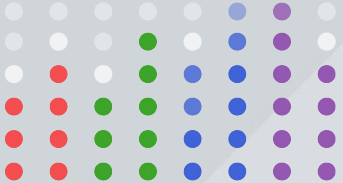

A brief history of Cxx.jl

Julia computing

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What is it?

- Interop package to combine C++/Julia in the same program
- One of two ways to combine Julia & C++
- One of the oldest Julia packages (> 8 years old originally targeted Julia 0.1)
- A C++ REPL environment
- A great proof of concept, that never got fully realized
- Disclaimer: Though I wrote most of the code, I haven't been maintaining it for > 3 years and haven't added new feature for > 6 years.

Features - Basic Usage

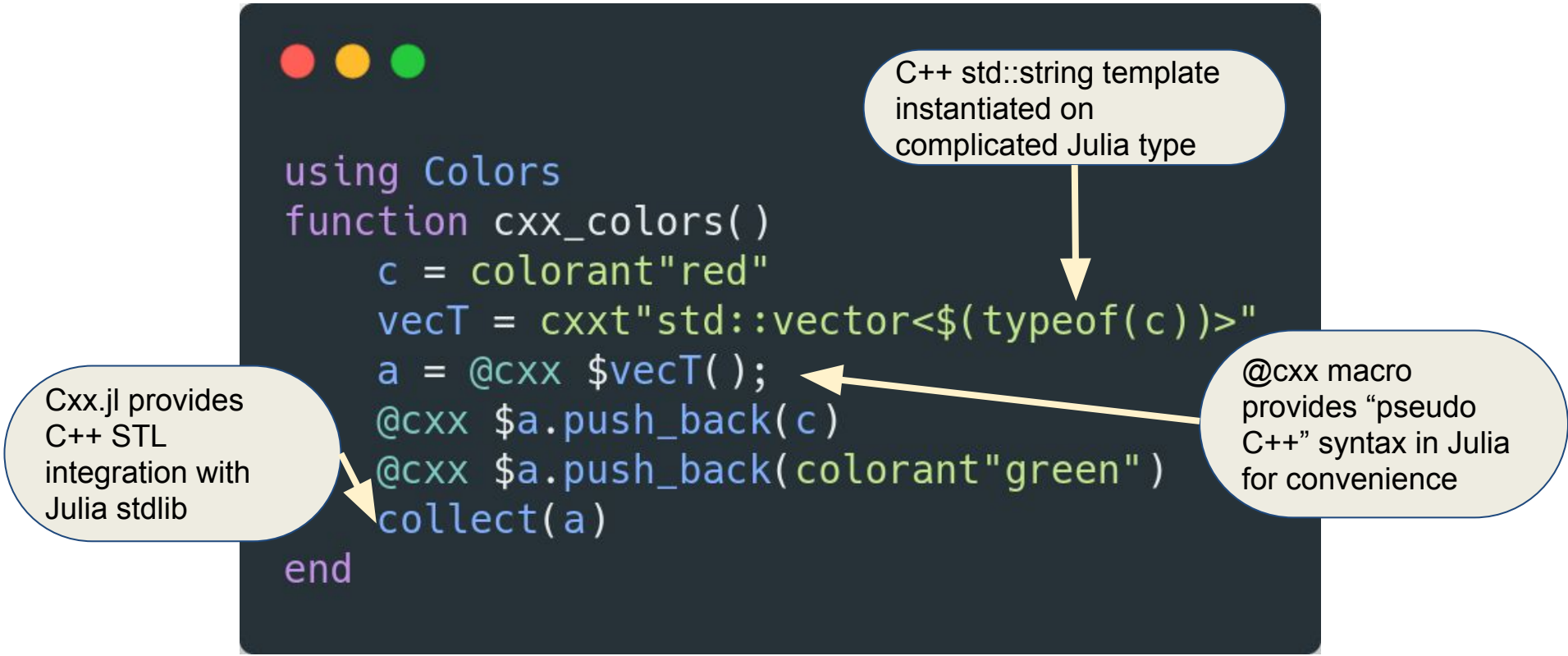
```
cxx"""
    #include <iostream>
"""

function cxx_hello_world()
    icxx"""
        std::cout << "Hello World" << std::endl;
    """
end
```

