PyCON HK

Introduction of Graalpython to execute multiple languages with one processing system at high performance

Amitpal Singh Dhillon

Regional Director, Asia-Pacific & Japan
Oracle Labs Research & Advanced Development

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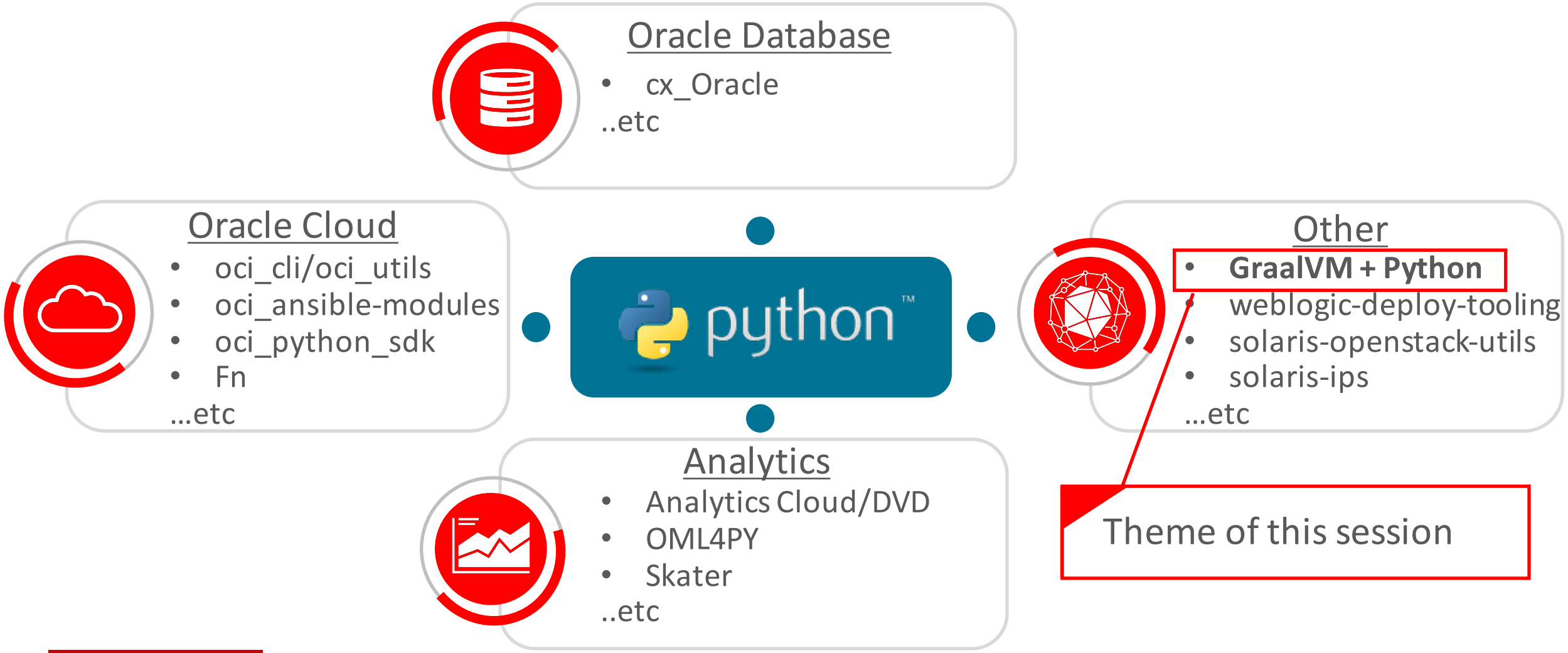
Relationship between Oracle and Python

