Write Your C Extension for Ruby

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@tonytonyjan

Bonjour

簡煒航

Jian, Weihang

tonytonyjan.net

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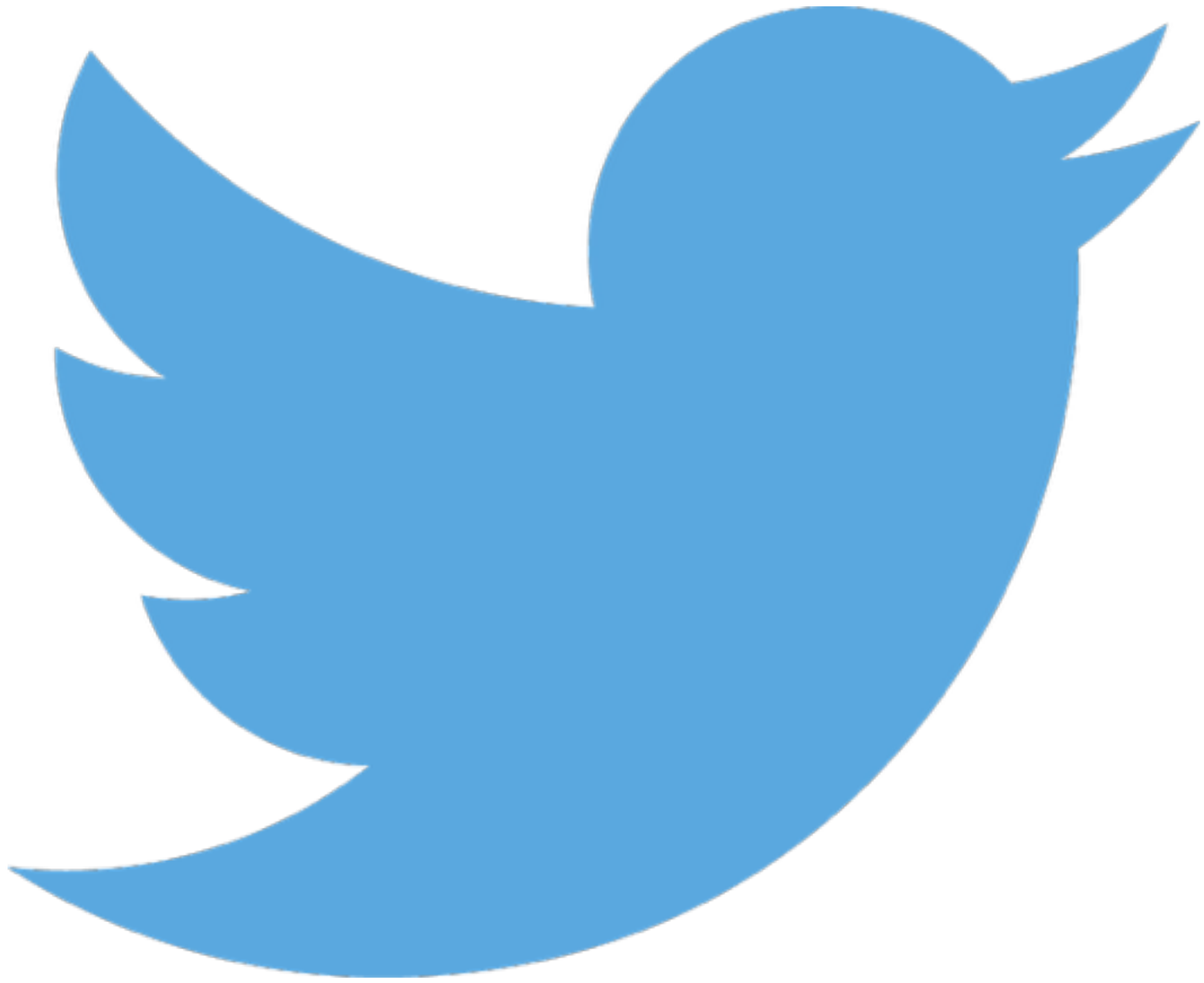

