julia

The programming language for scientists

Carsten Bauer @ University of Cologne, October 2019

thp Institute for Theoretical Physics University of Cologne

bcgs Bonn-Cologne Graduate School of Physics and Astronomy

What does science need from a programming language?

Easy to write and read !

Fast and scalable !

Interactive !

There's a plethora of programming languages

MATLAB

Java

GO

Fortran

There’s a plethora of programming languages

Fortran

Java

GO

MATLAB

There's a plethora of programming languages

Java

Fortran

Fast

Slow(ish)

MATLAB

There's a plethora of programming languages

C++

Java

Fortran

GO

R

Compiled

Interpreted

R

MATLAB

There’s a plethora of programming languages

Java

Fortran

GO

Static

Dynamic

MATLAB

There’s a plethora of programming languages

C++

Java

Fortran

GO

R

Speed

Convenience

MATLAB

R

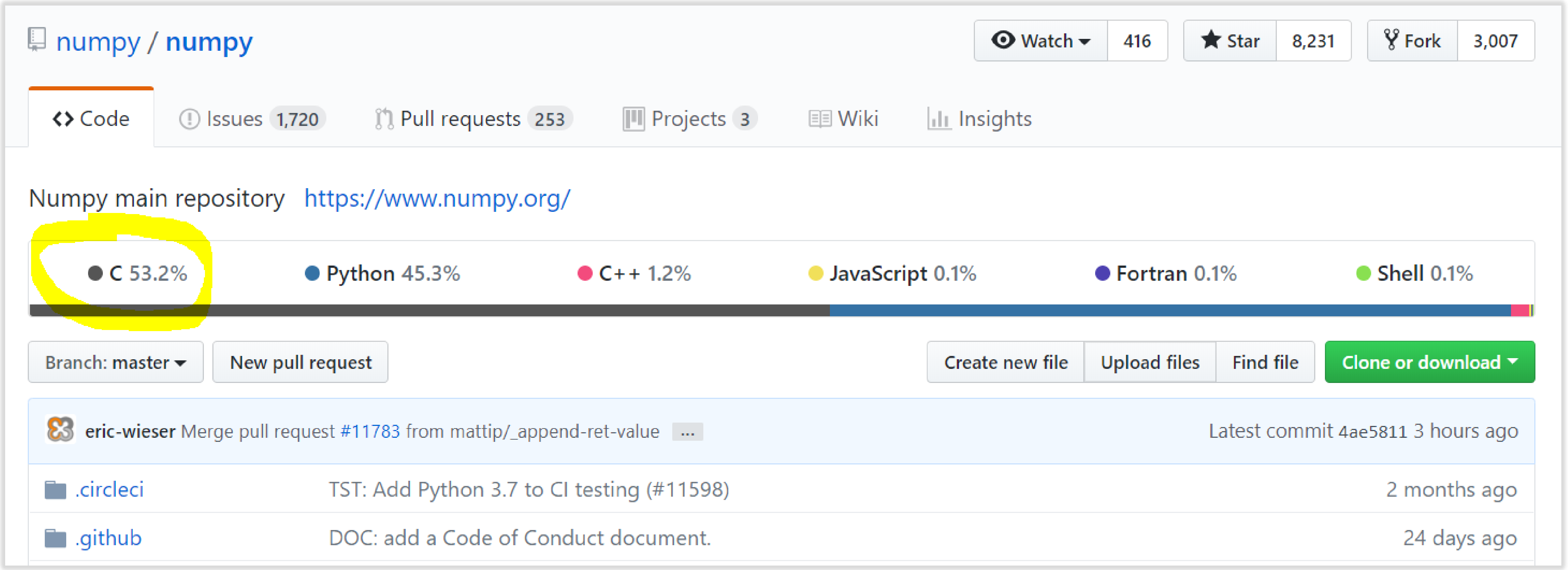
The “two language problem”

a.k.a Ousterhout's dichotomy

Prototype

Production

The "two language problem"



numpy / numpy

Watch 416 | Star 8,231 | Fork 3,007

Code | Issues 1,720 | Pull requests 253 | Projects 3 | Wiki | Insights

Numpy main repository https://www.numpy.org/

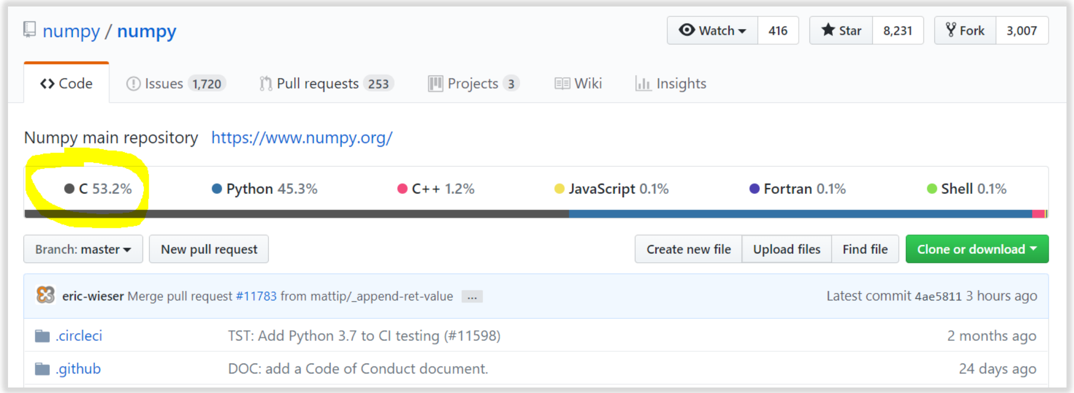
● C 53.2% ● Python 45.3% ● C++ 1.2% ● JavaScript 0.1% ● Fortran 0.1% ● Shell 0.1%

Branch: master | New pull request | Create new file | Upload files | Find file | Clone or download

eric-wieser Merge pull request #11783 from mattip/_append-ret-value ... Latest commit 4ae5811 3 hours ago

.circleci	TST: Add Python 3.7 to CI testing (#11598)	2 months ago
.github	DOC: add a Code of Conduct document.	24 days ago

The "two language problem"