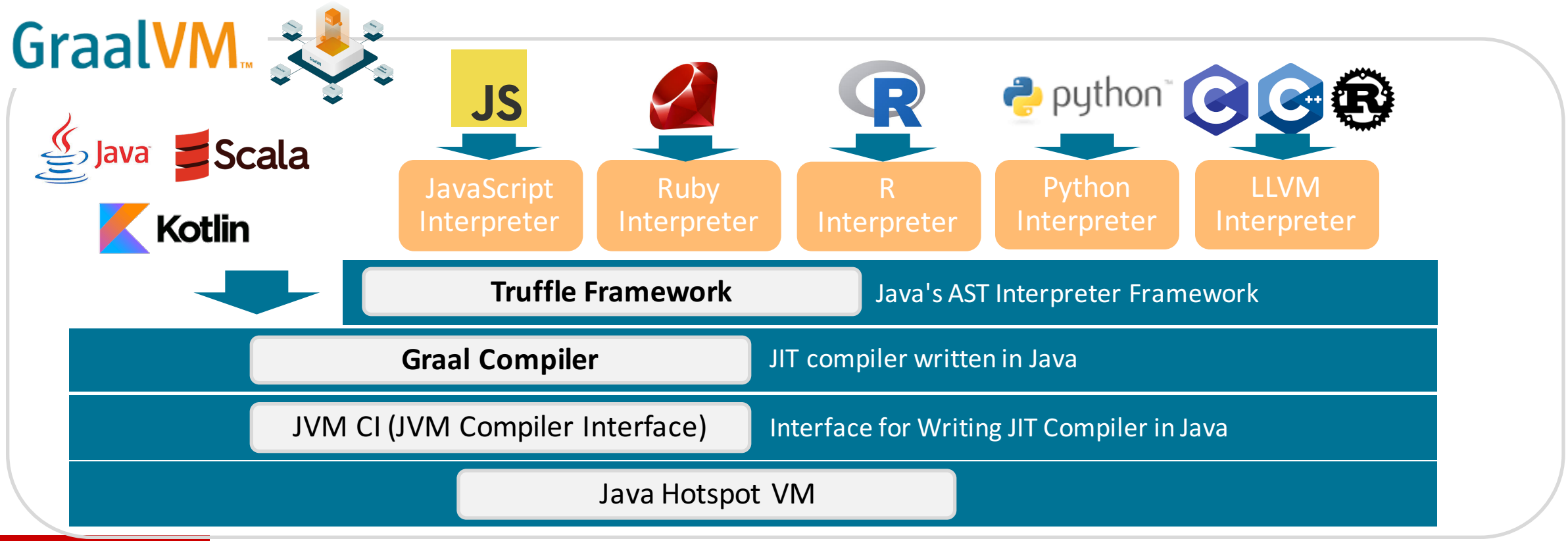


What is GraalVM

- A next generation VM that runs multiple languages fast with a single runtime

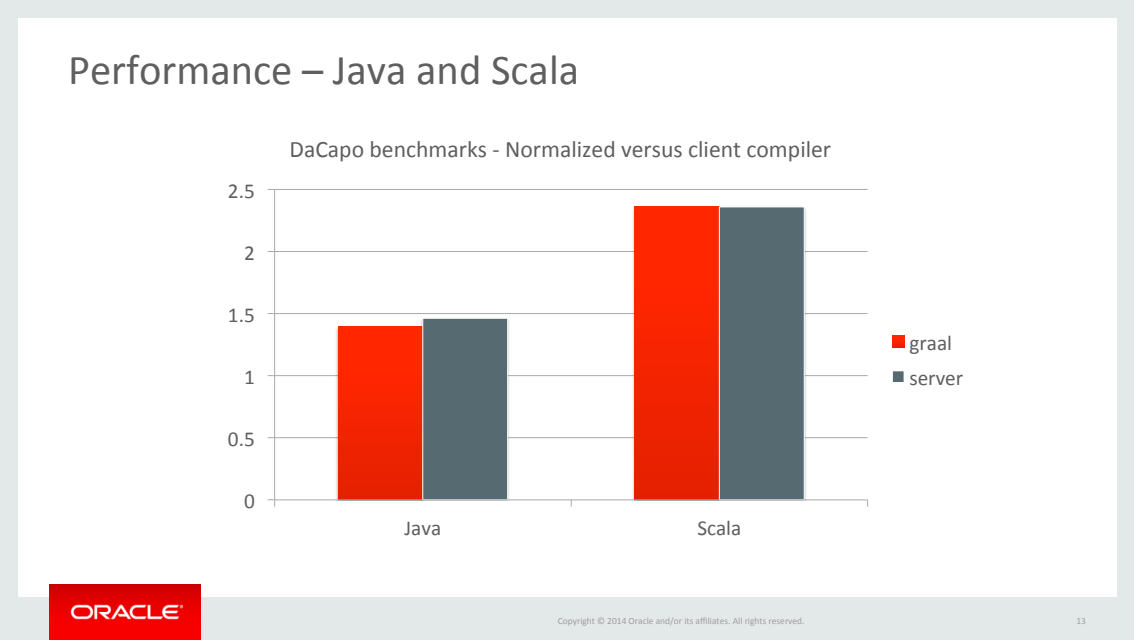
GraalVM Architecture

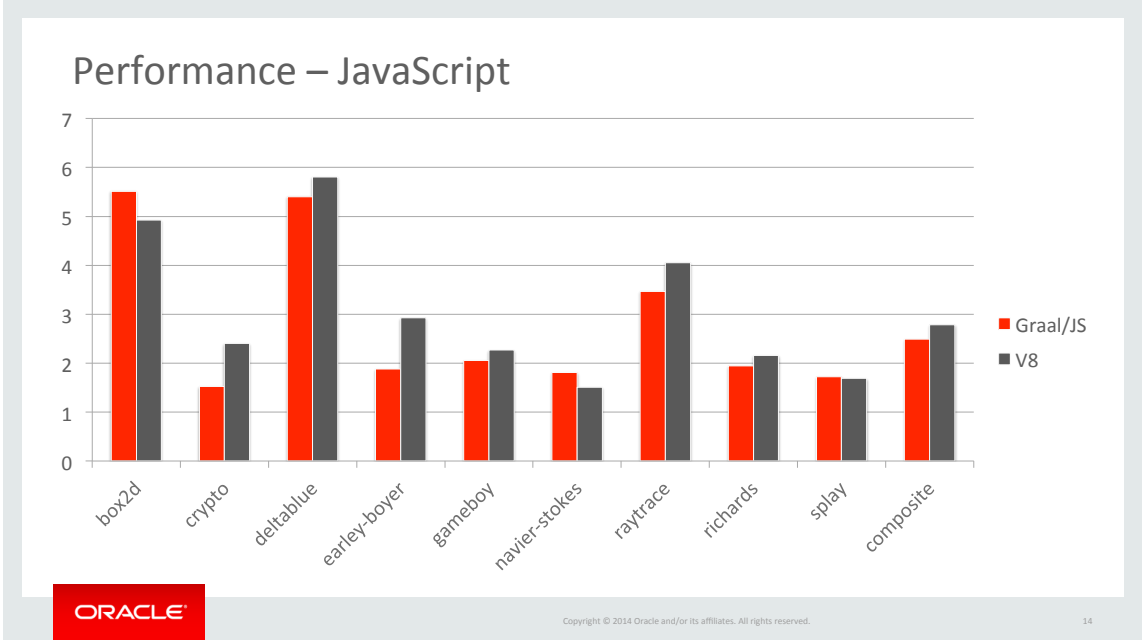
- Graal and Truffle for a High Performance Multilingual Executable VM Environment