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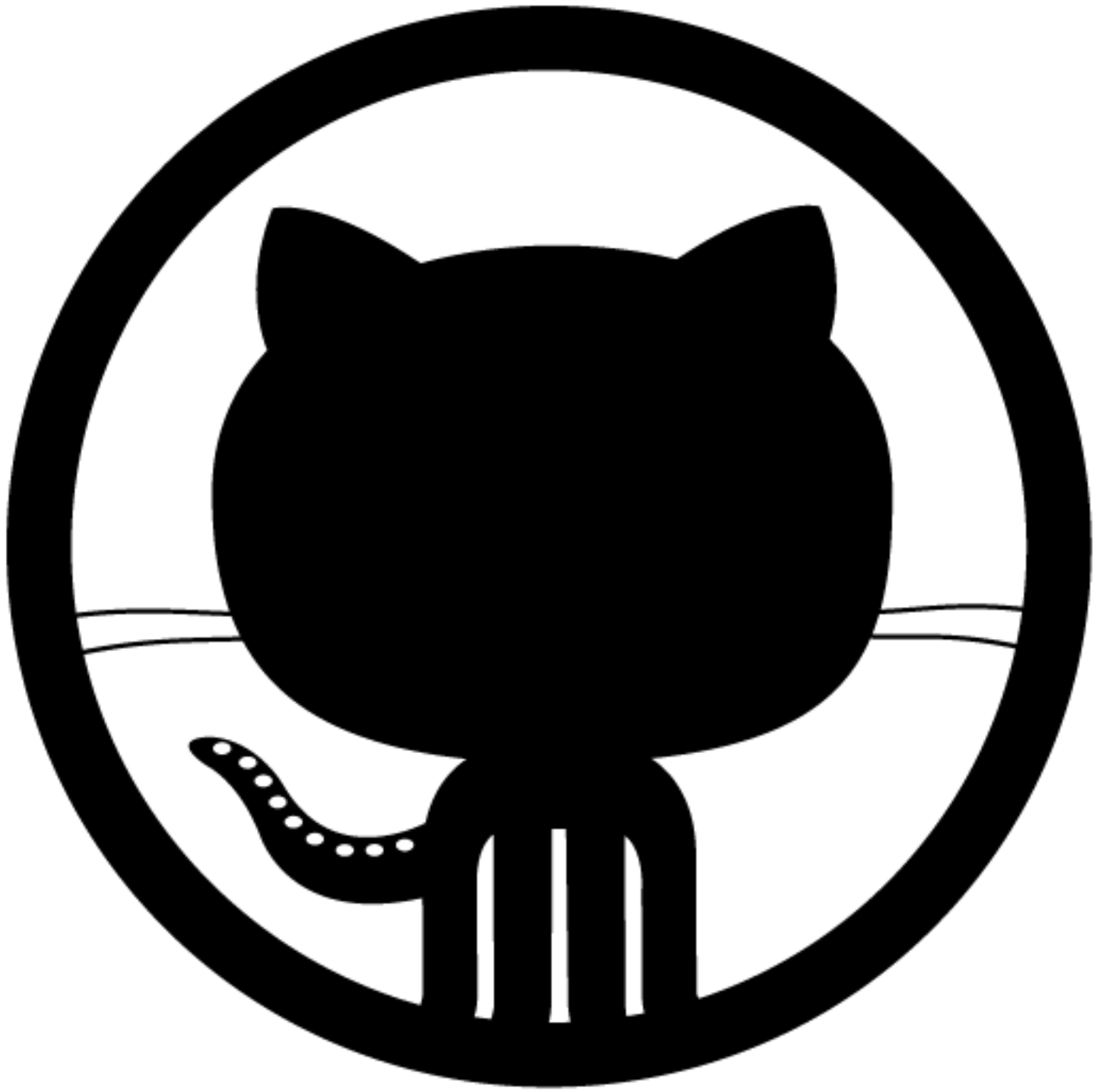

