;
  }
}

/**
 * Solves {@code b = Ax} for {@code x}.
 *
```

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```
  * @param A - the coefficient matrix
  * @param b - the expected values
  * @return x - the solution to the system of equations
  */
 public static Matrix solve(Matrix A, Matrix b) {

   // ensure that 'b' is a column vector
   if (b.getNumberOfColumns() > 1)  b = b.transpose();

   // ensure that 'A' and 'b' have the correct dimensions
   if (b.getNumberOfRows() != A.getNumberOfRows()) {
     throw new IllegalArgumentException(
       String.format("ERROR! Dimension mismatch when solving the "
         + "system of equations using b=Ax, b has dimension "
         + " %dx%d and A is %dx%d.", b.getNumberOfRows(),
         b.getNumberOfColumns(), A.getNumberOfRows(),
         A.getNumberOfColumns()));
   }

   // if A is an under-determined system of equations then use the
   // matrix-multiplication expression to solve for x
   if (A.getNumberOfRows() < A.getNumberOfColumns()) {
     Matrix At = A.transpose();
     return Matrix.multiply(Matrix.multiply(At,
         Matrix.multiply(A, At).getInverse() ), b);
   }

   // If A is a square matrix then use LU Decomposition, if it is an
   // over-determined system of equations then use QR Decomposition
   Double[] x = new Double[A.getNumberOfColumns()];
   if (A.isSquare()) {

     // when using 'solve' to calculate the inverse of a matrix we
     // only need to generate the LU Decomposition matrices once
     if (!calculatingInverse) A.makeLU();

     // solve Ly=b for y using forward substitution
     double[] y = new double[b.getNumberOfRows()];
     y[0] = b.getValue(0,0);
     for (int i=1; i<y.length; i++) {
       y[i] = b.getValue(i,0);
       for (int j=0; j<i; j++)
         y[i] -= A.getL().getValue(i,j)*y[j];
     }

     // solve Ux=y for x using backward substitution
     for (int i=x.length-1; i>-1; i--) {
       x[i] = y[i];
       for (int j=i+1; j<x.length; j++)
```

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```
        x[i] -= A.getU().getValue(i,j)*x[j];
      x[i] /= A.getU().getValue(i,i);
    }

  } else {

    A.makeQR();
    Matrix d = Matrix.multiply(A.getQ().transpose(), b);

    // solve Rx=d for x using backward substitution
    for (int i=x.length-1; i>-1; i--) {
      x[i] = d.getValue(i, 0);
      for (int j=i+1; j<x.length; j++)
        x[i] -= A.getR().getValue(i,j)*x[j];
      x[i] /= A.getR().getValue(i,i);
    }
  }

  return new Matrix(x).transpose();
}

/*
 *
 * The public methods.
 *
 *
 */

/** Returns the primitive data of the Matrix. */
public double[][] primitive() {
  return m;
}

/** Convert the Matrix to a string. */
@Override
public String toString() {
  StringBuffer sb = new StringBuffer();
  for (int i=0; i<m.length; i++) {
    for (int j=0; j<m[0].length; j++) {
      sb.append(String.format("%+.6e\t", m[i][j]));
    }
    sb.append("\n");
  }
  return sb.toString();
}

/** Returns the number of rows in the Matrix. */
public int getNumberOfRows() {
  return m.length;
```

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```
}

/** Returns the number of columns in the Matrix. */
public int getNumberOfColumns() {
  try {
    return m[0].length;
  } catch (ArrayIndexOutOfBoundsException e) {
    return 0;
  }
}

/** Returns the value at {@code row} and {@code col}. */
public double getValue(int row, int col) {
  return m[row][col];
}

/** Sets the value at {@code row} and {@code col} to be {@code value}. */
public void setValue(int row, int col, double value) {
  m[row][col] = value;
}

/** Returns the transpose of the Matrix. */
public Matrix transpose() {
  Matrix mt = new Matrix(m[0].length, m.length);
  for (int i=0; i<m.length; i++)
    for (int j=0; j<m[0].length; j++)
      mt.setValue(j, i, m[i][j]);
  return mt;
}

/** Returns whether the Matrix is a square Matrix. */
public boolean isSquare() {
  return m.length == m[0].length;
}

/** Returns the determinant of the Matrix. */
public double getDeterminant() {
  if (isSquare()) {
    makeLU();
    double det = 1.0;
    for (int i=0; i<m.length; i++)
      det *= U.getValue(i,i);
    // 's' is the number of row and column exchanges in LU Decomposition
    // but we are currently not using pivoting
    int s = 0;
    return Math.pow(-1.0, s)*det;
  } else {
    return Double.NaN;
  }
```