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User

Developer

The “two language problem”

static	dynamic
compiled	interpreted
user types	standard types
standalone	glue

julia

dynamic

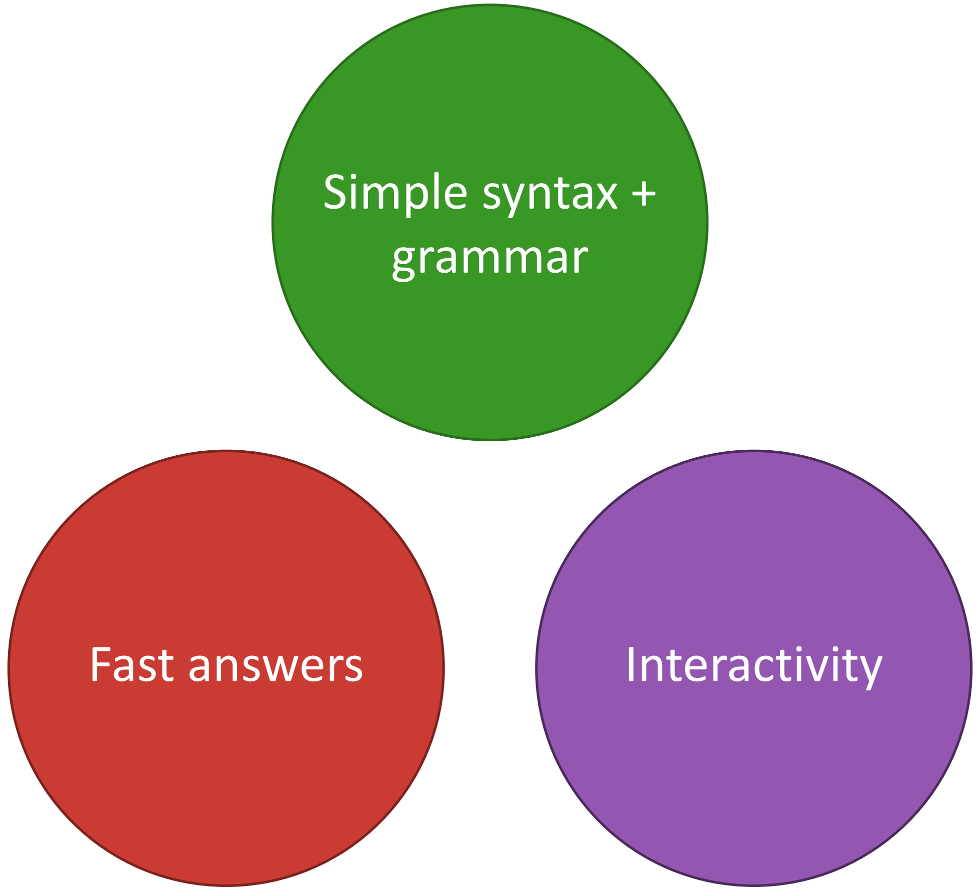
compiled

user types **and** standard types

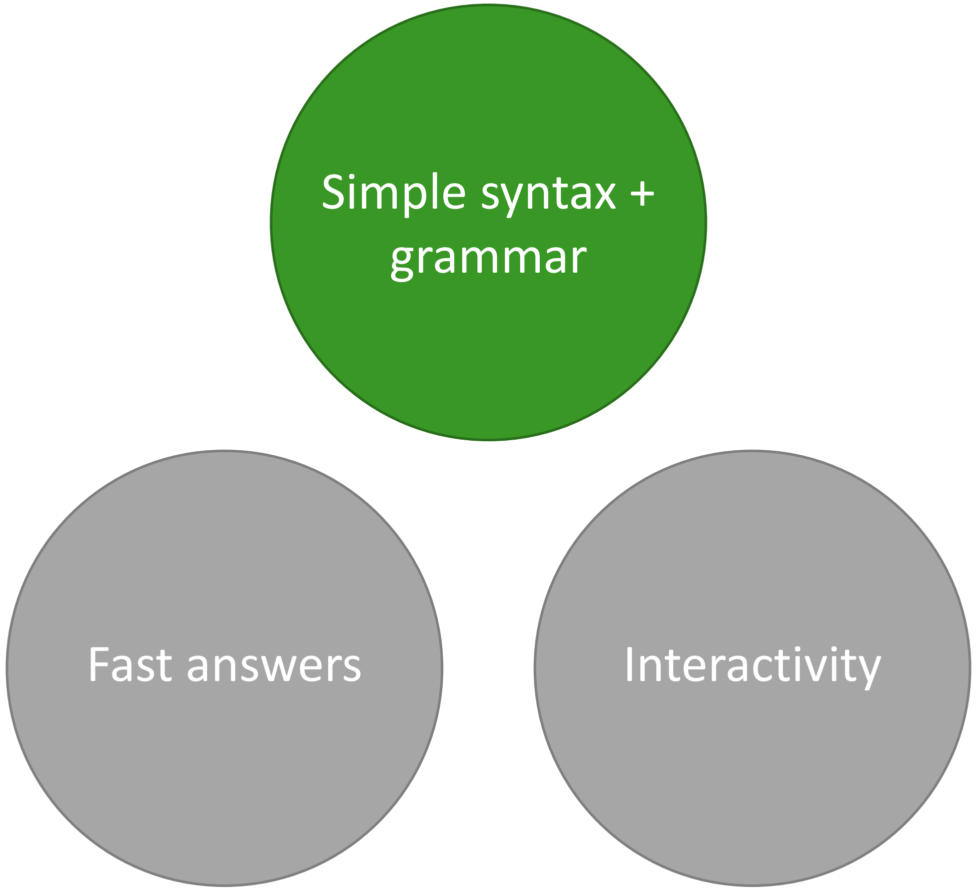
standalone **or** glue

“Feels like Python, runs like C”