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YouTube

Double Keyboard Player

Ruby

Postgraduate

Freelancer

Book Writer

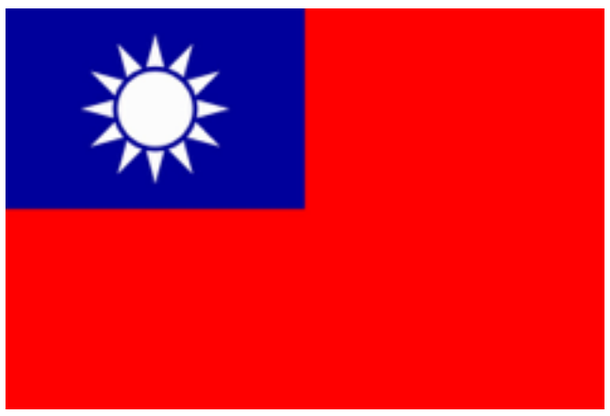
Coach of Rails Girls Taipei

Startup

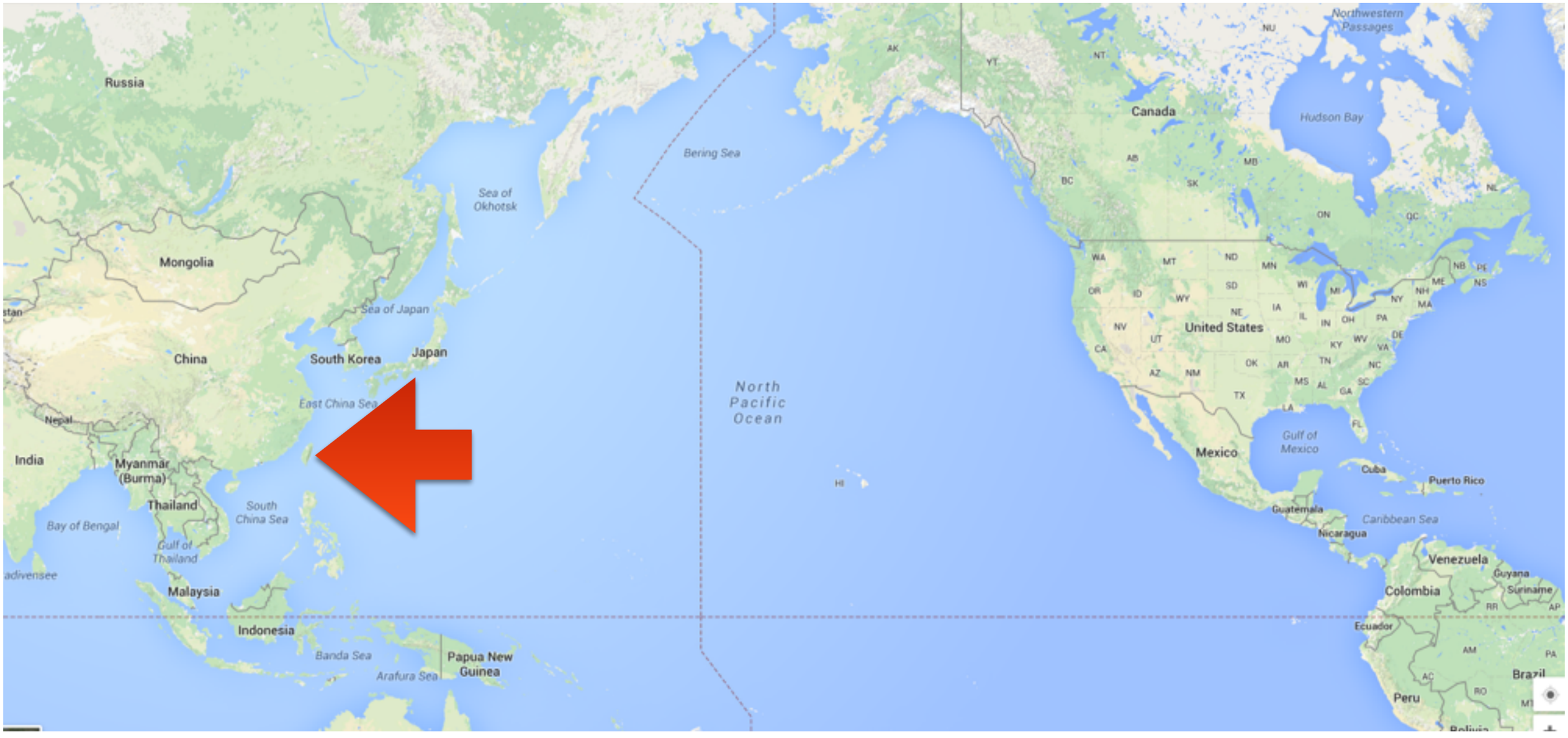
brainana.com

5xruby.tw

Taiwan



臺灣（Taiwan）


Russia
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Myanmar (Burma)
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2015-02-18