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```
}

/** Returns the lower-triangular Matrix, L, from a LU Decomposition */
public Matrix getL() {
  if (L==null) makeLU();
  return L;
}

/** Returns the upper-triangular Matrix, U, from a LU Decomposition */
public Matrix getU() {
  if (U==null) makeLU();
  return U;
}

/** Returns the orthogonal Matrix, Q, from a QR Decomposition */
public Matrix getQ() {
  if (Q==null) makeQR();
  return Q;
}

/** Returns the upper-triangular Matrix, R, from a QR Decomposition */
public Matrix getR() {
  if (R==null) makeQR();
  return R;
}

/** Returns the inverse of the Matrix, if it exists. */
public Matrix getInverse() {
  if (isSquare()) {
    Matrix inv = new Matrix(m.length);
    Matrix bb = new Matrix(m.length);
    for (int i=0; i<m.length; i++) {
      inv.setColumn(i, Matrix.solve(this, bb.getColumn(i)));
      calculatingInverse = true;
    }
    calculatingInverse = false;
    return inv;
  } else {
    throw new IllegalArgumentException(
      String.format("ERROR! Cannot calculate the inverse of a "
        + "%dx%d matrix, it must be a square Matrix",
        m.length, m[0].length));
  }
}


/*
 *
 * Private methods.
```

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```
 *
 *
 */

/**
 * Create the Lower, L, and Upper, U, triangular matrices, such that M=LU.
 * Does not use pivoting.
 */
private void makeLU() {
  L = new Matrix(m.length); // create an identity matrix
  U = new Matrix(this); // copy the values of this matrix
  double val;
  for (int k=0; k<m[0].length; k++) {
    for (int i=k+1; i<m.length; i++) {
      val = U.getValue(i,k)/U.getValue(k,k);
      L.setValue(i, k, val);
      for (int j=k; j<m[0].length; j++)
        U.setValue(i, j, U.getValue(i,j)-val*U.getValue(k,j));
    }
  }
}

/**
 * Computes the QR Factorization matrices using a modified
 * Gram-Schmidt process.<p>
 *
 * @see https://people.inf.ethz.ch/gander/papers/qrneu.pdf
 */
private void makeQR() {

  Q = new Matrix(m.length, m[0].length);
  R = new Matrix(m[0].length, m[0].length);
  Matrix A = new Matrix(this);

  double s;
  for (int k=0; k<m[0].length; k++) {
    s = 0.0;
    for (int j=0; j<m.length; j++)
      s += Math.pow(A.getValue(j, k), 2);
    s = Math.sqrt(s);
    R.setValue(k, k, s);
    for (int j=0; j<m.length; j++)
      Q.setValue(j, k, A.getValue(j, k)/s);
    for (int i=k+1; i<m[0].length; i++) {
      s = 0.0;
      for (int j=0; j<m.length; j++)
        s += A.getValue(j, i)*Q.getValue(j, k);
      R.setValue(k, i, s);
      for (int j=0; j<m.length; j++)
```

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```
          A.setValue(j, i, A.getValue(j,i)-R.getValue(k,i)*Q.getValue(j,k));
      }
    }
  }

  /** Returns a copy of the specified column. */
  private Matrix getColumn(int column) {
    if (column < m[0].length) {
      Matrix c = new Matrix(m.length, 1);
      for (int i=0; i<m.length; i++)
        c.setValue(i, 0, m[i][column]);
      return c;
    } else {
      throw new IllegalArgumentException(
        String.format("ERROR! Cannot get column %d in the Matrix "
          + "since it is > the number of columns in the "
          + "Matrix, %d.", column, m[0].length));
    }
  }

  /**
   * Replace the values in the specified column of the matrix to the values in
   * {@code vector}.
   *
   * The {@code vector} must be a 1D vector, can have dimension 1xN or Nx1.
   */
  private void setColumn(int column, Matrix vector) {