GraalVM performance

- Good performance has been reported in various languages (Java / Scala / R / JavaScript)

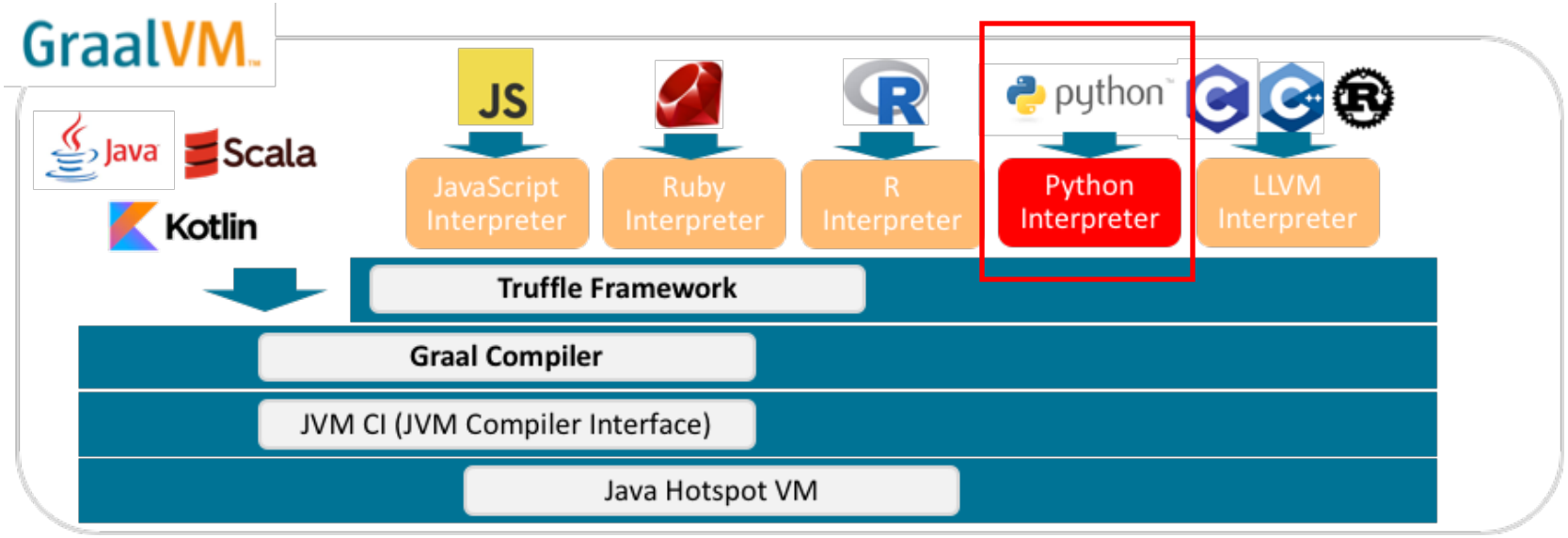




Ref.「**Graal VM: Multi-Language Execution**」**Thomas Wuerthinger**, Senior Research Director at Oracle
URL: https://www.slideshare.net/ThomasWuerthinger/jazoon2014-slides?from_action=save

What is graalpython

- Interpreter for Python 3 implementation built on GraalVM
- At the moment, "**early-stage experimental** implementation of Python"
- Ultimately, achieve full compatibility with Python 3.7 and aim for full support for Scipy and Scipy dependent libraries (Numpy, Pandas, Scikit-learn etc)



graalpython install & run

- Install with gu command of Graal and run GaalVM Python interpreter with graalpython command

Graalpython installation

```
$ gu -c install org.graalvm.python

$ graalpython --version

Graal Python 3.7.0 (GraalVM CE Native 1.0.0-rc15)
```

Run Graalpython

```
# Run a Python script
$ graalpython helloworld.py

# Run Python REPL
$ graalpython
Python 3.7.0 (Thu Apr 04 12:16:00 PDT 2019)
[GraalVM CE, Java 1.8.0_202] on darwin
Type "help", "copyright", "credits" or "license" for
more information.
Please note: This Python implementation is
in the very early stages, and can run little more than
basic benchmarks at this point.
>>>
```