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Happy Chinese New Year

It’s Year of the ~~RAM~~ Ram

Write Your C Extension for Ruby

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Overview

- Compilation
- File Structure
- Basic MRI API
- Pointer Wrapper

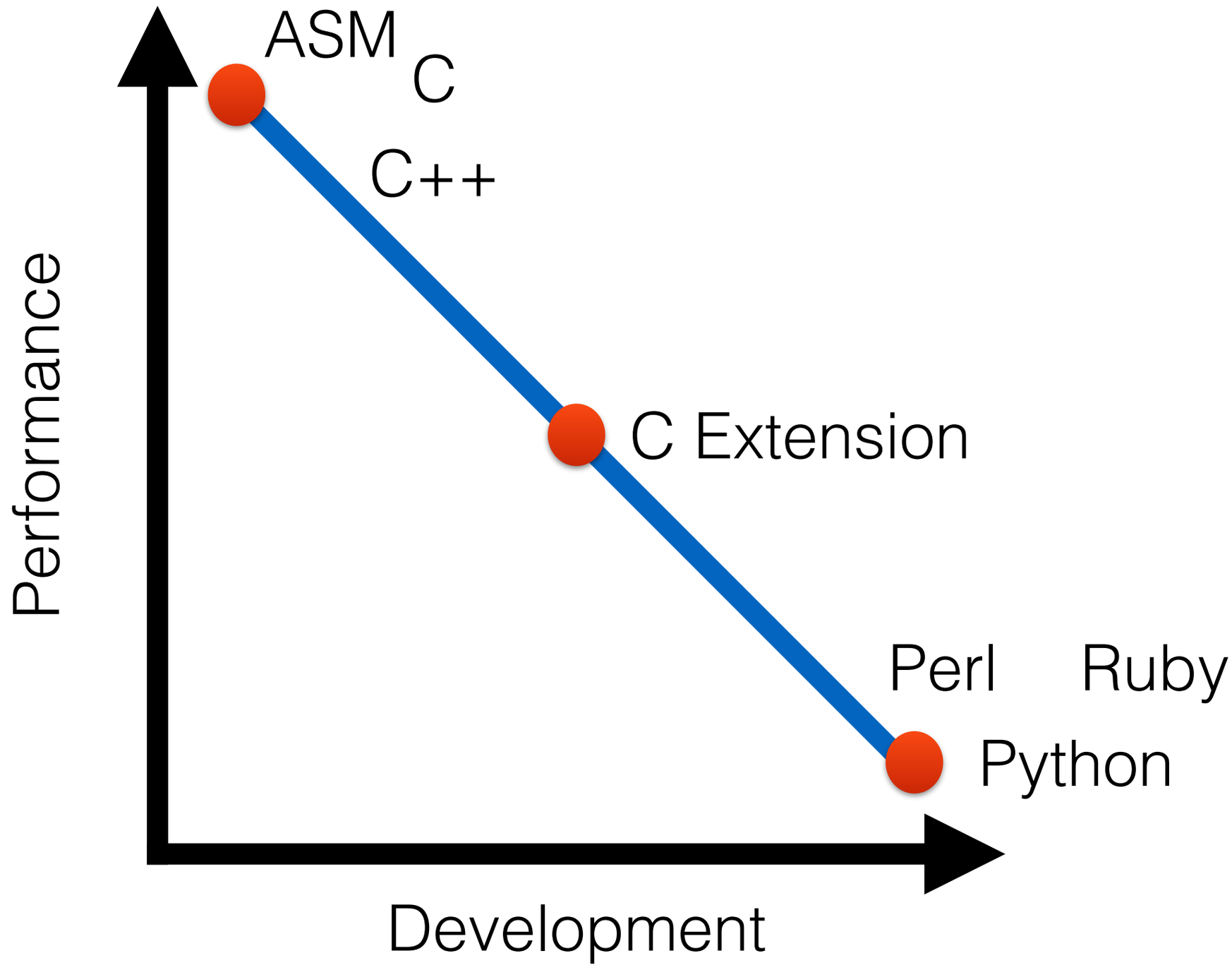
Why C Extension?

Beast from “Kung Fu Hustle”

“What a fast code!”

“You code fast!”

Code Performance
vs
Development Efficiency


ASM
C
C++
C Extension
Perl
Ruby
Python
Performance
Development

First step?

Profiling Tool

gem install ruby-prof

Jaro-winkler Distance
Pure Ruby Implementation

1.6918 ms

```
Total Time: 1.691791
Sort by: total_time

 %total   %self      total       self      wait     child             calls  Name
------------------------------------------------------------------------------
 100.00%  27.55%      1.692      0.466     0.000     1.226                 1  Global#[No method]
                      1.226      0.016     0.000     1.210               1/1  Integer#times
------------------------------------------------------------------------------
                      1.226      0.016     0.000     1.210               1/1  Global#[No method]
  72.45%   0.92%      1.226      0.016     0.000     1.210                 1  Integer#times
                      1.210      0.118     0.000     1.092     10000/10000  JaroWinkler#distance
------------------------------------------------------------------------------
                      1.210      0.118     0.000     1.092     10000/10000  Integer#times
  71.52%   6.98%      1.210      0.118     0.000     1.092           10000  JaroWinkler#distance
                      0.881      0.133     0.000     0.748     10000/10000  JaroWinkler#jaro_distance
                      0.092      0.013     0.000     0.079     10000/60000  Enumerable#each_with_index
                      0.042      0.014     0.000     0.028     10000/10000  Hash#merge
```

Replace with C Extension

0.5103 ms

```
Total Time: 0.5103410000000004
Sort by: total_time

 %total   %self      total       self      wait     child             calls   Name
------------------------------------------------------------------------------
 100.00%  95.59%      0.510      0.488     0.000     0.022                 1   Global#[No method]
                      0.022      0.013     0.000     0.009               1/1   Integer#times
------------------------------------------------------------------------------
                      0.022      0.013     0.000     0.009               1/1   Global#[No method]
   4.41%   2.61%      0.022      0.013     0.000     0.009                 1   Integer#times
                      0.009      0.009     0.000     0.000       10000/10000   JaroWinkler#distance
------------------------------------------------------------------------------
                      0.009      0.009     0.000     0.000       10000/10000   Integer#times
   1.80%   1.80%      0.009      0.009     0.000     0.000             10000   JaroWinkler#distance

* indicates recursively called methods
```