    // make sure that 'vector' is either a 1xN or Nx1 vector and not a NxM␣
↪Matrix
    if ( (vector.getNumberOfColumns() != 1) && (vector.getNumberOfRows() !=␣
↪1) ) {
      throw new IllegalArgumentException(
        String.format("ERROR! Require a 1D vector to replace the values "
          + "in a column of a matrix. Got a %dx%d vector.",
          vector.getNumberOfRows(), vector.getNumberOfColumns()));
    }

    // make sure we have a column vector
    if (vector.getNumberOfColumns() != 1) {
      vector = vector.transpose();
    }

    // make sure the 'vector' has the correct length
    if (vector.getNumberOfRows() != m.length) {
      throw new IllegalArgumentException(
        String.format("ERROR! Cannot replace a Matrix column of length "
          + "%d, with a column vector of length %d.",
          m.length, vector.getNumberOfRows()));
```

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```
    }

    // make sure the column is valid
    if (column >= m[0].length) {
      throw new IllegalArgumentException(
        String.format("ERROR! Cannot replace column %d in the Matrix "
        + "since it is > the number of columns in the matrix.", column));
    }

    for (int i=0; i<m.length; i++)
      m[i][column] = vector.getValue(i,0);
  }

}
```

1.6 Re-freezing the 32-bit server

If you want to make your own 32-bit server you will need

1) a 32-bit version of Python 2.7 or 3.5+ (whatever version you want)

2) PyInstaller

Using pip from the 32-bit Python interpreter run

```
pip install msl-loadlib pyinstaller
```

Note: If you want to include additional packages, for example, pythonnet, comtypes, numpy, etc. run

```
pip install pythonnet comtypes numpy
```

You have two options to create the 32-bit server

1) *Using the API*

2) *Using the CLI*

and you have two options to use the newly-created server

1. Copy the `server32-*` file to the `../site-packages/msl/loadlib` directory where you have MSL-LoadLib installed in your 64-bit version of Python to replace the existing server file.

2. Specify the directory where the `server32-*` file is located as the value of the `server32_dir` keyword argument in *`Client64`*.

1.6.1 Using the API

Launch an Interactive Console using the 32-bit Python interpreter

```
python
```

and enter

```
>>> from msl.loadlib import freeze_server32
>>> freeze_server32.main()
... PyInstaller logging messages ...
Server saved to ...
```

Specify the appropriate keyword arguments to the *main()* function.

1.6.2 Using the CLI

In this example, the GitHub repository is cloned and the server is created from the command line. Make sure that invoking *python* on your terminal uses the 32-bit Python interpreter or specify the full path to the 32-bit Python interpreter that you want to use.

```
git clone https://github.com/MSLNZ/msl-loadlib.git
cd msl-loadlib/msl/loadlib
python freeze_server32.py
```

To see the help for the *freeze_server32.py* module run

```
python freeze_server32.py --help
```

For example, if you wanted to bypass the error that pythonnet is not installed run

```
python freeze_server32.py --ignore-pythonnet
```

1.7 FAQ

Answers to frequently asked questions.

1.7.1 Access the console output of the 32-bit server

You have access to the console output of the 32-bit server once it has shut down. For example, suppose your 64-bit client class is called *MyClient*, you would do something like:

```
c = MyClient()
c.do_something()
c.do_something_else()
stdout, stderr = c.shutdown_server32()
print(stdout.read())
print(stderr.read())
```

If you want to be able to poll the console output in real time (while the server is running) you have two options:

1. Have the 32-bit server write to a file and the 64-bit client read from the file.
2. Implement a *polling* method on the 32-bit server for the 64-bit client to send requests to. The following is a runnable example:

```
import os

from msl.loadlib import Client64
from msl.loadlib import Server32

class Polling32(Server32):

    def __init__(self, host, port):
        # Loading a "dummy" 32-bit library for this example
        path = os.path.join(Server32.examples_dir(), 'cpp_lib32')
        super(Polling32, self).__init__(path, 'cdll', host, port)

        # Create a list to store 'print' messages in
        self._stdout = []

        # Use your own print method instead of calling the builtin print()␣
↪function
        self.print('Polling32 has been initiated')

    def say_hello(self, name):
        """Return a greeting."""
        self.print(f'say_hello was called with argument {name!r}')
        return f'Hello, {name}!'

    def poll(self):
        """Get the latest message."""
        try:
            return self._stdout[-1]
        except IndexError:
            return ''

    def flush(self):
        """Get all messages and clear the cache."""
        messages = '\n'.join(self._stdout)
        self._stdout.clear()
        return messages

    def print(self, message):
        """Append a message that you would have wanted to print to the␣
↪console."""
        self._stdout.append(message)

class Polling64(Client64):
```