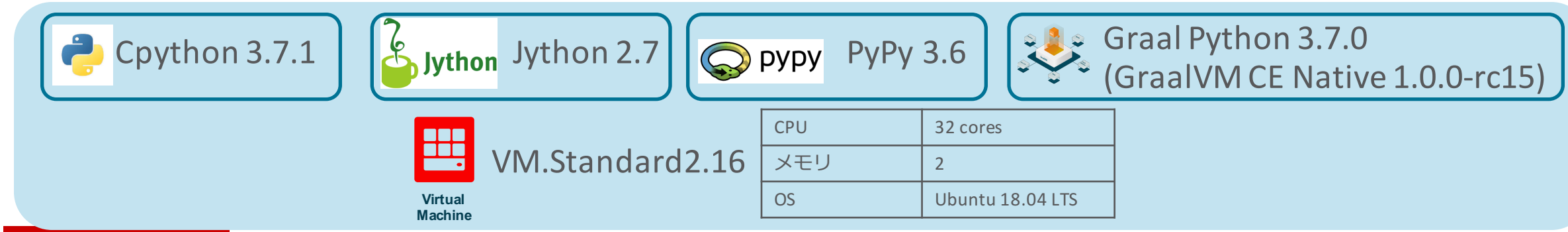
graalpython performance measurement

- In order to verify the high performance which is one of the attractiveness of graalpython, the following two benchmarks are executed on the Compute instance on OCI

  ① Some benchmark scripts run in the pyperfomance (*) library

  ② Python script to perform pi calculation by Monte Carlo method

- Compare three Python implementations (Cpython, Jython, PyPy) with graalpython



[Reference] Python Implementations

Implementation	Latest Version	Standard Python Compatible version	Feature
CPython	3.7.3	(Standard Python implementation)	Python language reference implementation https://www.python.org/
Jython	2.7.0	2.7	Java implementation of Python https://www.jython.org/
PyPy	3.6	3.6	A Python implementation of RPython designed to accelerate CPython https://pypy.org/index.html
graalpython	3.7 GraalVM 1.0.0-rc16	3.7 ※ However, because it is experimental, it is not yet fully compatible	Python implementation that runs on Graal VM https://github.com/graalvm/graalpython
Zippy	3.7	3.7	Python implementation that works on Truffle Framework https://github.com/securesystemslab/zippy

graalpython performance measurement – pyperformance

The following three scripts in pyperformance are slightly modified and executed because there are limitations on libraries that can be operated with graalpython

bm_spectral_norm.py

Script to solve "Hundred-Dollar, Hundred-Digit Challenge Problems"