Ruby EXIF Readers

```
$ ruby exif_benchmark.rb
                    user     system      total        real
mini_exiftool   0.150000   0.050000  12.400000 ( 12.540122)
exifr           0.080000   0.000000   0.080000 (  0.083251)
exif            0.010000   0.000000   0.010000 (  0.009855)
```

- mini_exiftool - CLI wrapper of Exiftool
- exifr - Pure Ruby
- exif - C Extension of libexif

GitHub

tonytonyjan/jaro_winkler

tonytonyjan/exif

Make C Extension

Solutions

- C API of Ruby
- rubyinline - mixing C code into Ruby
- SWIG - Simplified Wrapper and Interface Generator

rubyinline

```ruby
require "inline"
class MyTest
  inline do |builder|
    builder.c "
    long factorial(int max) {
      int i=max, result=1;
      while (i >= 2) { result *= i--; }
      return result;
    }"
  end
end
t = MyTest.new()
factorial_5 = t.factorial(5)
```

SWIG

1 function

1 declaration

foo.c foo.h libfoo.i

$ swig -ruby libfoo.i

foo.c foo.h libfoo_wrap.c

2k lines

clang/gcc

libfoo.so

3x bigger than MRI C API implementation

SWIG is similar to C, but not C

```
/* libfoo.i */
%module libfoo
%{
  #include "libfoo.h"
%}

%typemap(in, numinputs=0) (double *tax, double *rate) {
  $1 = (double *)malloc(1 * sizeof(double));
  $2 = (double *)malloc(1 * sizeof(double));
};
```

MRI API is just Fine

What happen in “require”

```
require 'foo'
```

It will load “foo.rb”

foo.so, foo.o and foo.bundle

RbConfig::CONFIG['DLEXT']

To write a loadable Ruby module is easy.

What about write a native loadable module?

Entry of a C Program

```c
// main.c
#include <stdio.h>

int main(int argc, char const *argv[]){
  printf("Hello World");
  return 0;
}
```

Entry of C Extension

```c
#include <ruby.h>

int Init_foo(){
  printf("Hello World\n");
  return 0;
}
```

```
$ ruby -e 'require "foo"'
Hello World
```

Compilation

How to compile?

- Compile in-line
- autoconf/pkg-config
- MakeMakefile (recommended)

Compile in-line

```
clang \
-I/RUBY/PATH/include/ruby-2.2.0/PLATFORM_NAME \
-I/RUBY/PATH/include/ruby-2.2.0 \
-Wl,-undefined,dynamic_lookup -Wl,-multiply_defined,suppress \
-lpthread -lgmp -ldl -lobjc \
-o foo.bundle foo.c
```

pkg-config

```
export PKG_CONFIG_PATH=/RUBY/PATH/lib/pkgconfig
clang $(pkg-config --libs --cflags ruby-2.2) -o foo.bundle foo.c
```

mkmf (Make Makefile)

```ruby
# extconf.rb
require 'mkmf'
create_makefile('foo')
```

$ ruby extconf.rb
$ make

```
.
├── Makefile
├── extconf.rb
├── foo.bundle
├── foo.c
└── foo.o

0 directories, 5 files
```

installation path

```
create_makefile("foo_ext")
```

```
require 'foo_ext'
```

```
create_makefile("foo/bar")
```

```
require 'foo/bar'
```

custom source path

```
create_makefile("foo_ext" "src")
```

```
.
├── extconf.rb
└── src
    ├── bar.c
    ├── bar.h
    ├── foo.c
    └── foo.h
```

$ ruby extconf.rb
$ make

```
.
├── Makefile
├── bar.o
├── extconf.rb
├── foo.o
├── foo_ext.bundle
└── src
    ├── bar.c
    ├── bar.h
    ├── foo.c
    └── foo.h
```

Conditional Processing

Conditional Processing

```
AC_CHECK_HEADERS([foo.h])
AC_CHECK_HEADERS([bar.h], [], [],
[#ifdef HAVE_FOO_H
# include <foo.h>
#endif
])
```

AutoConfig - Generic Header Checks

Conditional Processing

mkmf methods	Compilor Optoins
have_header(“foo”)	-DHAVE_FOO_H
have_library(“foo”)	-lexif
have_type(“foo”)	-DHAVE_TYPE_FOO
have_var(“foo”)	-DHAVE_FOO
have_struct_member('struct foo', 'bar')	-DHAVE_STRUCT_FOO_BAR
have_func(“foo”)	-DHAVE_FOO

