SKILLPILLS

Skill Pill: Julia

Lecture 1: Introduction

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July 7, 2017

OIST

1. The foreign world, using Julia to reuse prior work
2. Macros and metaprogramming
3. The Julia compiler
4. Performance
5. Performance analysis

Using Fortran and C in Julia

Julia allows you to use other languages (such as Fortran or C) by using the `ccall` function:

```
julia> t = ccall((:clock, "libc"), Int32, ())
2292761
```

Here, we are calling the `clock` function from the `libc` library in C.

Your legacy code

Let's say you want to use a simply multiply function in Fortran:

```
!! We'll be using subroutines intead of functions
subroutine multiply(A, B, C)
    REAL*8 :: A, B, C
    C = A * B
    return
end
```

or C:

```
// Nothing fancy here...
double multiply(double A, double B){
    return A*B;
}
```

Preparing your legacy code

In order to use your favorite C or Fortran code in Julia, you need to compile it into a library, like so:

```
gcc -shared -O2 multiply.c -fPIC -o c_multiply.so
gfortran -shared -O2 multiply.f90 -fPIC -o
    fortran_multiply.so
```

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These will create libraries with all of the necessary functions you could want, but beware:

C and Fortran compilers mangle function names!

Using your legacy code

There are 3 things to keep. Make sure you

1. Have the right mangled name
2. Are using the right type
3. Are using the function correctly.

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For example, in C:

```
# This function multiplies a and b into c by using the
# created C library
function call_c()
    a = Cdouble(1.0)
    b = Cdouble(3.0)
    c = ccall((:multiply, "/full/path/to/c_multiply"),
        Cdouble,(Cdouble, Cdouble),a,b)
    println(c)
end
```

Using your legacy code

Pointers are okay! For example, in Fortran:

```
# This function multiplies a and b into c by using
# the created FORTRAN library
function call_fortran()
    a = Cdouble[1.0]
    b = Cdouble[2.0]
    c = Cdouble[0.0]
    ccall((:multiply_, "/full/path/to/fortran_multiply"),
       Void,(Ptr{Float64},Ptr{Float64},Ptr{Float64}),
             a,b,c)
    println(c[1])
end
```

Using your legacy code

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# the created FORTRAN library
function call_fortran()
    a = Cdouble[1.0]
    b = Cdouble[2.0]
    c = Cdouble[0.0]
    ccall((:multiply_, "/full/path/to/fortran_multiply"),
       Void,(Ptr{Float64},Ptr{Float64},Ptr{Float64}),
             a,b,c)
    println(c[1])
end
```

More information can be found here: `https://docs.julialang.org/en/stable/manual/calling-c-and-fortran-code/`

Support for other languages

Python	https://github.com/JuliaPy/PyCall.jl
R	https://github.com/JuliaInterop/RCall.jl
C++	https://github.com/Keno/Cxx.jl
Matlab	I have heard rumours of such a thing existing, but the horror ...

Conclusion

Start writing Julia code now without being worried about losing your prior work!

Macros and metaprogramming

The stages of the compiler

1. Surface syntax (the code you write)
2. Desugared AST —@code_lowered—
3. Type-inferred AST —@code_typed—
4. LLVM IR —@code_llvm—
5. Native assembly —@code_native—

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- Check for type-instabilities with —@code_warntype—
- Measure runtime and allocations with —@time—
- Benchmark using —@btime—, and —@benchmark— from —BenchmarkTools.jl—
- Profiler and —ProfileView.jl—
- Memory Allocation tracker

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Read the performance tips section of the Julia manual `https://docs.julialang.org/en/stable/manual/performance-tips/`

Type instabilities

Using BenchmarksTools.jl

Using the Profiler

Using the memory allocation tracker

A simple example

```
function mysum(A)
  acc = 0
  for x in A
     acc += x
  end
  return acc
end
```

A supposedly simple task

```
function myfun()
  s = 0.0
  N = 10000
  for i=1:N
      s+=det(randn(3,3))
  end
  s/N
end
```

What is next?

Next Session Data Structures and Algorithms

Last Session Parallel computing, threading, GPUs? Up to grabs.