https://pyperformance.readthedocs.io/benchmarks.html#spectral-norm

bm_nqueens.py

Script that solves N-Queen problem with simple solver

https://pyperformance.readthedocs.io/benchmarks.html#nqueens

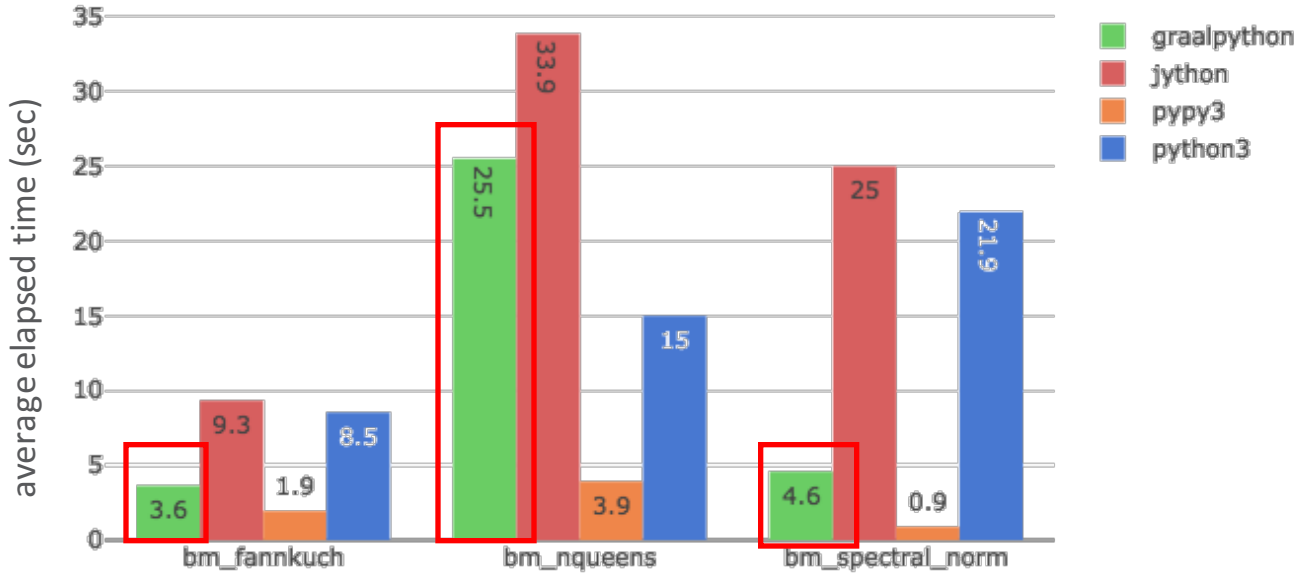
bm_fannkuch.py

Game script for computer language benchmark

https://pyperformance.readthedocs.io/benchmarks.html#fannkuch

Results

pyperformance benchmark tests



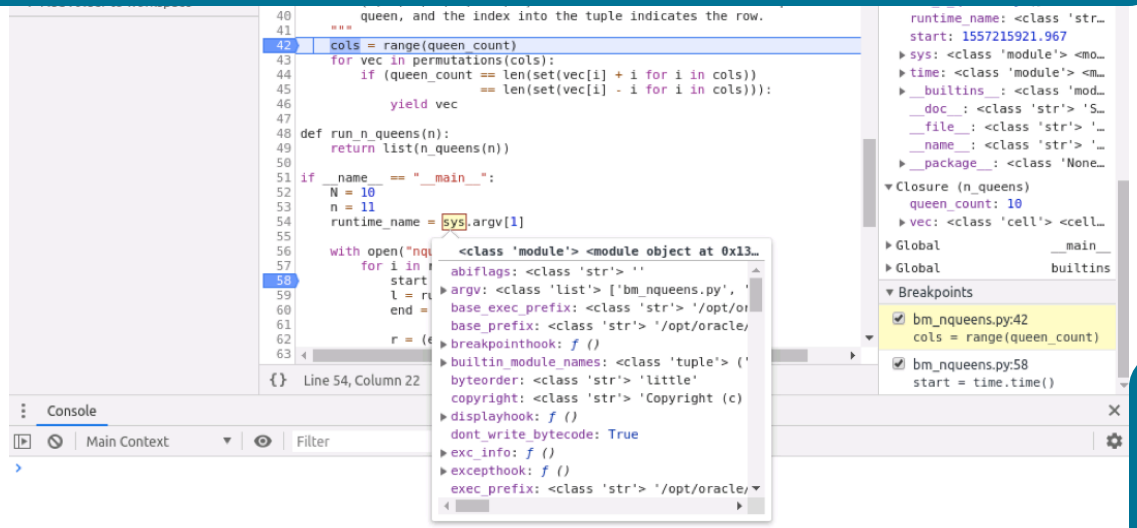
pyperformance tests

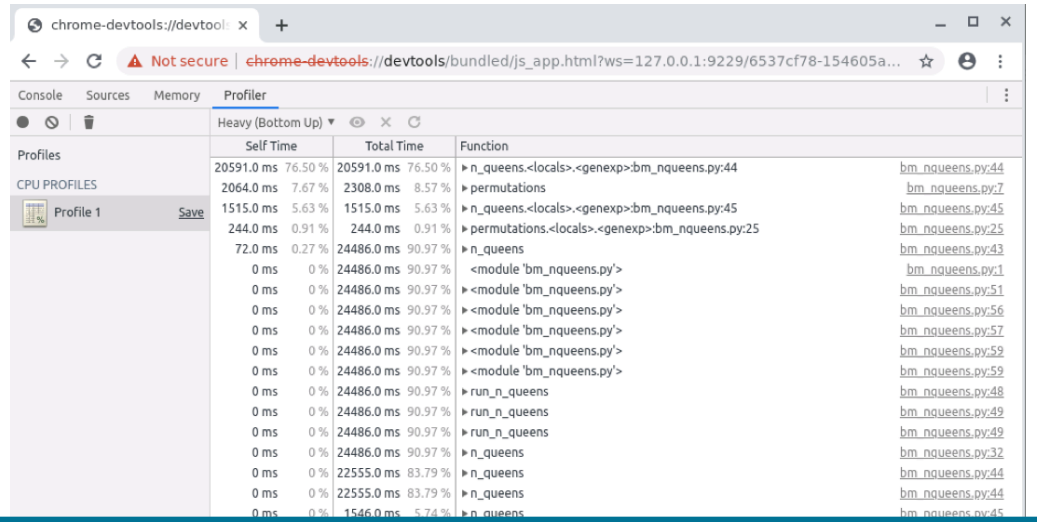
- graalpython outperforms PyPy but gives better performance than Cpython
- ”bm_nqueens.py" uses Generator extensively, and it seems that the execution speed of CPython, which is the standard implementation, is optimized and executed more than graalpython.

[Reference] GraalVM Debugging Tools - chrome-devtools

```
$ graalpython --jvm --inspect <your_python_script_name>.py
Debugger listening on port 9229.
To start debugging, open the following URL in Chrome:
    chrome-devtools://devtools/bundled/js_app.html?ws=127.0.0.1:9229/6537cf78-154605af4255
```

- Settings Break Point
- Executing Python functions on browser console
- Referencing to variables