It’s just DSL

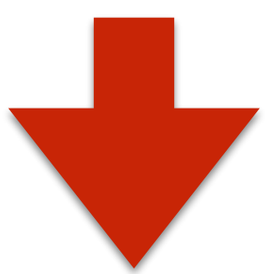
```
have_func 'PQconnectionUsedPassword' or
  abort "Your PostgreSQL is too old. Either install an older version " +
        "of this gem or upgrade your database."
have_func 'PQisthreadsafe'
have_func 'PQprepare'
have_func 'PQexecParams'
have_func 'PQescapeString'
```

Configurable Target Path

```
gem install mysql2 -- --with-mysql-dir=prefix
gem install mysql2 -- --with-mysql-include=lib --with-mysql-lib=dir
```

dir_config

```
dir_config('foo')
```



```
gem install foo -- --with-foo-dir=prefix
gem install foo -- --with-foo-include=lib --with-foo-lib=dir
```

Setup Gemspec

```ruby
# foo.gemspec
Gem::Specification.new 'foo', '1.0.0' do |s|
  s.name = 'foo'
  s.summary = 'foo'
  s.authors = %w[tonytonyjan]
  s.files = %w[foo.c]
  s.extensions = %w[extconf.rb]
end
```

That’s it

Yon’t need autotools,
mkmf gives you the best.

File Structure

```
$ bundle gem NAME --ext
```

Typical File Structure

```
.
├── Gemfile
├── Rakefile
├── ext
│   └── foo
│       ├── extconf.rb
│       ├── foo.c
│       └── foo.h
├── foo.gemspec
└── lib
    ├── foo
    │   └── version.rb
    └── foo.rb

4 directories, 8 files
```

```ruby
# ext/extconf.rb
require "mkmf"
create_makefile("foo/foo")
```

```ruby
# lib/foo.rb
require "foo/version"
require "foo/foo"
```

mysql2, nokogiri, sqlite3

```
require 'foo/foo'
```

It's ambiguous!

Better File Structure

```
.
├── Gemfile
├── Rakefile
├── ext
│   ├── extconf.rb
│   ├── foo.c
│   └── foo.h
├── foo.gemspec
└── lib
    ├── foo
    │   └── version.rb
    └── foo.rb

3 directories, 8 files
```

```
# ext/extconf.rb
require "mkmf"
create_makefile("foo_ext")
```

```
# lib/foo.rb
require "foo/version"
require "foo_ext"
```

pg, bcrypt, eventmachine

Development Workflow

`gem install` will generate Makefile & build automatically.

While developing...

```
$ cd ext/
$ ruby extconf.rb
$ make
$ cd ..
$ ruby -I ext -r foo_ext -e '...'
```

It's too tedious.

Life can be easier.

gem install rake-compiler

```
# Rakefile
require "rake/extensiontask"


Rake::ExtensionTask.new("foo_ext") do |ext|
  ext.ext_dir = "ext"
end
```

$ rake -D

```
rake clean
    Remove any temporary products.

rake clobber
    Remove any generated file.

rake compile
    Compile all the extensions

rake compile:foo_ext
    Compile foo_ext
```

Using rake-compiler

$ rake compile test

rake-compiler is for development.

It’s nothing to do with gem installation.

Basic C API

Key Knowledge

- Ruby is OO, C is not.
- C variables have types but data don't.
- Ruby variables have no types but data do.
- Data in Ruby are represented by C type "VALUE", and "VALUE" data has its own data-type.

Define Module/Class

Ruby

```ruby
module Foo; end
class Bar; end
```

```ruby
Bar.superclass #=> Object
```

C

```c
void
Init_foo_ext(void)
{
  VALUE rb_mFoo = rb_define_module("Foo");
  VALUE rb_cBar = rb_define_class("Bar", rb_cObject);
}
```

Nested Class/Module

Ruby

```ruby
module Foo
  class Bar; end
  module Buz; end
end
```

C

```c
void Init_foo_ext(void){
  VALUE rb_mFoo = rb_define_module("Foo");
  VALUE rb_cBar = rb_define_class_under(rb_mFoo, "Bar", rb_cObject);
  VALUE rb_mBuz = rb_define_module_under(rb_mFoo, "Buz");
}
```

```c
VALUE rb_define_class(const char *name, VALUE super);
VALUE rb_define_module(const char *name);
VALUE rb_define_class_under(VALUE outer, const char *name, VALUE super);
VALUE rb_define_module_under(VALUE outer, const char *name);
```

Define Method

Ruby

```ruby
class Bar
  def self.hello(name); puts "Hello, #{name}" end
  def world; puts "World" end
end
```

C

```c
rb_define_singleton_method(rb_cBar, "hello", hello, 1);
rb_define_method(rb_cBar, "world", helllo, 0);
```

function pointer

argc

self

```c
VALUE hello(VALUE instance, VALUE name){
  printf("hello %s\n", StringValueCStr(name));
  return Qnil;
}
```

