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Numba: A Python Compiler

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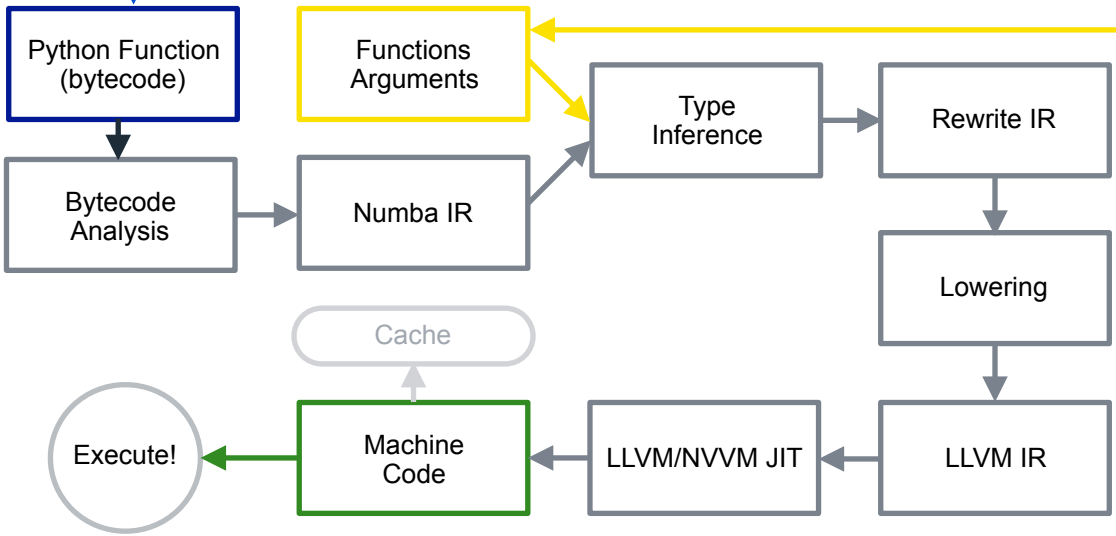
Numba: A JIT Compiler for Python Functions

- An open-source, function-at-a-time compiler library for Python
- Compiler toolbox for different targets and execution models:
  - single-threaded CPU, multi-threaded CPU, GPU
  - regular functions, “universal functions” (array functions), GPU kernels
- Speedup: 2x (compared to basic NumPy code) to 200x (compared to pure Python)
- Combine ease of writing Python with speeds approaching FORTRAN
- Empowers data scientists who make tools for *themselves and other data scientists*

How does Numba work?

```
@jit
def do_math(a, b):
    …
>>> do_math(x, y)
```



Supported Platforms and Hardware

OS	HW	SW
Windows (7 and later)	32 and 64-bit x86 CPUs	Python 2 and 3
OS X (10.9 and later)	CUDA & HSA Capable GPUs	NumPy 1.7 through 1.11
Linux (RHEL 5 and later)	Experimental support for ARM, Xeon Phi, AMD Fiji GPUs	

Tutorial Acknowledgements

- These Numba tutorial materials are adapted from the Numba Tutorial at SciPy 2016 by Gil Forsyth and Lorena Barba
- I've made some adjustments and additions, and also had to skip quite a bit of material for time.
- Check out https://github.com/barbagroup/numba_tutorial_scipy2016 for more details.

Notebook 1: Numba Basics

Notebook 2: How Numba Works

Ex01: Intro to JIT

That's it?

- Mostly, yes.
- The Secret of Numba is:
  - *If it doesn't need to be fast, leave it alone. (See the profiler section of this tutorial.)*
  - *Stick to the well-worn path: Numba works best on loop-heavy numerical algorithms.*
  - *Choose the right data structures: Numba works best on NumPy arrays and scalars.*

Ex02: Direct Summation

There is more, though.

- Numba can compile other kinds of functions:
  - Universal function (ufuncs) apply a scalar function to elements of the input arrays according to the broadcast rules:

```
numpy.add([1, 2, 3], 1) == [2, 3, 4]

numpy.add([1, 2, 3], [10, 20, 30]) == [11, 12, 13]
```

Notebook 3: Ufuncs

More Advanced Topics

- Generalized ufuncs:
  - Instead of broadcasting all dimensions into a scalar function, you can control how input dimensions are broadcast.
  - Example: Writing a norm() function
  - http://numba.pydata.org/numba-doc/0.29.0/user/vectorize.html#the-guvectorize-decorator
- Calling external code:
  - Numba can call C code that has been wrapped with ctypes or CFFI
  - http://numba.pydata.org/numba-doc/0.29.0/reference/pysupported.html#ctypes
  - http://numba.pydata.org/numba-doc/0.29.0/reference/pysupported.html#cffi
- Ahead of time compilation:
  - http://numba.pydata.org/numba-doc/dev/user/pycc.html