The julia unification

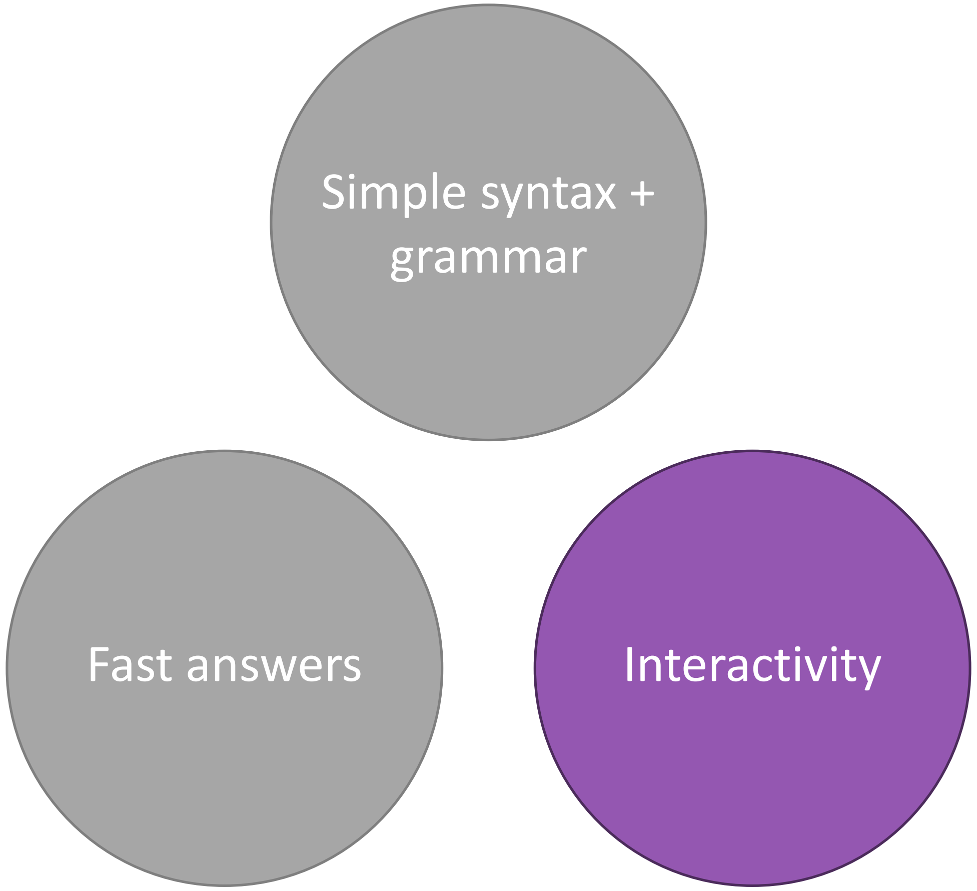


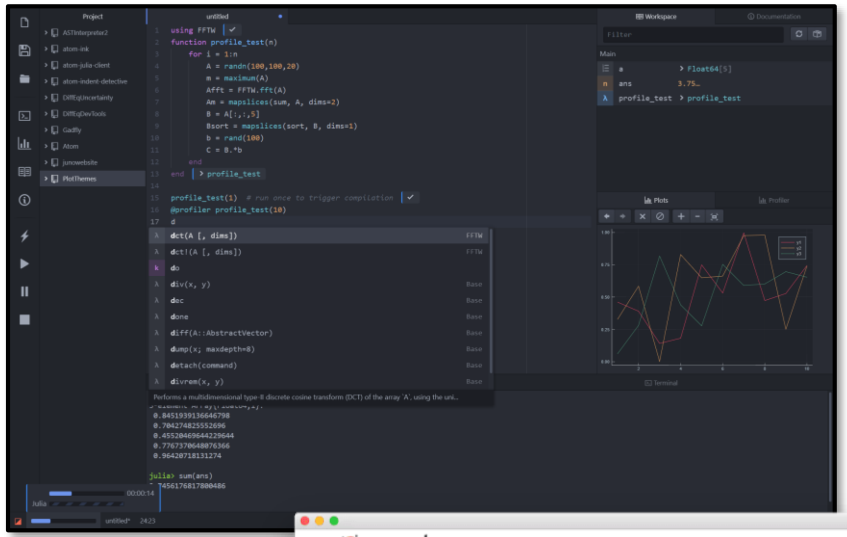
The julia unification



```
function babylonian(α; N = 10)
    @assert α > 0 "α must be > 0"
    t = (1+α)/2
    for i = 2:N
        t = (t + α/t)/2
    end
    t
end

babylonian(π) ≈ √π
```