Convert Ruby String to C String

Singleton Instance of rb_cNilClass
(there are also Qfalse, Qtrue)

```c
VALUE world(VALUE klass){
  printf("world\n");
  return Qnil;
}
```

self

Ruby data <-> C data

	Fixnum	Numeric	String
int	FIX2INT(value) INT2FIX(i)	NUM2INT(value) INT2NUM(I)	
long	FIX2LONG(value) LONG2FIX(l)	NUM2LONG(value) LONG2NUM(l)	
double		NUM2DBL(value) rb_float_new(f)	
char*			StringValueCStr(value) rb_str_new_cstr(s)

Steps of implementation

```
VALUE func(VALUE self, VALUE argv...){
  // 1. Check types of arguments
  // 2. convert arguments to C data
  // 3. process C data
  // 4. return VALUE object
}
```

Type Checking

Ruby

```ruby
case obj
when Modeul then # ...
when Class then # ...
else raise 'not valid'
end
```

C

```c
switch (TYPE(rb_mFoo)){
  case T_MODULE:
    // process Module
    break;
  case T_CLASS:
    // process Class
    break;
  default:
    rb_raise(rb_eTypeError, "not valid value");
    break;
}
```

internal VALUE Types

T_NIL	T_STRING	T_STRUCT	T_FILE
T_OBJECT	T_REGEXP	T_BIGNUM	T_TRUE
T_CLASS	T_ARRAY	T_FIXNUM	T_FALSE
T_MODULE	T_HASH	T_COMPLEX	T_DATA
T_FLOAT	T_SYMBOL	T_RATIONAL	