cxx string macro provides C++ global scope

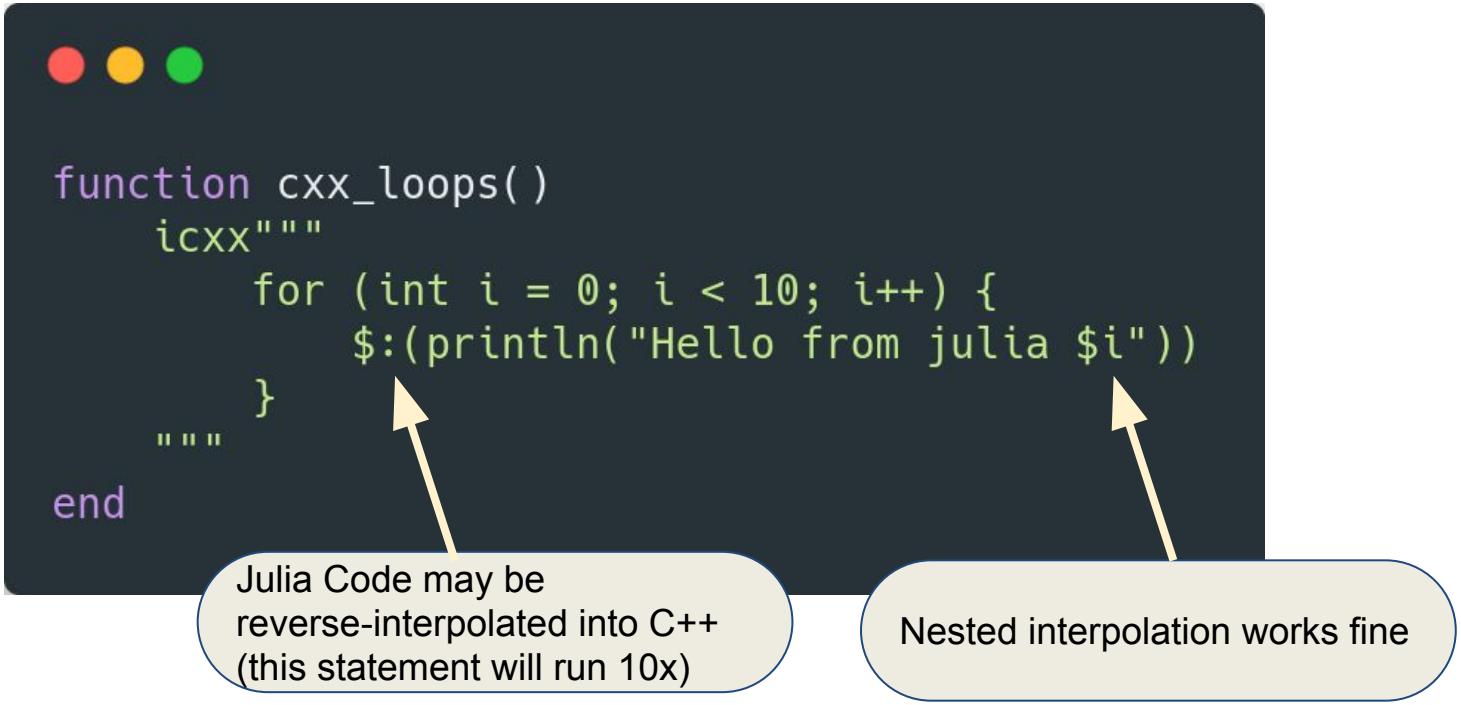
icxx string macro provides C++ local scope