The julia unification



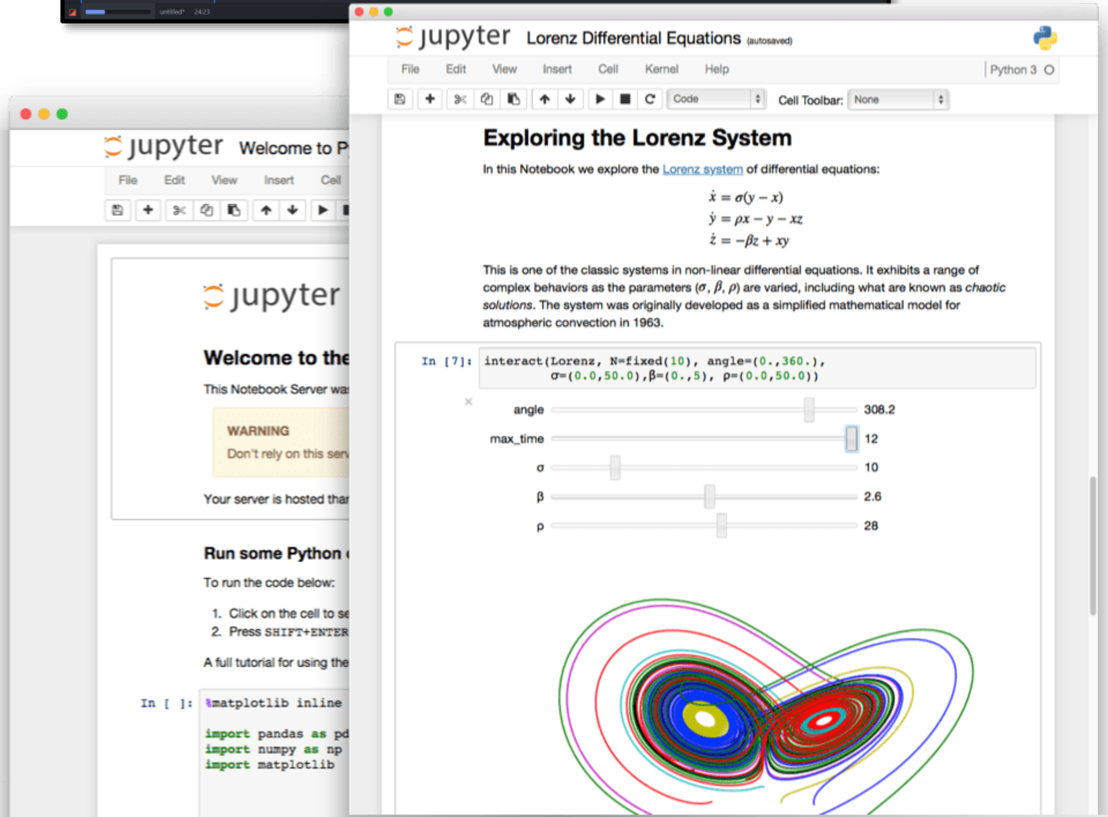


```
using FFTW
function profile_test(n)
    for i = 1:n
        A = randn(100,100,20)
        m = maximum(A)
        Afft = FFTW.fft(A)
        Am = mapslices(sum, A, dims=2)
        B = A[:,:,5]
        Bsort = mapslices(sort, B, dims=1)
        b = rand(100)
        C = B.*b
    end
end

profile_test(1)  # run once to trigger compilation
@profiler profile_test(10)
d
```

```
dct(A [, dims])            FFTW
dct!(A [, dims])           FFTW
do
div(x, y)                  Base
dec                        Base
done                       Base
diff(A::AbstractVector)    Base
dump(x; maxdepth=8)        Base
detach(command)            Base
divrem(x, y)               Base
```

Performs a multidimensional type-II discrete cosine transform (DCT) of the array `A`, using the uni...

```
 0.8451939136646798
 0.704274825552696
 0.4552046964422964
 0.7767370648076366
 0.9642071813274

julia> sum(ans)
3.7456176817800486
```



jupyter Welcome to P

jupyter

Welcome to the

This Notebook Server wa

WARNING

Don't rely on this serv

Your server is hosted tha

Run some Python

To run the code below:

1. Click on the cell to se
2. Press SHIFT+ENTER

A full tutorial for using the

```
In [ ]: %matplotlib inline

        import pandas as pd
        import numpy as np
        import matplotlib
```

jupyter Lorenz Differential Equations (autosaved)

Exploring the Lorenz System

In this Notebook we explore the Lorenz system of differential equations:

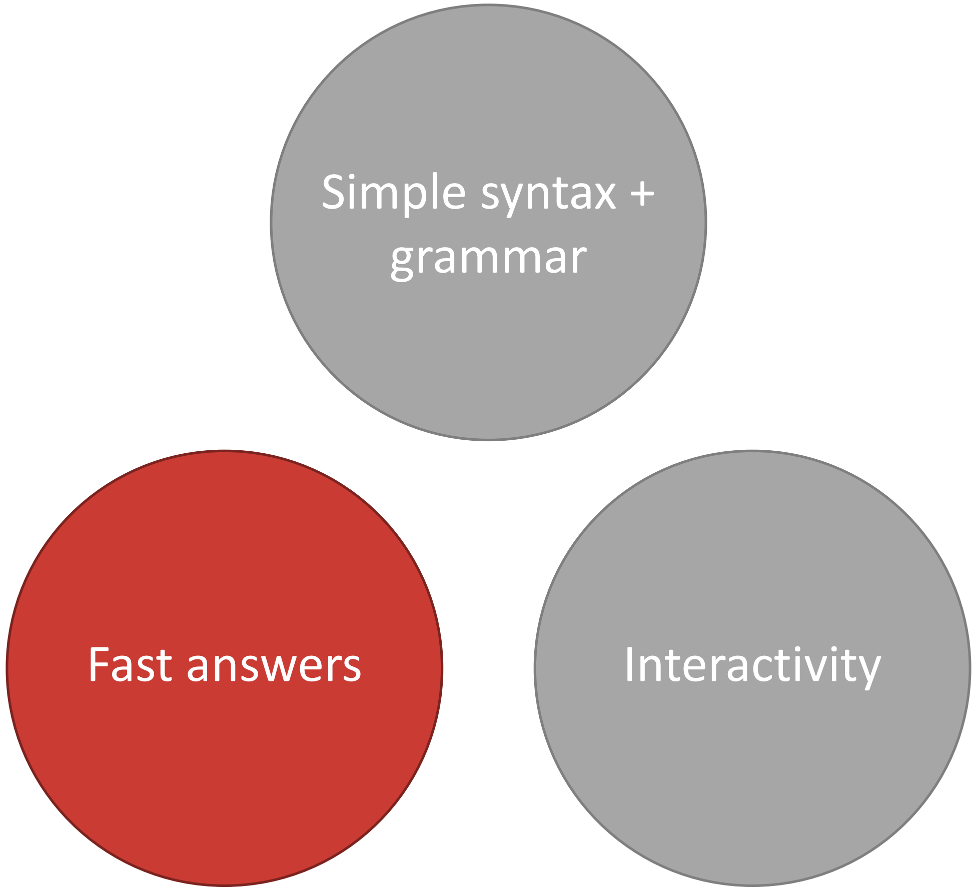
$$\dot{x} = \sigma(y - x)$$
$$\dot{y} = \rho x - y - xz$$
$$\dot{z} = -\beta z + xy$$

