The Julia language: easy, generic, fast — but no free lunch

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September 2022

Greeting

Welcome to this series of four seminars

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4. Solving the two-language problem and the expression problem: Julia for HPC?

Outline

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- an early(-ish) paper: Bezanson *et al.*, arXiv 19 July 2015
- and a recent podcast: `https://www.youtube.com/watch?v=W6I1zQ16_44`

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The introductory paragraphs of the launching blog post makes the motivation pretty clear!

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"A fundamental change is occurring in the way people write computer programs, away from system programming languages such as C or C++ to scripting languages such as Perl or Tcl. . . . scripting languages will handle many of the programming tasks in the next century better than system programming languages. System programming languages were designed for building data structures and algorithms from scratch, starting from the most primitive computer elements. Scripting languages are designed for gluing. They assume the existence of a set of powerful components and are intended primarily for connecting components."

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This percentage is even higher in some of the big projects that use Julia—eg `DifferentialEquations.jl`, the topic on 21 September, is 100% Julia.

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For me personally, I came for the speed, and stayed also for the speed and have not had any real disappointments.

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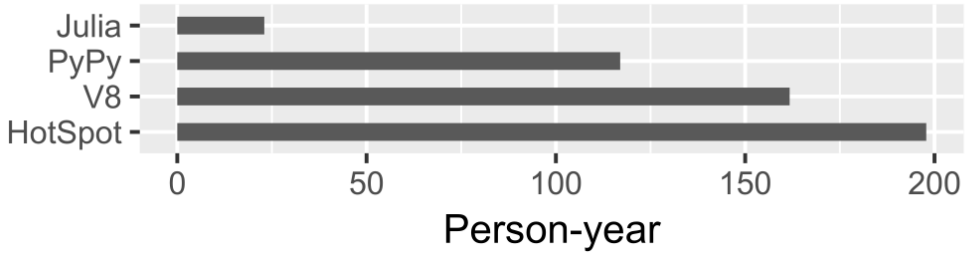
Notable projects: Celeste, CliMA (for more, see Julia Computing's home page, though it is rather biased).

Rapid development



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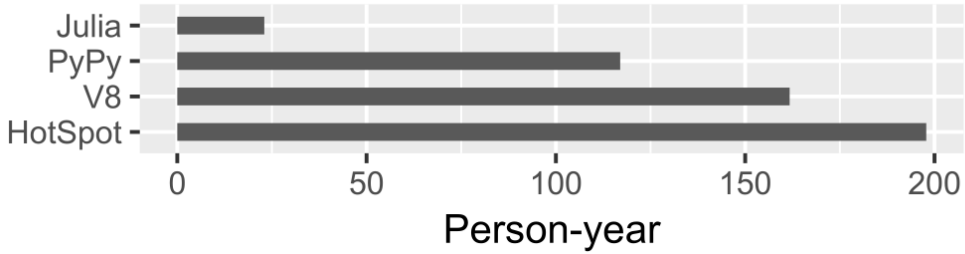

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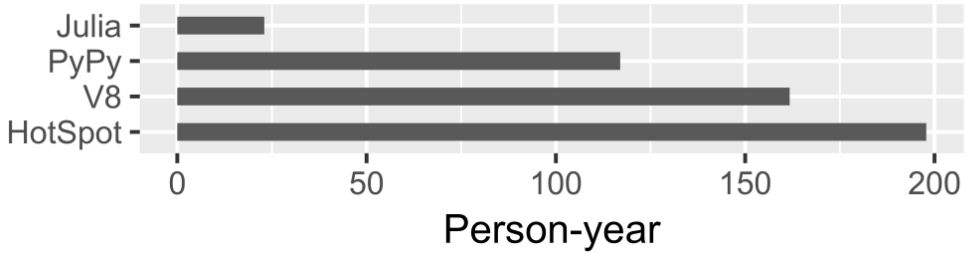

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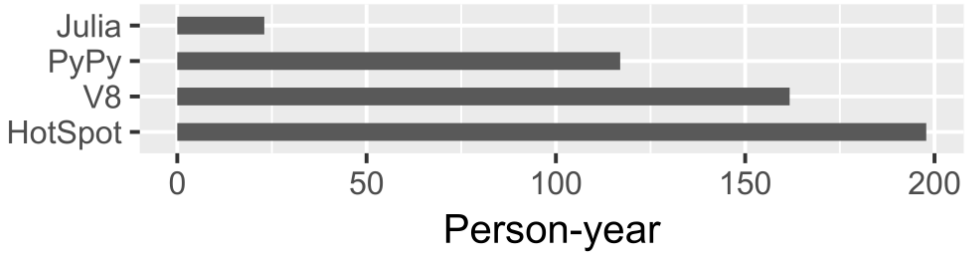

"... shows the person-years invested in several language implementations. These rough measures were obtained using commit histories: two commits made by the same developer in one week were counted as one person-week of effort."