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```
    def __init__(self):
        super(Polling64, self).__init__(__file__)

    def __getattr__(self, name):
        def send(*args, **kwargs):
            return self.request32(name, *args, **kwargs)
        return send

# Only execute this section of code on the 64-bit client (not on the 32-bit␣
↪server).
# Typically, you may write the Server32 class and the Client64 class in␣
↪separate files.
if not Server32.is_interpreter():
    p = Polling64()
    print('poll ->', p.poll())
    print('say_hello ->', p.say_hello('world'))
    print('poll ->', p.poll())
    print('flush ->', repr(p.flush()))
    print('poll ->', repr(p.poll()))
    p.shutdown_server32()
```

Running the above script will output:

```
poll -> Polling32 has been initiated
say_hello -> Hello, world!
poll -> say_hello was called with argument 'world'
flush -> "Polling32 has been initiated\nsay_hello was called with argument
↪'world'"
poll -> ''
```

1.7.2 Freezing the MSL-LoadLib package

If you want to use PyInstaller or cx-Freeze to bundle msl-loadlib in a frozen application, the 32-bit server must be added as a data file.

For example, using PyInstaller on Windows you would include an `--add-data` option

```
pyinstaller --add-data "..\site-packages\msl\loadlib\server32-windows.exe;."
```

where you must replace the leading `..` prefix with the parent directories to the file (i.e., specify the absolute path to the file). On Linux, replace `server32-windows.exe;.` with `server32-linux:.`

If the server is loading a .NET library that was compiled with .NET < 4.0, you must also add the `server32-windows.exe.config` data file. Otherwise, you do not need to add this config file.

cx-Freeze appears to automatically bundle the 32-bit server (tested with cx-Freeze version 6.14.5) so there may not be anything you need to do. If the *server32* executable is not bundled, you can specify the absolute path to the *server32* executable as the `include_files` option for the `build_exe` command.

1.8 License

1.9 Developers

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1.10 Changelog

1.10.1 Version 0.10.0 (2023-06-16)

This release will be the last to support Python 2.7, 3.5, 3.6 and 3.7

- The 32-bit server is frozen with the following versions
  - `server32-windows.exe` – Python 3.11.4, pythonnet 3.0.1, comtypes 1.2.0
  - `server32-linux` – Python 3.11.4 (built with GLIBC 2.27)
- Added
  - can now specify the destination directory when freezing the 32-bit server
  - the *server32_dir* keyword argument to *Client64* (fixes issue #35)
  - Support for Python 3.10 and 3.11
  - *LoadLibrary* and *Client64* can be used as a context manager (The with statement)
  - *LoadLibrary.cleanup()* method

  - `~/.local/share/py4j` to the search paths when looking for the `py4j<version>.jar` file

- Changed
  - *is_port_in_use()* only checks TCP ports and it uses the `ss` command instead of `netstat` on linux
  - the example libraries for FORTRAN now depend on *libgfortran5* on linux

- Fixed
  - issue #31 - suppress console popups when using `pythonw.exe`
  - issue #24 - starting the 32-bit server could block forever by not honouring the timeout

1.10.2 Version 0.9.0 (2021-05-13)

- The 32-bit server is frozen with the following versions
  - `server32-windows.exe` – Python 3.7.10, pythonnet 2.5.2, comtypes 1.1.10
  - `server32-linux` – Python 3.7.10, pythonnet 2.4.0

- Added
  - support for loading an ActiveX library
  - the following static methods to *Server32*: *remove_site_packages_64bit()*, *is_interpreter()*, *examples_dir()*
  - the *generate_com_wrapper()* function

- Changed
  - the `sys.coinit_flags` attribute is now set to `COINIT_MULTITHREADED` (only if this attribute was not already defined prior to importing *msl.loadlib*)

- Fixed
  - `Client64.__del__` could have written a warning to stderr indicating that no `self._conn` attribute existed