This is one of the classic systems in non-linear differential equations. It exhibits a range of complex behaviors as the parameters (σ, β, ρ) are varied, including what are known as *chaotic solutions*. The system was originally developed as a simplified mathematical model for atmospheric convection in 1963.

```
In [7]: interact(Lorenz, N=fixed(10), angle=(0.,360.),
                 σ=(0.0,50.0),β=(0.,5), ρ=(0.0,50.0))
```

angle	308.2
max_time	12
σ	10
β	2.6
ρ	28

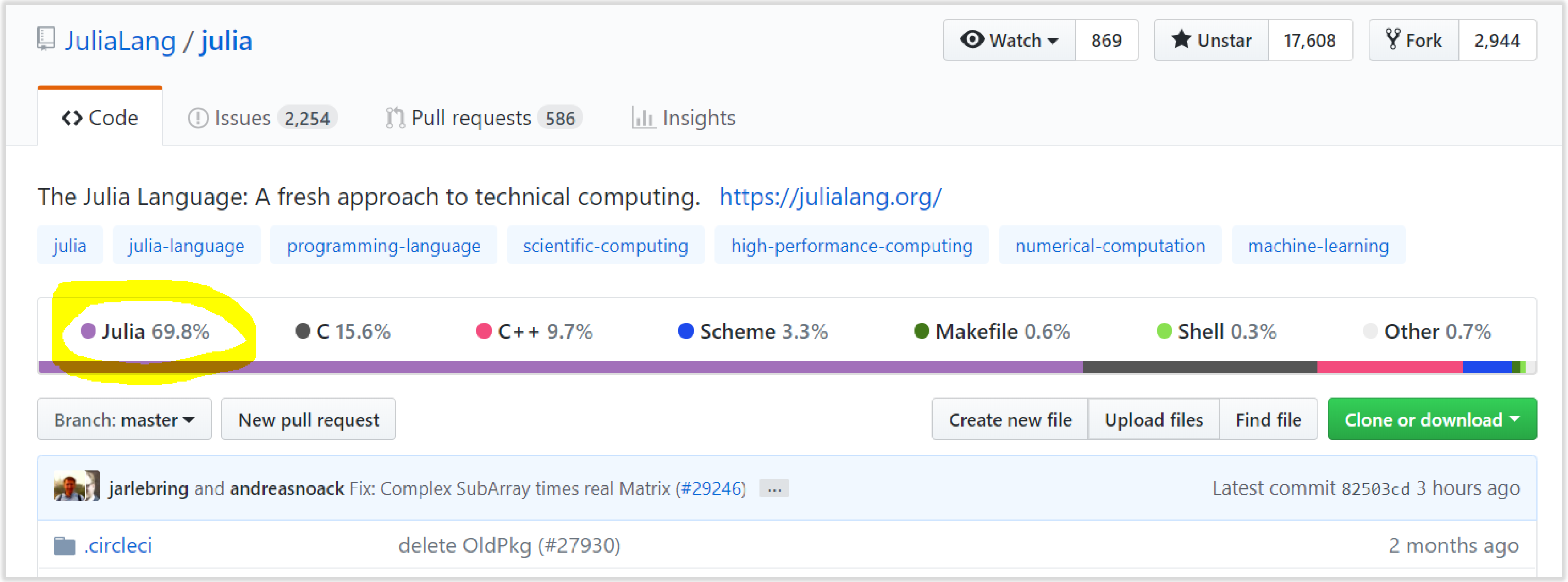
The julia unification



```
julia> function sumup()
           x = 0
           for i in 1:100
               x += i
           end
           x
       end
sumup (generic function with 2 methods)

julia> @code_llvm debuginfo=:none sumup()

; Function Attrs: uwtable
define i64 @julia_sumup_12626() #0 {
top:
  ret i64 5050
}
```

Just returns the answer!
(The for loop was compiled away)

It is free and open source



JuliaLang / julia

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Code | Issues 2,254 | Pull requests 586 | Insights

The Julia Language: A fresh approach to technical computing. https://julialang.org/

julia | julia-language | programming-language | scientific-computing | high-performance-computing | numerical-computation | machine-learning

● Julia 69.8% ● C 15.6% ● C++ 9.7% ● Scheme 3.3% ● Makefile 0.6% ● Shell 0.3% ● Other 0.7%

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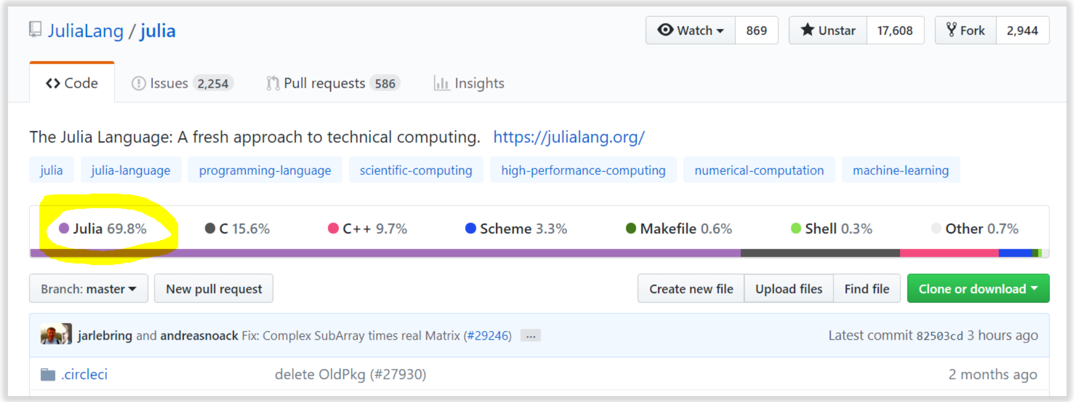
jarlebring and andreasnoack Fix: Complex SubArray times real Matrix (#29246) … Latest commit 82503cd 3 hours ago