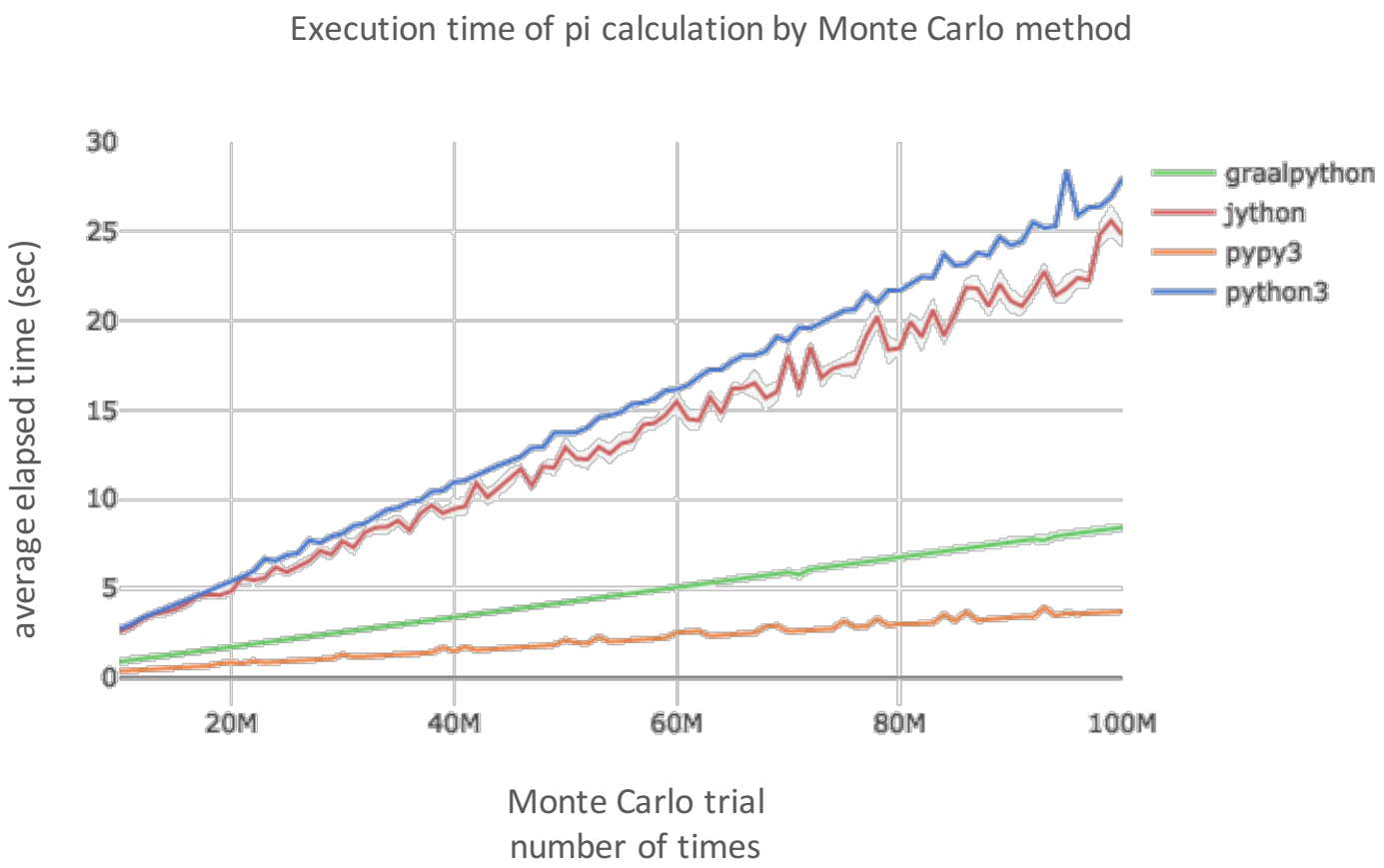




- Profiling Python scripts to see which functions have consumed how much time

graalpython performance measurement-Monte Carlo method 1

Execute script to approximate pi by Monte Carlo method (*)