  - `sys:1: ResourceWarning: unclosed file <_io.BufferedReader name=...>` warnings could be written to stderr when a *Client64* object is destroyed
  - issue #23 - the `useLegacyV2RuntimeActivationPolicy` property was no longer created

1.10.3 Version 0.8.0 (2021-02-20)

- Added
  - support for Python 3.9
  - the *protocol* keyword argument to *Client64*
  - the ability to request non-callable attributes from the 32-bit server class (e.g., methods that use the *@property* decorator and class/instance variables)

- Changed
  - `server32-windows.exe` uses Python 3.7.10, pythonnet 2.5.2 and comtypes 1.1.8

  - `server32-linux` uses Python 3.7.10 and pythonnet 2.4.0 (there are problems with later versions of pythonnet on 32-bit linux, see issue #1210 for more details)
  - call `clr.AddReference` before `clr.System.Reflection.Assembly.LoadFile` when loading a .NET library
  - use PIPE's for *stdout* and *stderr* for the 32-bit server subprocess and for the py4j *GatewayServer*
  - *shutdown_server32()* now returns the *(stdout, stderr)* streams from the 32-bit server subprocess
  - the *quiet* keyword argument for *Client64* is deprecated
- Fixed
  - issue #21 - an `UnsupportedOperation: fileno` exception was raised when running within the Spyder IDE
- Removed
  - `cygwin` from the *IS_WINDOWS* check

1.10.4 Version 0.7.0 (2020-03-17)

- Added
  - support for Python 3.8
  - compiled the C++ and FORTRAN examples for 64-bit macOS
- Changed
  - the frozen server32 executable uses Python 3.7.7 (Windows and Linux), pythonnet 2.4.0 (Windows and Linux) and comtypes 1.1.7 (Windows)
  - use `__package__` as the logger name
  - renamed `port_in_use()` to *is_port_in_use()* and added support for checking the status of a port in macOS
  - changes to how a .NET library is loaded: include the System namespace by default, do not automatically create a class instance
- Removed
  - Support for Python 3.4

1.10.5 Version 0.6.0 (2019-05-07)

- Added
  - a *shutdown_handler()* method to *Server32* (PR #19)
  - a section to the docs that explains how to re-freeze the 32-bit server
  - a *kill_timeout* keyword argument to *Client64.shutdown_server32()*
  - the *rpc_timeout* keyword argument to *Client64* (thanks to @fake-name)

  - search *HKEY_CLASSES_ROOT\Wow6432Node\CLSID* in the Windows Registry for additional COM *ProgID*'s
  - *extras_require* parameter to *setup.py* with keys: *clr*, *java*, *com*, *all*
- Changed
  - the frozen server32 executable (for Windows/Linux) now uses Python 3.7.3 and Python.NET 2.4.0
  - rename the optional *-asp* and *-aep* command line arguments to be *-s* and *-e* respectively
  - the current working directory where the 64-bit Python interpreter was executed from is now automatically appended to `os.environ['PATH']` on the 32-bit server
  - *freeze_server32.py* uses an *ArgumentParser* instead of directly reading from *sys.argv*
- Fixed
  - use `sys.executable -m PyInstaller` to create the 32-bit server (part of PR #18)
  - the 32-bit server prints error messages to *sys.stderr* instead of *sys.stdout*
  - issue #15 - wait for the subprocess that starts the 32-bit server to terminate and set a value for the *returncode*
  - issue #14 - use *os.kill* to stop the 32-bit server if it won't stop after *kill_timeout* seconds

1.10.6 Version 0.5.0 (2019-01-06)

- Added
  - support for loading a Component Object Model (COM) library on Windows
  - the *requires_pythonnet* and *requires_comtypes* kwargs to `freeze_server32.main()`
  - `'clr'` as an alias for `'net'` for the *libtype* parameter in *LoadLibrary*
  - the `utils.get_com_info()` function
  - support for unicode paths in Python 2
  - examples for working with numpy arrays and C++ structs
- Changed
  - the frozen server32 executable (for Windows/Linux) now runs on Python 3.6.8
  - if loading a .NET assembly succeeds but calling *GetTypes()* fails then a detailed error message is logged rather than raising the exception - the value of *lib* will be *None*