Features - Type System Mapping

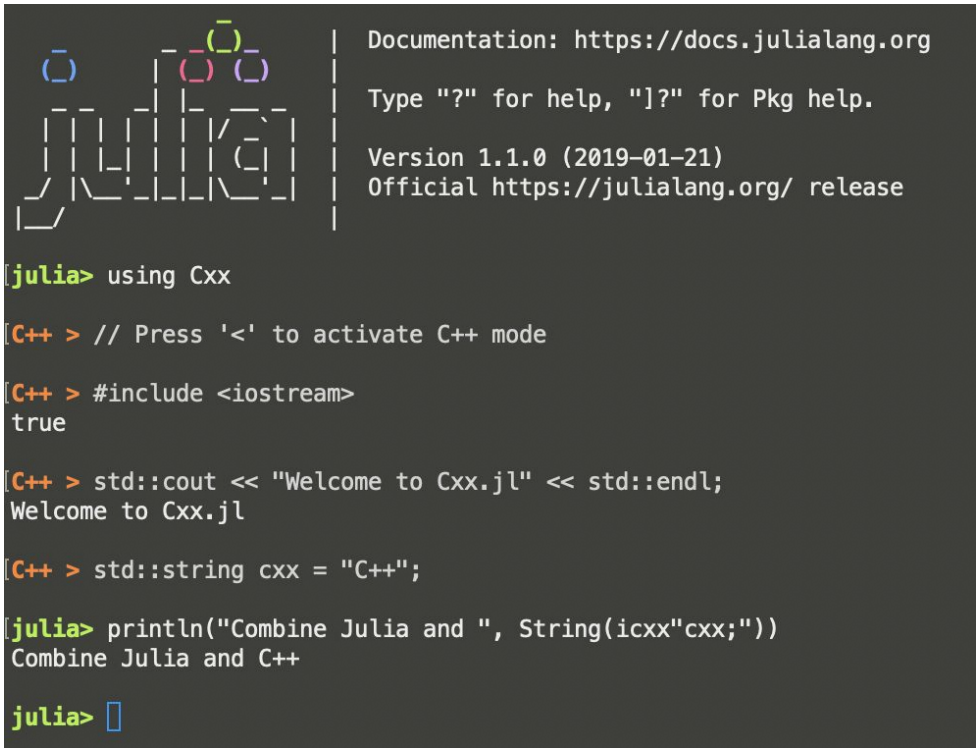
Features - Julia Type Mapping



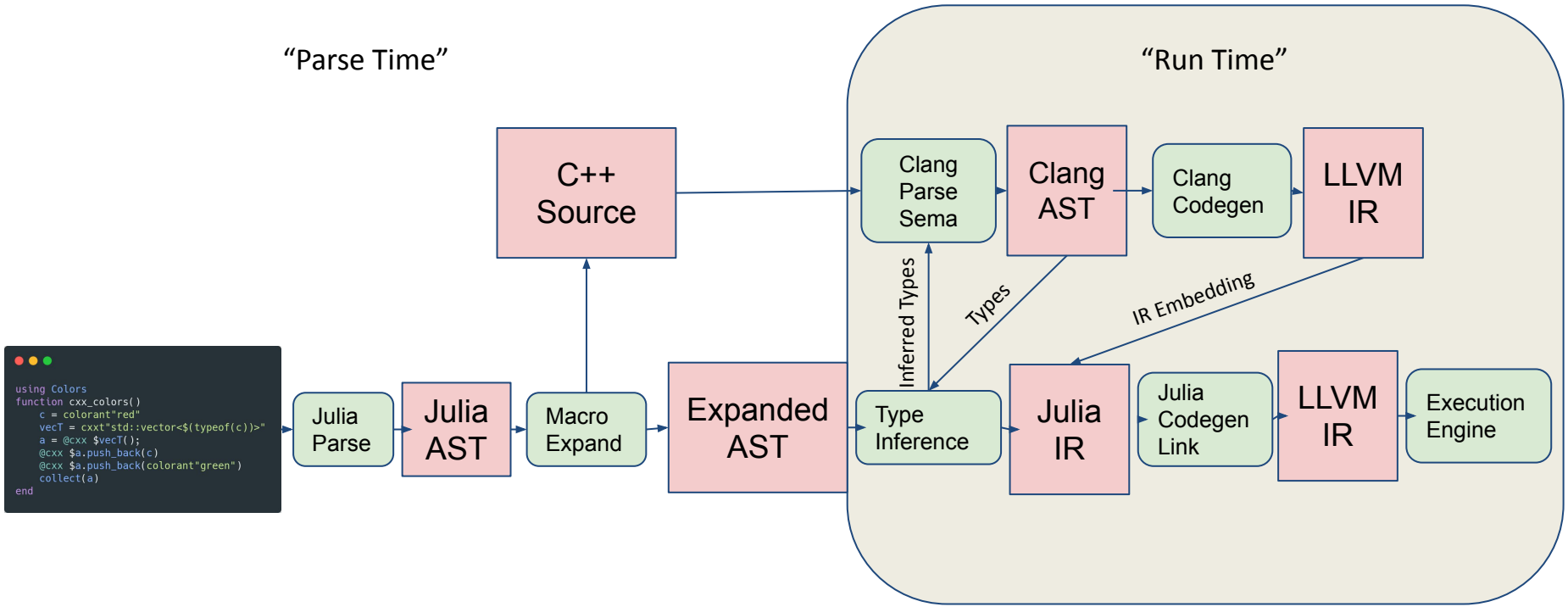
Features - Back and Forth



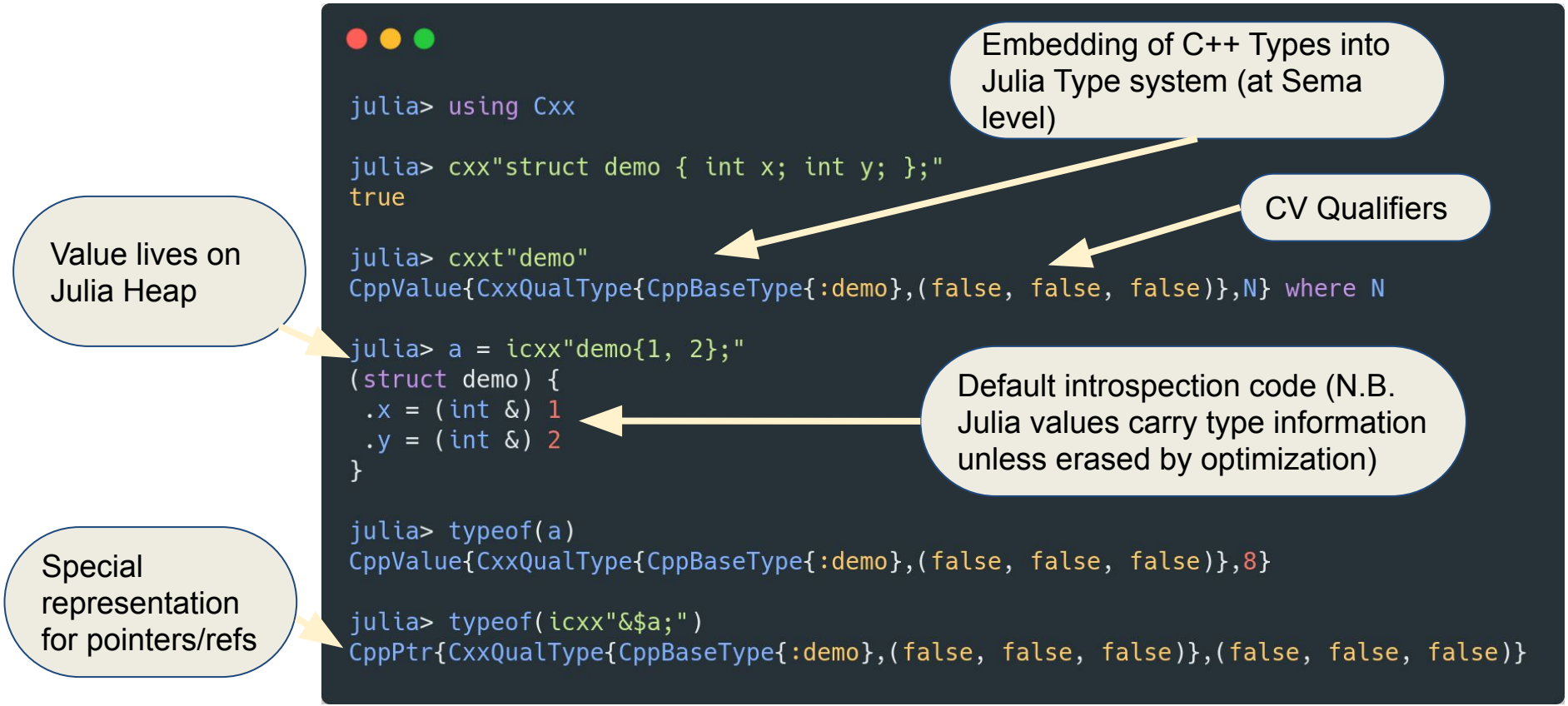
Features - Interactive C++ REPL



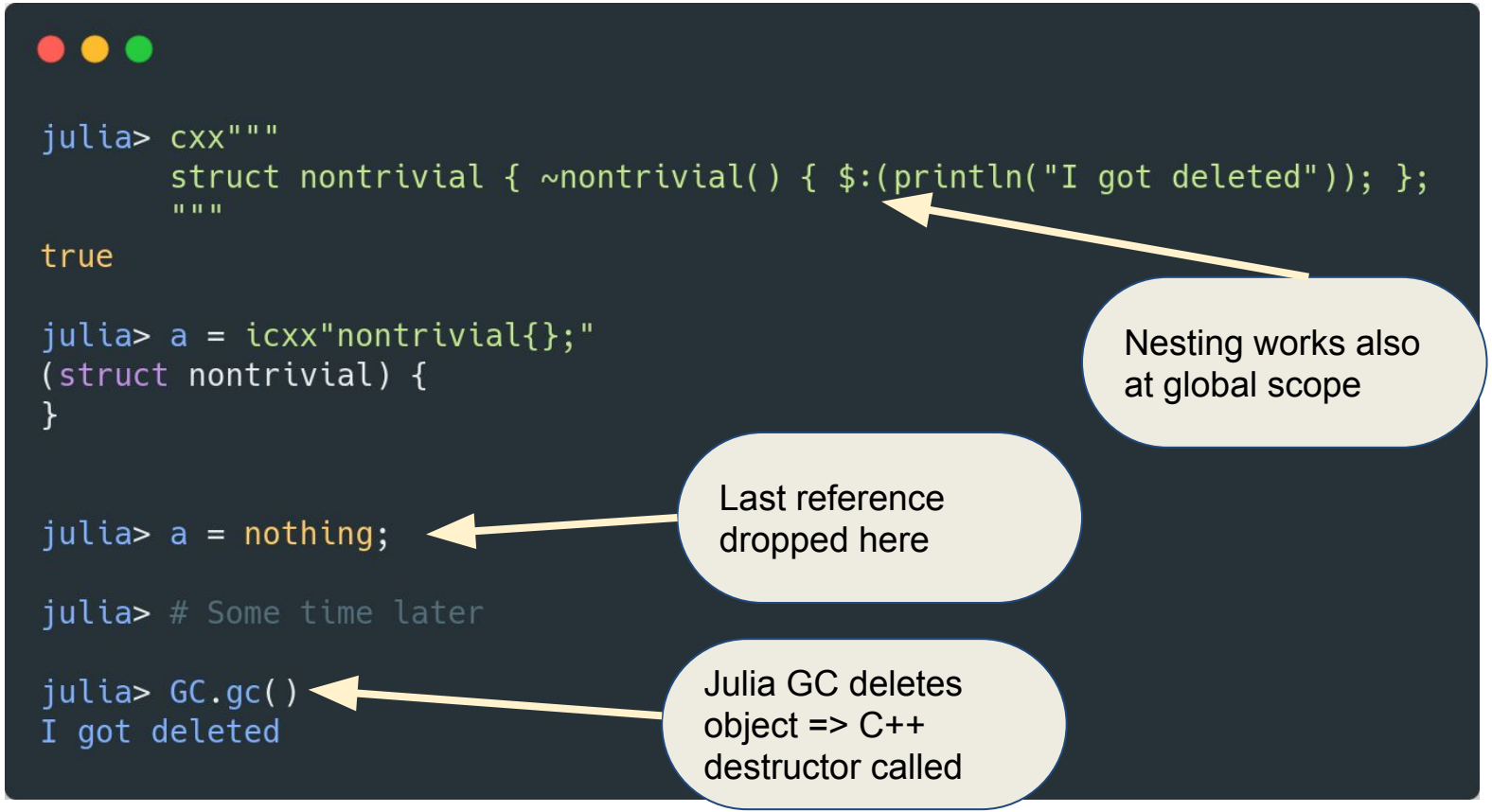
How does it work? - Compiler



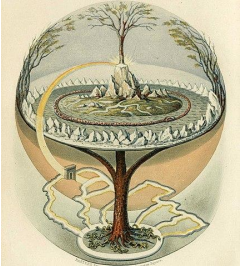
How does it work? - Runtime



How does it work? - Runtime



Challenges - Deployment



- Users likely got Julia as a binary package
  - Probably have no or an incompatible C++ stdlib/header environment
- Shipping Clang is a significant binary dependency
- Need story for shipping headers as well as binaries
- In recent versions, Julia community has taken control of binary dependencies - see github.com/JuliaPackaging/Yggdrasil
  - Likely easy to solve deployment challenges now, but additional work is required to plumb through all the required information