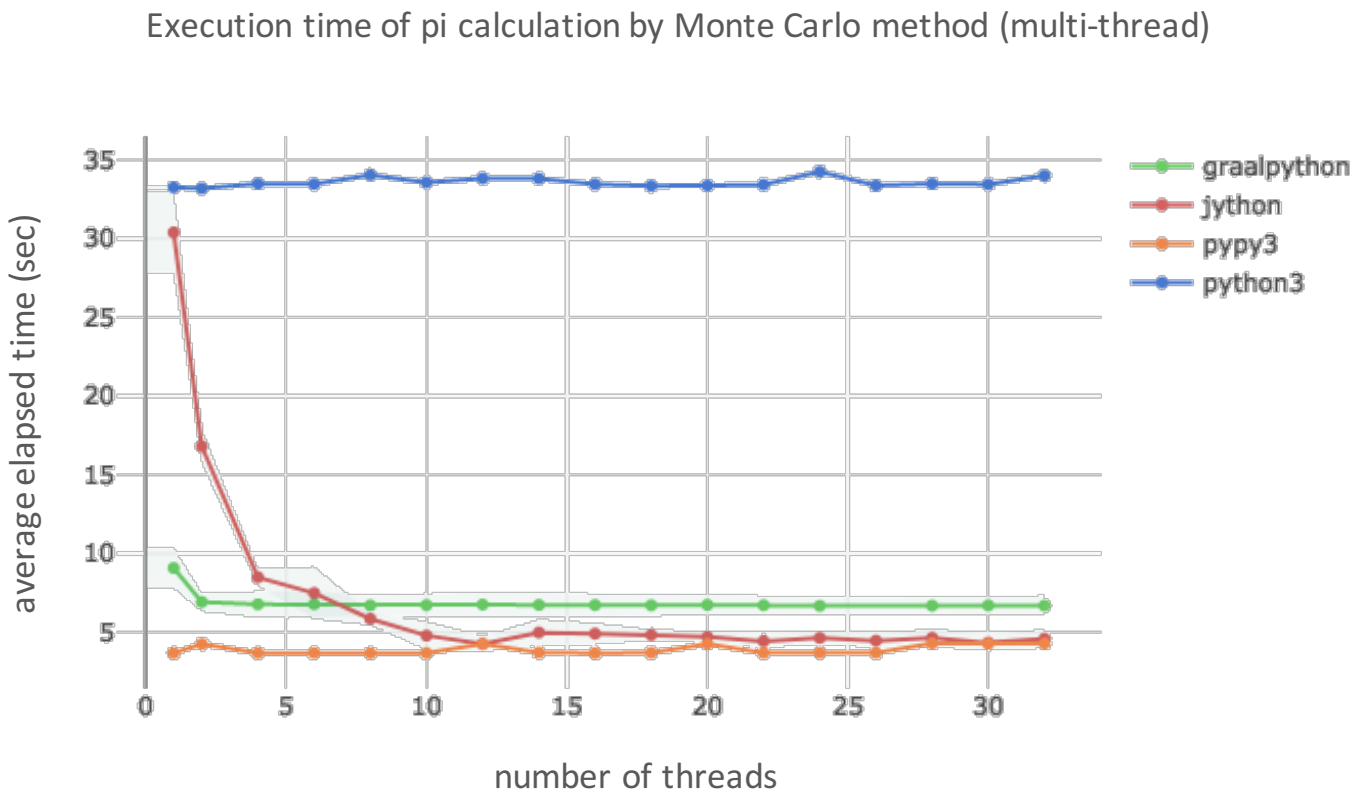


- Even in the Monte Carlo calculation, although it is not comparable to PyPy, the result is higher than CPython and Jython.
- A simple CPU bound process without I / O such as Monte Carlo calculation may be considered as an optimized calculation.

(*) ref. **Monte Carlo method (Wikipedia)**
https://en.wikipedia.org/wiki/Monte_Carlo_method

graalpython performance measurement-Monte Carlo method 2

Execute script that approximates pi by multi-thread (*) by Monte Carlo method

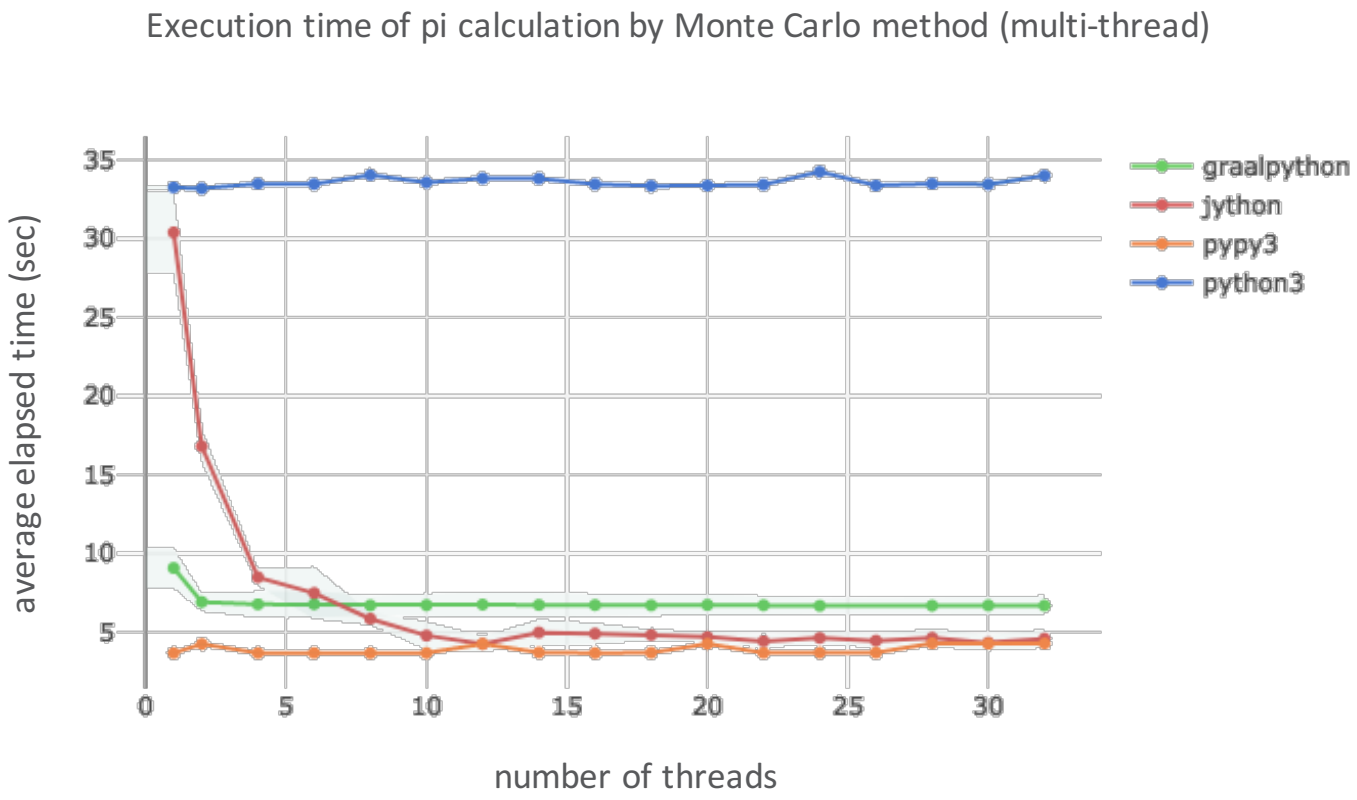


- Graalpython seems to be a processing system with GIL as well as CPython and PyPy, because the processing time hardly changes even if the number of threads is increased.
- On the other hand, Jython that does not have GIL has a shorter processing time as the number of threads increases, and it can be seen that multi-thread execution can be performed with multiple cores.