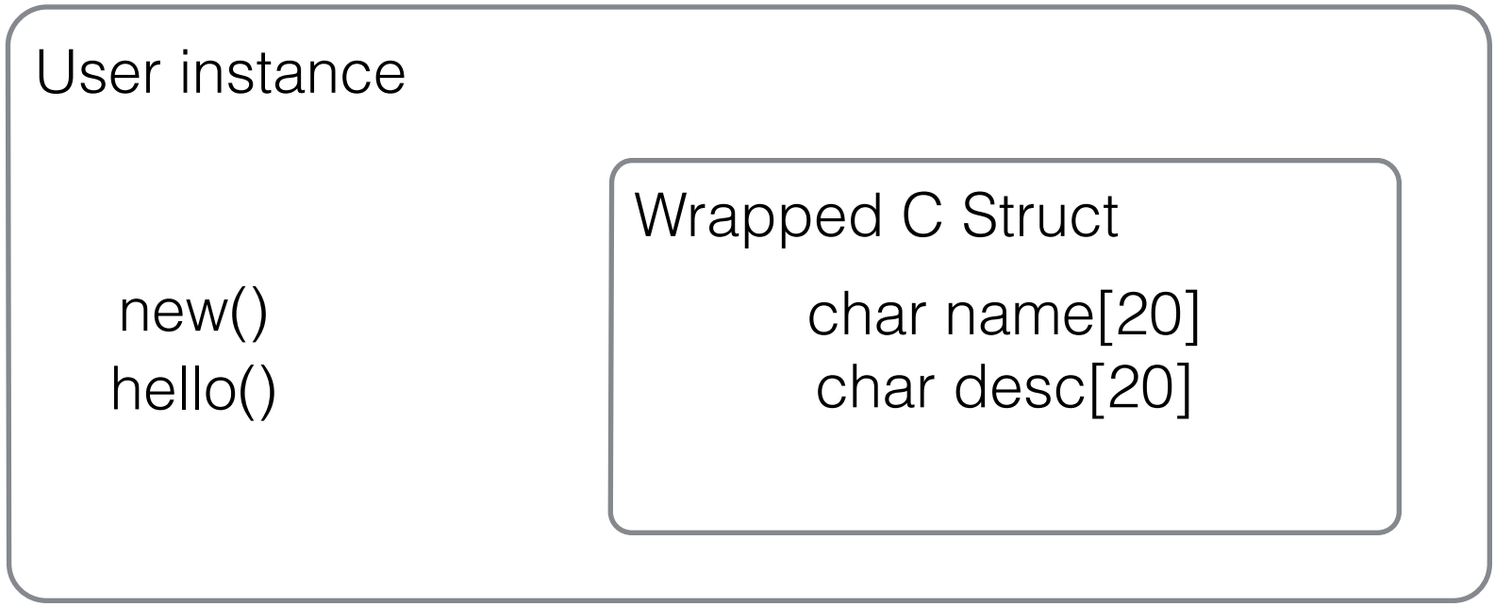
Pointer Wrapper

C is not OOP

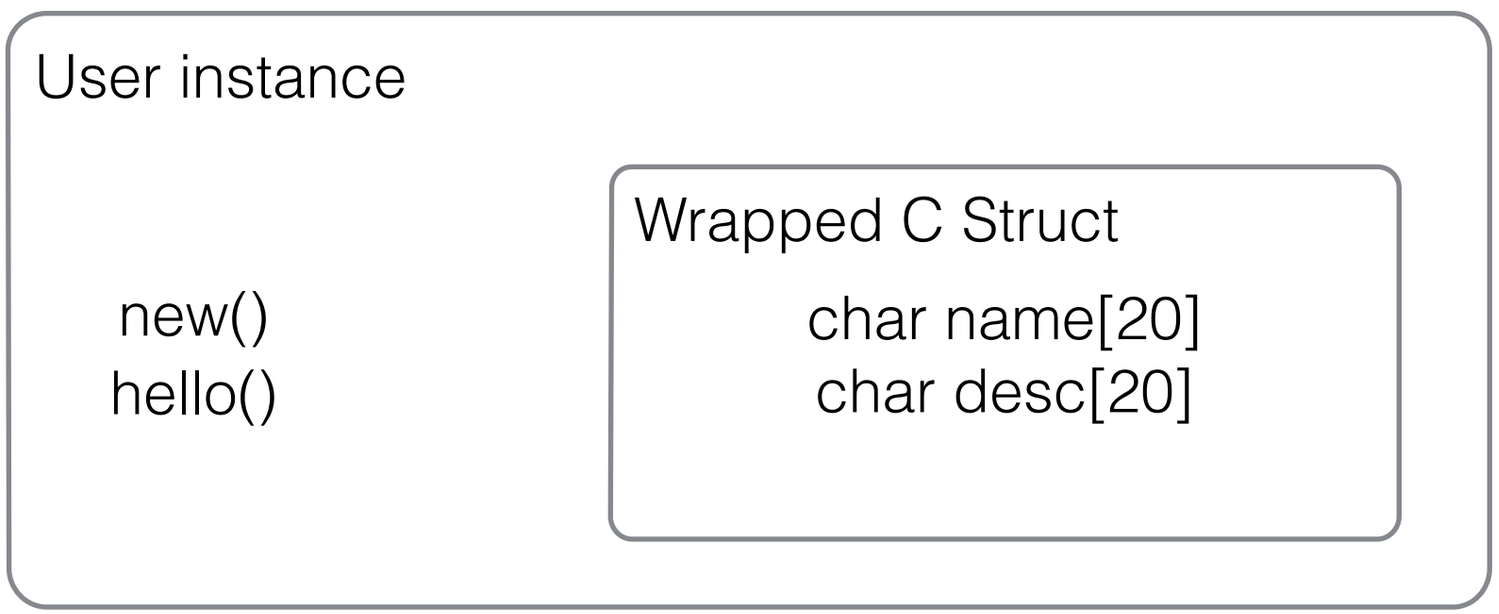
However, there is structure in C.

```ruby
u = User.new("Weihang", "An engineer")
u.hello # => print: "Hi, I'm Weihang"
```

u1 = User.new(…)



u2 = User.new(…)



```c
// user.h
typedef struct {
    char name[20];
    char desc[20];
} User;
```

```c
static VALUE new(VALUE self, VALUE name, VALUE desc);
static VALUE hello(VALUE self);
```

```c
VALUE rb_cBar = rb_define_class_under(rb_mFoo, "Bar", rb_cObject);
rb_define_singleton_method(rb_cBar, "new", new, 2);
rb_define_method(rb_cBar, "hello", hello, 0);
```

User#new(name, desc)

Ruby class C struct return

```
static VALUE new(VALUE self, VALUE name, VALUE desc){
  User* user;
  VALUE rb_user = Data_Make_Struct(self, User, 0, -1, user);
  strncpy(user->name, StringValueCStr(name), 19);
  strncpy(user->desc, StringValueCStr(desc), 19);
  return rb_user;
}
```

mark function pointer

ActiveRecord::Persistence#destroy free function pointer

User#hello

Ruby instance C struct return

```c
static VALUE hello(VALUE self){
  User* user;
  Data_Get_Struct(self, User, user);
  printf("Hi, I'm %s\n", user->name);
  return Qnil;
}
```

What about C++?

```cpp
#include <iostream>
#include "foo.h"
using namespace std;

extern "C" void Init_foo(){
    cout << "Hello, World" << endl;
}
```

That’s it!

Leaning Resources

- Official Guide
  - http://guides.rubygems.org/gems-with-extensions/
- README.EXT in ruby source code
- @tenderlove
  - http://tenderlovemaking.com/2009/12/18/writing-ruby-c-extensions-part-1.html
  - http://tenderlovemaking.com/2010/12/11/writing-ruby-c-extensions-part-2.html
- Source code of pg, sqlite2, mysql2, nokogiri, kgio, bcrypt, etc
- MRI source code

Thanks for your listening