  - the default timeout value when waiting for the 32-bit server to start is now 10 seconds
  - the *Client64* class now raises *Server32Error* if the 32-bit server raises an exception
  - the *Client64* class now inherits from *object* and the reference to *HTTPConnection* is now a property value
  - the *__repr__* methods no longer include the id as a hex number
- Fixed
  - set `sys.stdout = io.StringIO()` if *quiet=True* on the server

1.10.7 Version 0.4.1 (2018-08-24)

- Added
  - the `version_info` namedtuple now includes a *releaselevel*
  - Support for Python 3.7
- Fixed
  - Issue #11
  - `utils.wait_for_server()` raised *NameError: name 'TimeoutError' is not defined* for Python 2.7
  - `utils.port_in_use()` raised *UnicodeDecodeError* (PR #9)
  - `setup.py` is now also compatible with Sphinx 1.7+
- Changed
  - the frozen server32 executable (for Windows/Linux) now runs on Python 3.6.6
  - pythonnet is now an optional dependency on Windows and py4j is now optional for all OS
  - rename *Dummy* example to *Echo*
- Removed
  - Support for Python 3.3

1.10.8 Version 0.4.0 (2018-02-28)

- Added
  - Py4J wrapper for loading `.jar` and `.class` Java files
  - example on how to load a library that was built with LabVIEW
- Fixed
  - Issue #8
  - Issue #7
  - `AttributeError("'LoadLibrary' object has no attribute '_lib'") raised in repr()`
- Changed
  - rename `DotNetContainer` to `DotNet`
  - use `socket.socket.bind` to select an available port instead of checking of calling `utils.port_in_use`
  - **moved the static methods to the `msl.loadlib.utils` module:**
    - Client64.port_in_use -> utils.port_in_use
    - Client64.get_available_port -> utils.get_available_port
    - Client64.wait_for_server -> utils.wait_for_server
    - LoadLibrary.check_dot_net_config -> utils.check_dot_net_config

* LoadLibrary.is_pythonnet_installed -> utils.is_pythonnet_installed

1.10.9 Version 0.3.2 (2017-10-18)

- Added
  - include `os.environ['PATH']` as a search path when loading a shared library
  - the frozen server32 executable (for Windows/Linux) now runs on Python 3.6.3
  - support that the package can now be installed by `pip install msl-loadlib`
- Fixed
  - remove `sys.getsitepackages()` error for virtualenv (issue #5)
  - received `RecursionError` when freezing freeze_server32.py with PyInstaller 3.3
  - replaced `FileNotFoundError` with `IOError` (for Python 2.7 support)
  - recompile cpp_lib*.dll and fortran_lib*.dll to not depend on external dependencies

1.10.10 Version 0.3.1 (2017-05-15)

- fix ReadTheDocs build error – AttributeError: module 'site' has no attribute 'getsitepackages'
- strip whitespace from append_sys_path and append_environ_path
- make pythonnet a required dependency only for Windows

1.10.11 Version 0.3.0 (2017-05-09)

NOTE: This release breaks backward compatibility

- can now pass **kwargs from the Client64 constructor to the Server32-subclass constructor
- new command line arguments for starting the 32-bit server: –kwargs, –append_environ_path
- renamed the –append_path command line argument to –append_sys_path
- Server32.interactive_console() works on Windows and Linux
- edit documentation (thanks to @karna48 for the pull request)

1.10.12 Version 0.2.3 (2017-04-11)

- the frozen server32 executable (for Windows/Linux) now uses Python v3.6.1 and Python.NET v2.3.0
- include ctypes.util.find_library and sys.path when searching for shared library

1.10.13 Version 0.2.2 (2017-03-03)

- refreeze server32 executables

1.10.14 Version 0.2.1 (2017-03-02)

- fix releaselevel bug

1.10.15 Version 0.2.0 (2017-03-02)

- examples now working in Linux
- fix MSL namespace
- include all C# modules, classes and System.Type objects in the .NET loaded-library object
- create a custom C# library for the examples
- edit docstrings and documentation
- many bug fixes

1.10.16 Version 0.1.0 (2017-02-15)

- Initial release

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