(*) Implementation using threading's threading.Thread class, which is a Python standard library
https://docs.python.org/3/library/threading.html#threading.Thread

graalpython performance measurement-Monte Carlo method 2

Execute script that approximates pi by multi-thread (*) by Monte Carlo method



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graalpython and GIL (Global Interpreter Lock)

- GIL (Global Interpreter Lock) is a protection mechanism to limit the number of threads that can be executed at one time on the interpreter to one
  - It can simplify low-level processing such as memory management and cooperation of C extension
- Graalpython uses GIL in the C extension part (*),
  and multi-thread processing is executed by one CPU core as CPython

Implementation	With or without GIL
CPython	With GIL
Jython	**Without GIL**
PyPy	With GIL ※ However, Software Transactional Memory (STM) can avoid GIL http://doc.pypy.org/en/latest/stm.html
graalpython	With GIL

(*) Ref: https://github.com/graalvm/graalpython/blob/master/graalpython/com.oracle.graal.python.cext/include/pystate.h#L378-L432

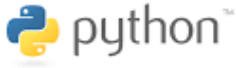
Another attraction of graalpython (Polyglot) 1

- The attraction of graalpython is not only high performance, but also the ability to run Polyglot (multilingual execution) programs easily and without any loss of performance

※ However, as of May 2019 graalpython does not support Scikit-Learn

[Example]
data analysis with R and Python

tidyverse library Modern data shaping used



Machine Learning Model Execution with Scikit-Learn Library

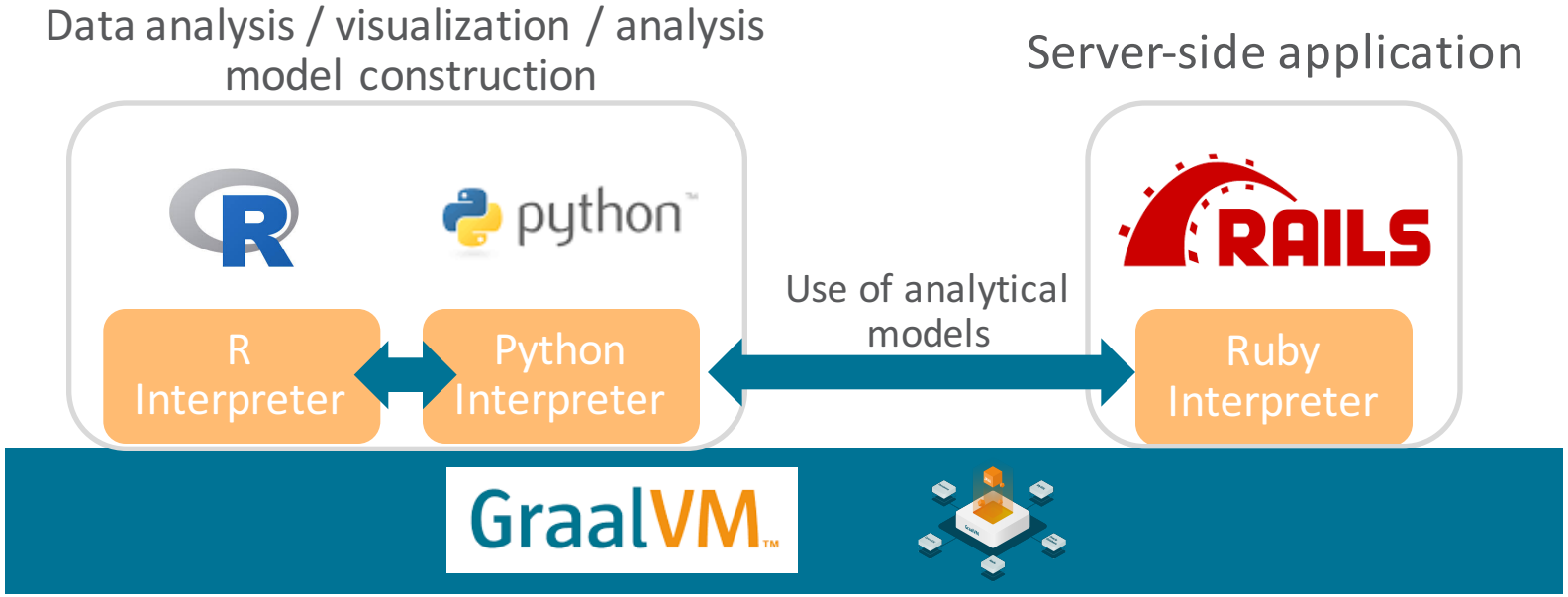
sample_polyglot.py

```
import polyglot
import sklearn

df = polyglot.eval(string="
        library(tidiverse)
        iris %>% dplyr::group_neset(Species) %>% dplyr::summarise_all(mean) …
")
…

clt = sklearn.ensemble.RandomForestClassifier()
clt.fit(df["X"], df["y"]
clf.feature_importances_
```

Another attraction of graalpython (Polyglot) 2

- Furthermore, combining with JavaScript and Ruby makes server-side collaboration easy and reduces the restriction on programming language selection for creating applications

- For example, the following machine learning model embedded application can be configured in the future



Summary

- graalpython is currently an experimental implementation, but performs better than CPython (the standard Python implementation)
- Not only performance but also Polyglot is one of the attractiveness of graalpython
  - In the area of Analytics, which is the main usage scene of Python, it is also possible to analyze combining R and Python, for example
  - It is possible to use different languages according to the characteristics of the program on a single Graal VM

Try graalpython ! GraalVM + python