.circleci delete OldPkg (#27930) 2 months ago

It is inviting



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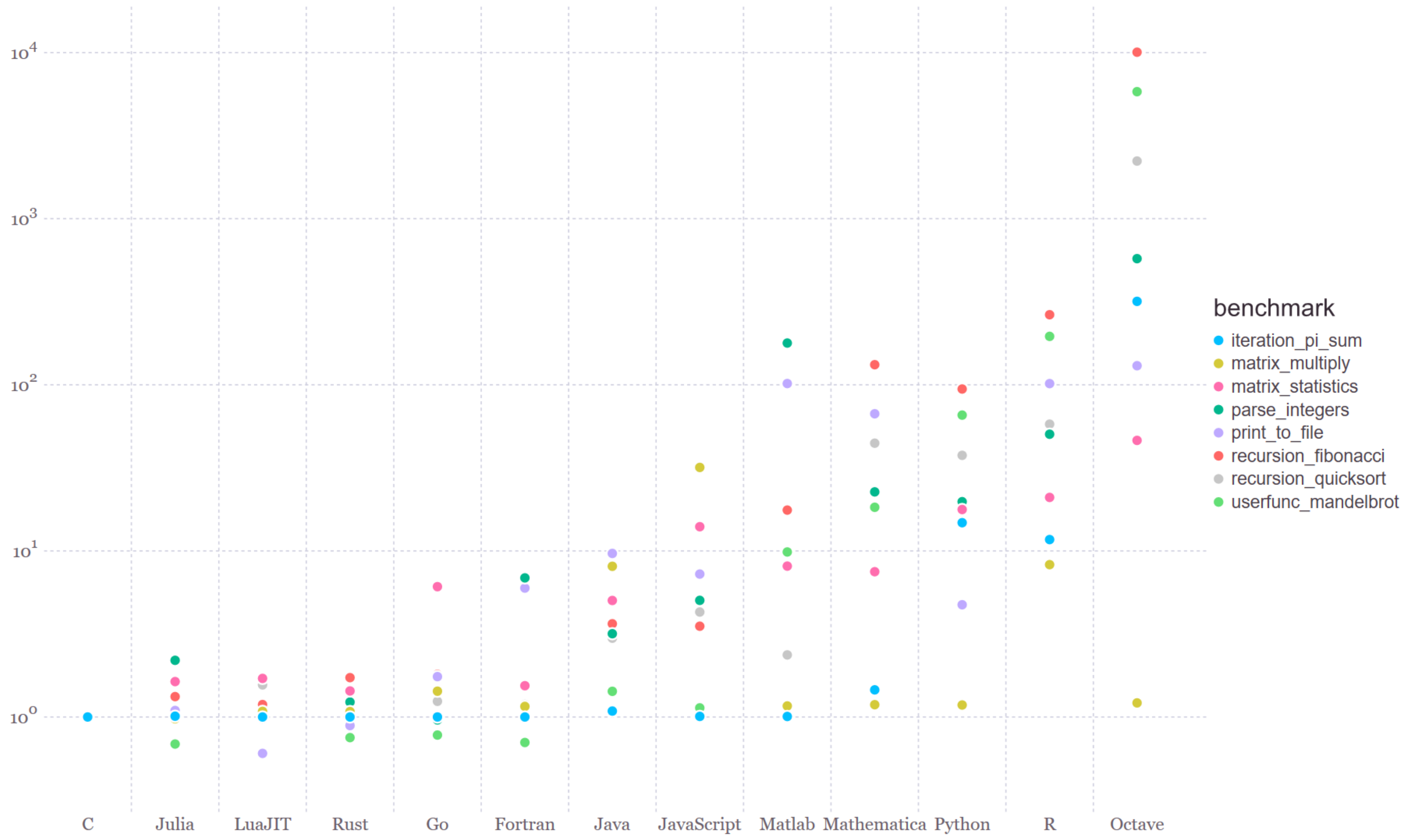
User

