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Graal: A Polyglot VM for a Polyglot IDE

Chris Seaton
Research Manager
Oracle Labs
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Programming languages

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Why can't there be an “ultimate” programming language?

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Why can't there be an “ultimate” programming language?

closed as not constructive by Tim, Bo Persson, Devon_C_Miller, Mark, Graviton Jan 17 at 5:58

JavaScript: **One language to rule them all** | VentureBeat

venturebeat.com/2011/.../javascript-**one-language-to-rule-them**-...

by Peter Yared - in 23 Google+ circles

Jul 29, 2011 - Why code in two different scripting languages, one on the client and one on the server? It's time for **one language to rule them all**. Peter Yared **...**

[PDF] Python: **One** Script (**Language**) **to rule them all** - Ian Darwin

www.darwinsys.com/python/python4unix.pdf

Another **Language**? ▸ Python was invented in 1991 by Guido van. Rossum. ▫ Named after the comedy troupe, not the snake. ▸ Simple. ▫ They **all** say that!

Q & Stuff: **One Language to Rule Them All - Java**

qstuff.**blogspot**.com/2005/10/**one-language-to-rule-them-all-java**.html

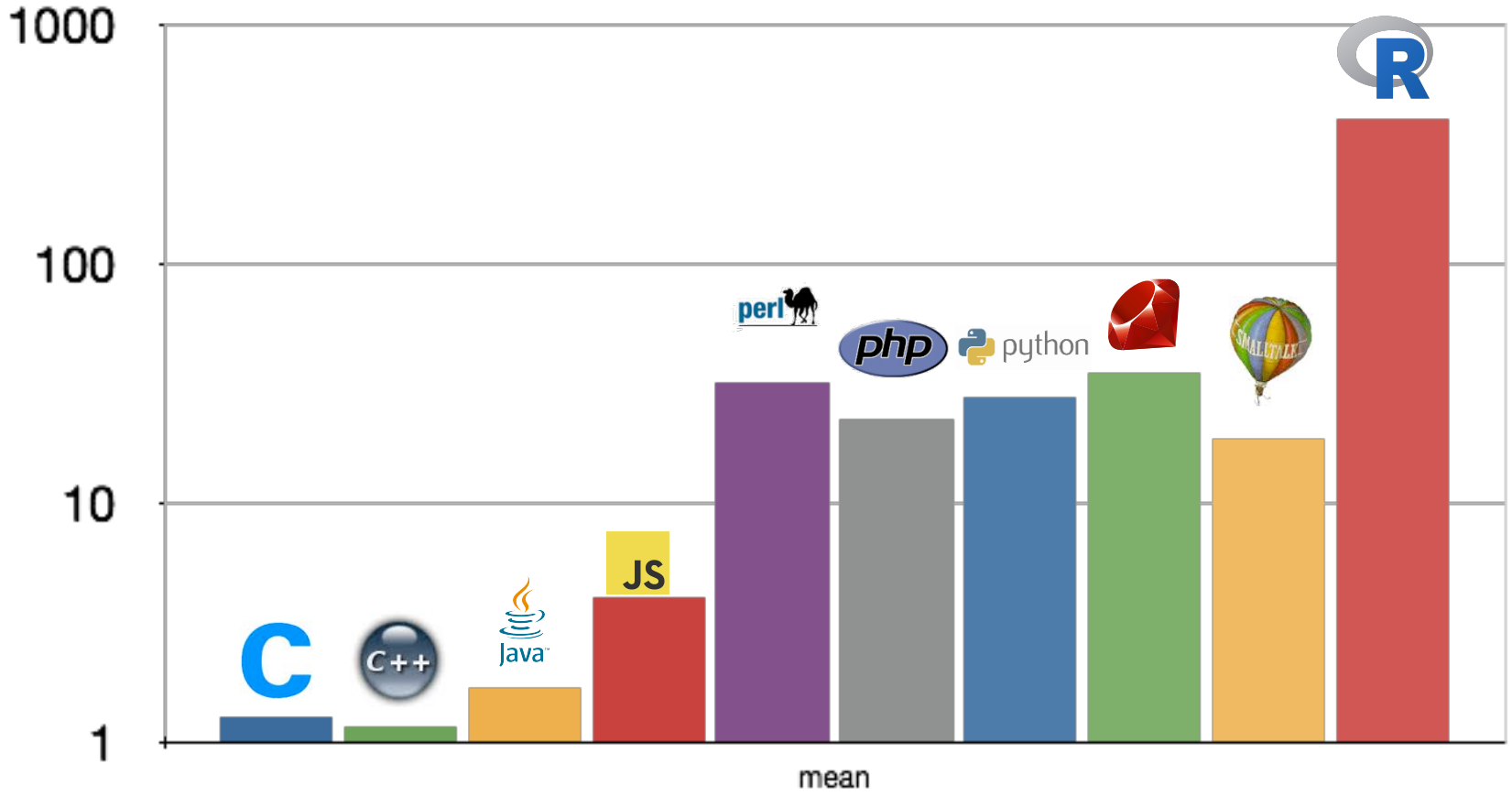
Oct 10, 2005 - **One Language to Rule Them All - Java**. For a long time I'd been hoping to add a scripting language to LibQ, to use in any of my (or other **...**