Challenges - Clang

- Clang not really designed for incremental compilation
  - Requires reaching into private internals to make it work
  - APIs generally unstable, but private APIs doubly so => significant maintenance burden with each version bump
  - Clang Occasionally gets into bad states
    - Particularly if the user makes C++ syntax errors => hard to unwind Clang state
  - Understand this is being worked on

Challenges - Julia (1)

- Clang dependency is big and slow to load
  - Ideally could load clang only if compilation is required, but currently no clear way to distinguish this case
    - Also an issue for Julia proper and being worked on, but no concrete timeline
- LLVM IR interop works, but somewhat half-hearted (e.g. not cacheable, incompatible with distributed computing)
- Julia has no scope-based lifetimes
  - Makes using C++ libraries that want RAII hard
  - May come in a future Julia version, but not yet designed
- Generic introspection utilities can violate C++ invariants (e.g. by not calling copy constructors)
  - No way to disallow this

Challenges - Julia (2)

- Julia Finalizers somewhat slow
  - Were design for small number of objects (e.g. files)
  - With Cxx, every C++ object with non-trivial destructor gets a finalizer
- Mapped C++ types are large => slow
  - Deeply nested C++ templates get mapped to deeply nested Julia type parameters
    - The Julia type system does not like this very much
- Julia LLVM pipeline not customizable
  - C++ and Julia need different passes => Cxx.jl can be slower than clang proper
  - Actively being worked on

Challenges - Fundamental (1)

- Lots of state that needs to be synchronized
  - LLVM IR
  - Julia IR
  - Clang AST
- For compilation speed Julia caches/reloads individual packages
  - How do we save/reload clang state?
    - PCMs may be an option, but when last investigated (~5-ish years ago were too complicated and required manual work for each C++ package)

Challenges - Fundamental (2)

- Different C++ packages require different compilation options
  - E.g. RTTI vs no-RTTI, exceptions vs no-exceptions
  - Cxx.jl supports multiple parallel Clang instances, but complicated
    - Need to be careful which compiler instance is used for every C++ statement
    - Type space is shared between instances, but options have ABI effects
- C++ compilation is slow (ok standalone, annoying at runtime)
- Julia users expect live-reload (hard to implement)

Cxx.jl consistently popular

Cxx.jl is the coolest thing ever!

Offtopic

klaff Sep 2019

I didn't find a Place_to_Praise_Julia category, so I'll post here.

I had a situation today in which an algorithm was supplied in the form of C snippets, and having a vague memory that one could compile C++ functions from a Julia REPL, I searched and found Cxx.jl. I tried the Cxx example, then a little copyy/paste with the snippets and whammo!, instant answers at the REPL! So much fun!

Here's a big Thank You to the authors and contributors of Cxx.jl and all of Julia.

31

created	last reply	2	822	3	36
Sep 2019	Sep 2019	replies	views	users	likes

cdsousa 13h

> giordano:
>
> `CxxWrap.jl` which is currently widely used to interface C++ libraries and isn't limited to Julia up to v1.3, so I don't understand the strong need for `Cxx.jl` (besides the fact it's cool)

`Cxx.jl` is not only cool, but it is also strongly helpful for doing quick and dirty experiments with C++ libs. It may not be robust to wrap libraries in the long term, but it enables the REPL driven development with C++ that we like so much in Julia!

I even used to rely a lot in `Cxx.jl` for quick checks when developing in C++ 🙂

I miss being able to quickly trying using some `C++`-only algorithms within my Julia code 😟 (I'm currently trying using `cppyy` through `PyCall`)

A call to action

- Cxx.jl is currently only partially maintained
  - Works on Julia 1.3 / LLVM 6, but hasn't been keeping up
  - Several people interested in helping, but limited Clang knowledge
- Only 5-6 kloc, half of which on the C++ side
- Deeper integration with Cling/ROOT?
  - Regularly requested by HEP community
  - Quick prototype 6 years ago, but never went anywhere
- Reach out
  - keno@juliacomputing.com ; discourse.julialang.org ; julialang.org/slack/