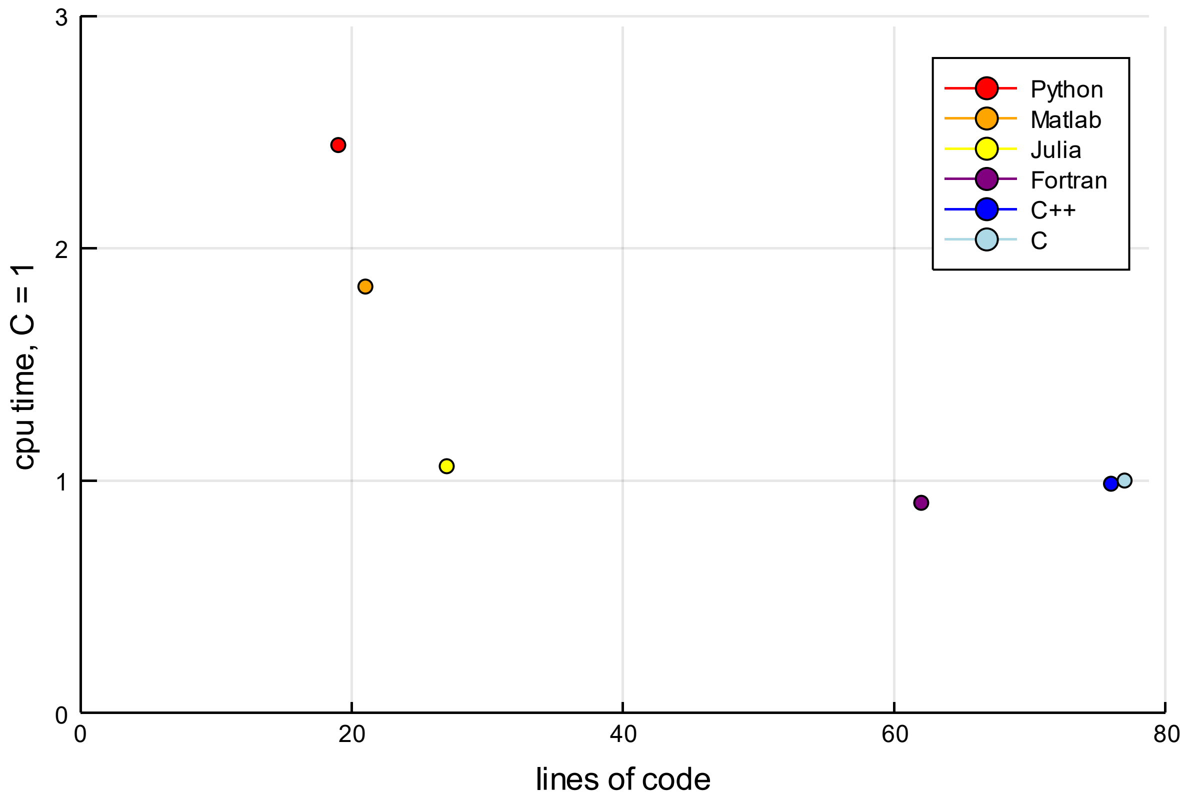
Developer

It is fast



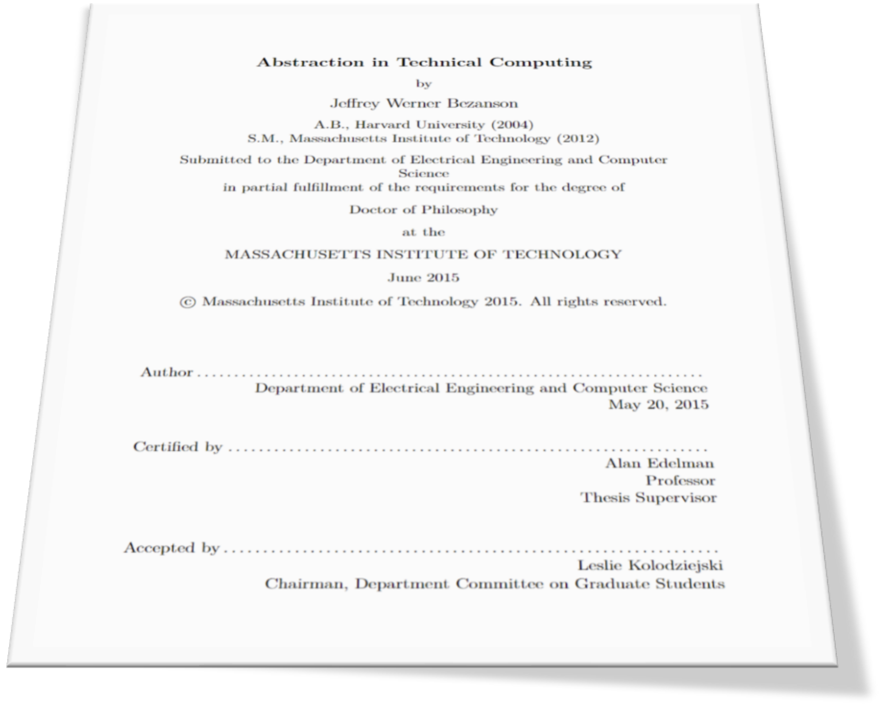
10^4
10^3
10^2
10^1
10^0
C
Julia
LuaJIT
Rust
Go
Fortran
Java
JavaScript
Matlab
Mathematica
Python
R
Octave
benchmark
iteration_pi_sum
matrix_multiply
matrix_statistics
parse_integers
print_to_file
recursion_fibonacci
recursion_quicksort
userfunc_mandelbrot

It is expressive



How old is Julia?

- 2009 Jeff, Stefan, Viral, and Alan start working on Julia
- 2012 Blog post: [Why we created Julia]()
- 2015 Jeff's PhD & JuliaComputing
- 2018 Julia 1.0



Abstraction in Technical Computing
by
Jeffrey Werner Bezanson
A.B., Harvard University (2004)
S.M., Massachusetts Institute of Technology (2012)
Submitted to the Department of Electrical Engineering and Computer Science
in partial fulfillment of the requirements for the degree of
Doctor of Philosophy
at the
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
June 2015
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Author ....
Department of Electrical Engineering and Computer Science
May 20, 2015

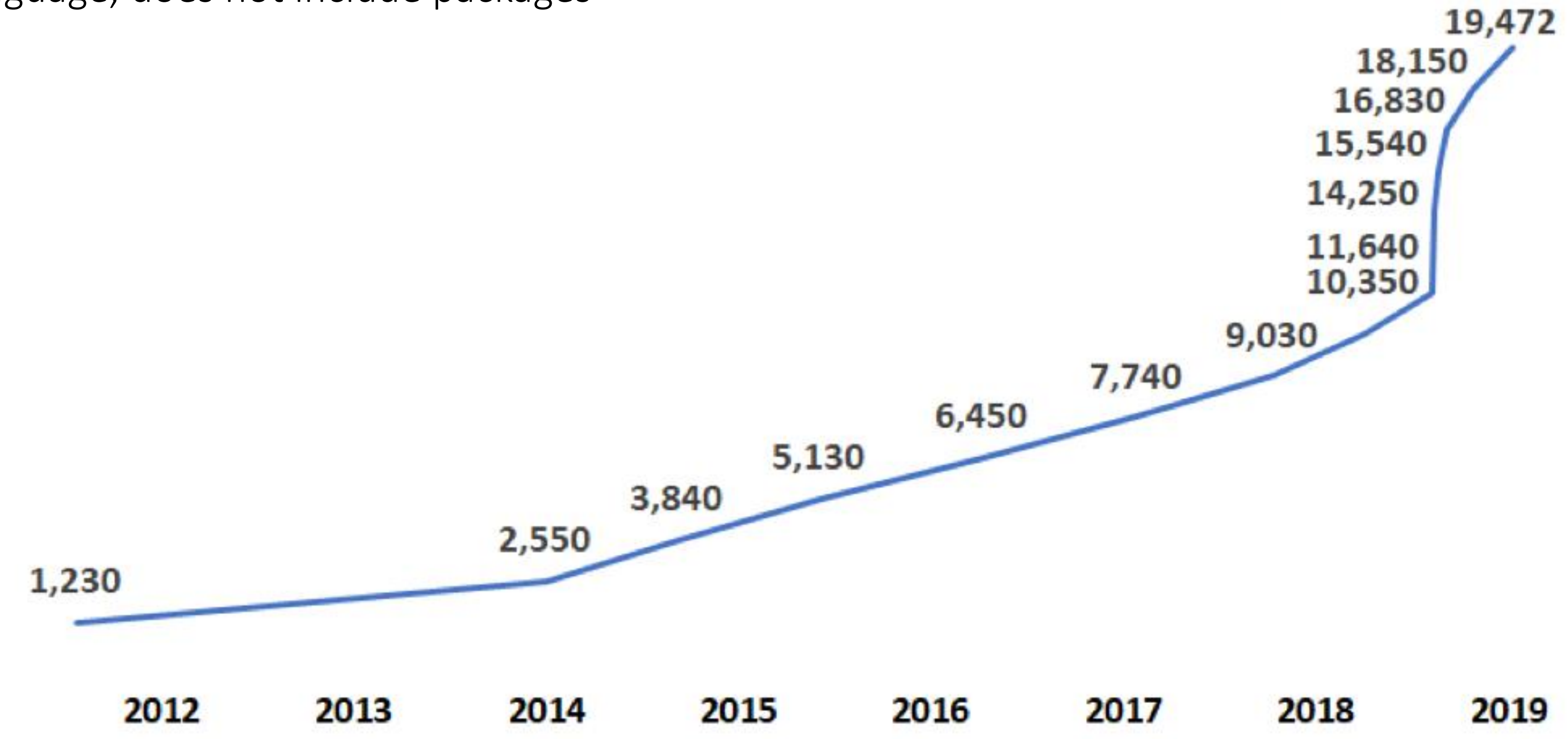
Certified by ....
Alan Edelman
Professor
Thesis Supervisor