`DifferentialEquations.jl` (21 Sep talk) also shows remarkable output for low investment of programming effort.

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My view is that the ease of coding and code reading in Julia goes far beyond these lessons: it comes from multiple dispatch (on which more later).

Overview

Straightforward, elegant, interactive, performant, adaptable, composable, extendible

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Has three further modes: help, shell and Pkg.

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Let's try the following out in the REPL

$\alpha^2(x) = x^2; \alpha^3(x) = x^3$

$\alpha = 22$
$\sqrt{\alpha^3(\alpha)} == 22^{3/2}$ `# type-insensitive equality comparison`

🐈 = 5

2🐈

Example of user-extension: `OhMyREPL`

`https://kristofferc.github.io/OhMyREPL.jl/latest/`

Let's try it out

Code introspection!

Some like to say it like this: Julia is homoiconic

Well illustrated by the macro `@code_llvm`.

Multiple dispatch

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from OOP point of view, this prefers composition to inheritance (and seems to be superior; I'll return to this on 28 Sep),

user-defined types for purpose of calling user-defined code bodies is absolutely the standard paradigm in Julia packages.

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To make `Plots` work with dimensional values requires an extension: `UnitfulRecipes.jl`, which defines several new functions and three new types. Then the three-way composition also works!

The virtues of Julia package management

It is well integrated with the interactive environments.

It is supported by a worldwide network of servers.

It enables project management via git (fully integrated).

It can guarantee fully reproducible environments.

A few other interactive environments

IJulia (Jupyter notebooks).

Pluto (reactive, not merely interactive).

The VS Code (Codium) extension for Julia.

Brief demo of IJulia and Pluto

Julia's people

Very approachable, very responsive and friendly community (warmer and more respectful than most in my experience!)

But the communication is somewhat inhouse: more Julia Discourse, Zulip and Github than Stackexchange and Reddit.

As noted, the package system is superb (even offers to install missing packages, and does so with no fuss at all if asked).

The two major public faces are the Julia Language group (`https://julialang.org`) and the Julia Computing company (`https://juliacomputing.com`).

Compilation costs

Have to be paid!

But most of time they are not onerous. Load times used to be long but despite Julia's growth they are markedly lower now.

However, recompilations can be a pain: the TTFP and related phenomena. This situation is likewise improving (but will never entirely disappear).

When high performance stays away ...

Does happen . . . sigh . . .

But AFAIK has always yielded to concerted effort—that is, Julia does not seem to have any areas of necessarily low performance.

Error messages (oh dear)

Can be opaque, even very opaque, eg. they might reference `Union` types that take up dozens of lines.

Also, they are almost entirely stack traces. Very useful if you know how to read them, very daunting at first.

Very large runtime

This makes distributing small free-standing programs, apps difficult.

That said, static compilation and other developments will soon make this far less of a problem.

Julia's tooling a tad skimpy

The interactive offerings work well, as we saw.

Profiling, debugging, editing: it's there, it works but not as well as for, say, Python and C++.

As to autogenerated code . . . I don't know (but does it matter?).

Integration with git is excellent, therefore so is project management, thanks to `Pkg`.

Large projects

Definitely possible (Celeste in pre-v1 days, CliMA now, DifferentialEquations.jl pre- and post-v1)

. . . but I've seen discussions that this is largely up to the group concerned, its policies and leadership, and less because Julia has good ways of ensuring effective collaboration.

Closing remarks

So this is Julia: easy, generic and fast.
But certainly no free lunch!

Looking forward to the next three presentations:

14 Sep goes into the technical aspects of Julia
21 Sep presents DifferentialEquations.jl,
the best-in-class general-purpose package for DEs
28 Sep returns to the expression and two-language problems,
and in that light discusses Julia for HPC

THANKS!