Accepted by ....
Leslie Kolodziejski
Chairman, Department Committee on Graduate Students

Founders talk @ JuliaCon 2018: https://www.youtube.com/watch?v=1jN5wKvN-Uk

Julia GitHub stars

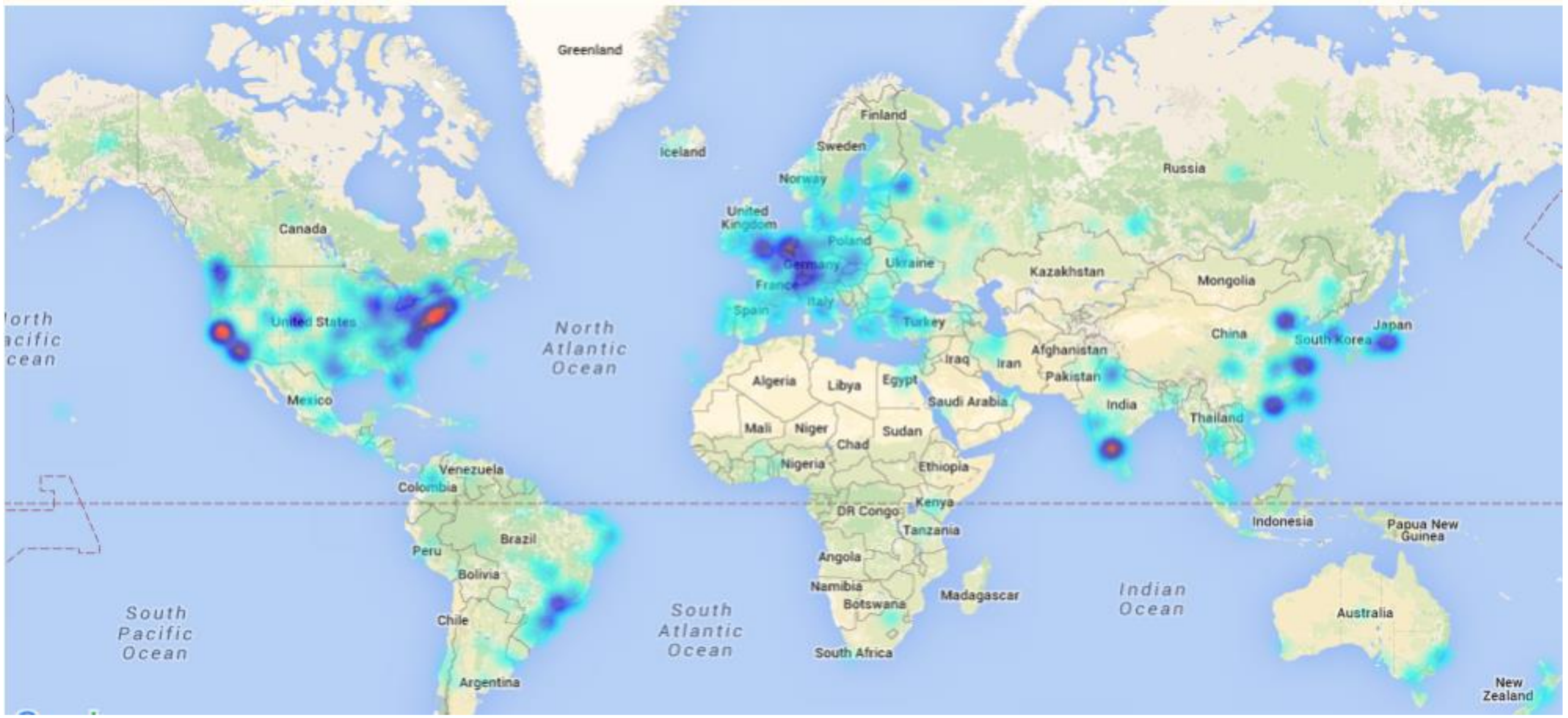
* Base language, does not include packages



https://juliacomputing.com/blog/2019/01/04/january-newsletter.html

A global community

More than 3 Million downloads, 2500 packages



James H. Wilkinson Prize For Numerical Software	Forbes 30 under 30	IEEE Babbage Prize IEEE Fellow
Stefan Karpinski Viral B. Shah Jeff Bezanson	Keno Fischer	Prof. Alan Edelman
(2019)	(2019)	(2018)

BROWN UNIVERSITY

CORNELL UNIVERSITY FOUNDED A.D. 1865

EMORY UNIVERSITY

NORTHEASTERN UNIVERSITY LVX VERITAS VIRTVS FOUNDED A.D. 1898 BOSTON, MASSACHUSETTS

PSU PENN STATE UNIVERSITY

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Stanford University

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VIA VERITAS VITA UNIVERSITY of GLASGOW

UNIVERSITY of SOUTH FLORIDA TRUTH WISDOM 1956

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UNIVERSITY OF CONNECTICUT 1881

Universitas leodiensis

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1878 Western UNIVERSITY · CANADA

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Data Science

Image Processing

flux

Deep Learning

JUMP

Mathematical Optimization

Signal Processing

Computational Biology

Recommended talks

Nick Eubank: What Julia Offers Academic Researchers

George Datseris: Why Julia is the most suitable language for science