Dart : **one language to rule them all** - MixIT 2013 - Slideshare

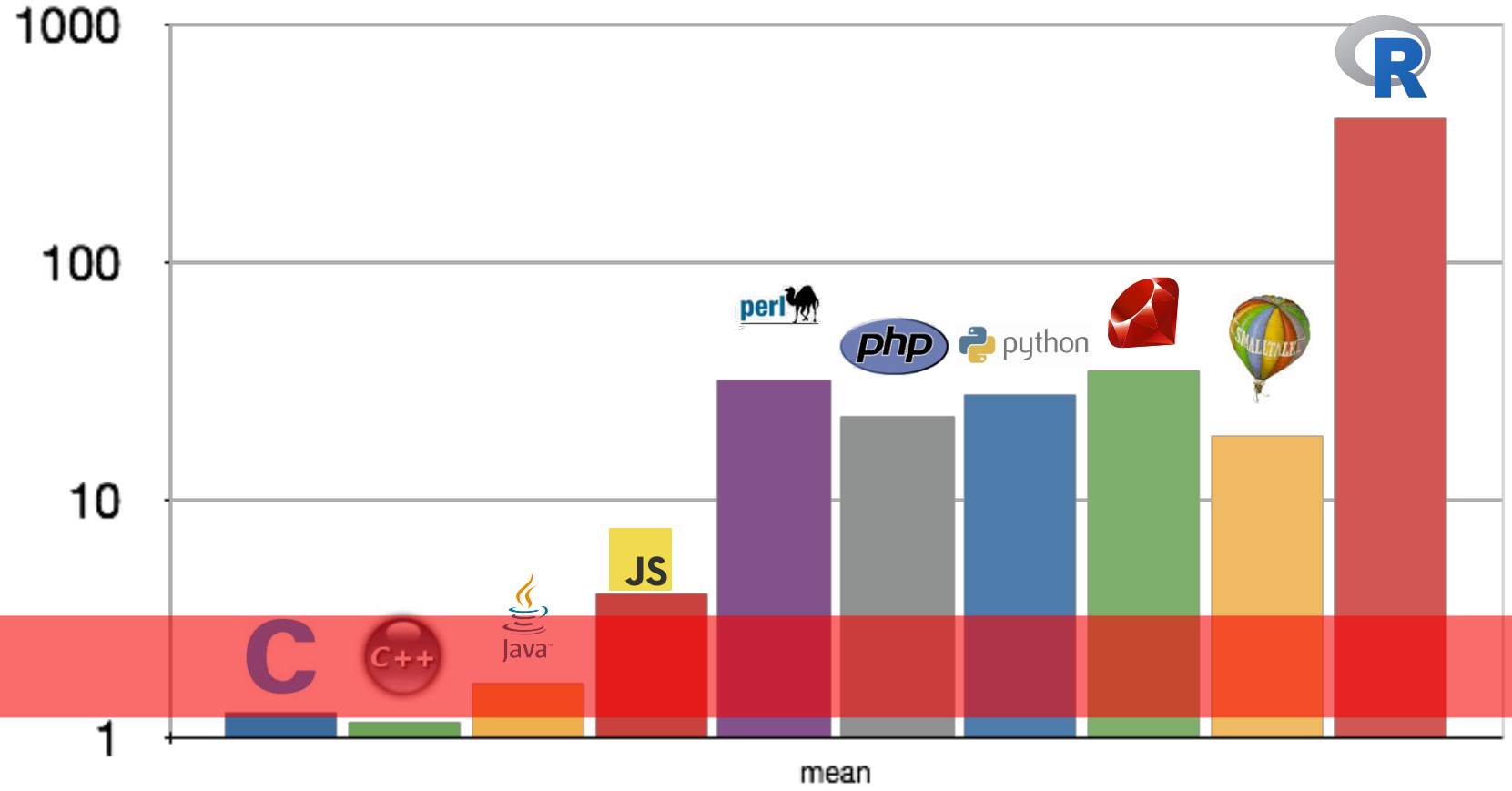
fr.slideshare.net/sdeleuze/dart-mixit2013en

DartSébastien Deleuze - @sdeleuzeMix-IT 2013One **language to rule them all** ...

Computer Language Benchmarks Game



Computer Language Benchmarks Game



Goal:

Current situation

Prototype a new language

Parser and language work to build syntax tree (AST), AST Interpreter

Write a “real” VM

In C/C++, still using AST interpreter, spend a lot of time implementing runtime system, GC, …

People start using it

People complain about performance

Define a bytecode format and write bytecode interpreter

Performance is still bad

Write a JIT compiler
Improve the garbage collector

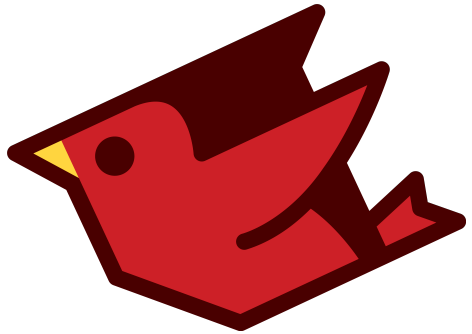
Current situation

- Prototype a new language
  - Parser and language work to build syntax tree (AST), AST Interpreter
- Write a “real” VM
  - In C/C++, still using AST interpreter, spend a lot of time implementing runtime system, GC, …
- People start using it
- People complain about performance
  - Define a bytecode format and write bytecode interpreter
- Performance is still bad
  - Write a JIT compiler
  - Improve the garbage collector

How it should be

- Prototype a new language in Java
  - Parser and language work to build syntax tree (AST)
  - Execute using AST interpreter
- People start using it
  - And it is already fast

The Graal Approach



Jython

renjin

Conventional JVM implementations of languages work by emitting JVM bytecode – the same thing that the Java compiler does

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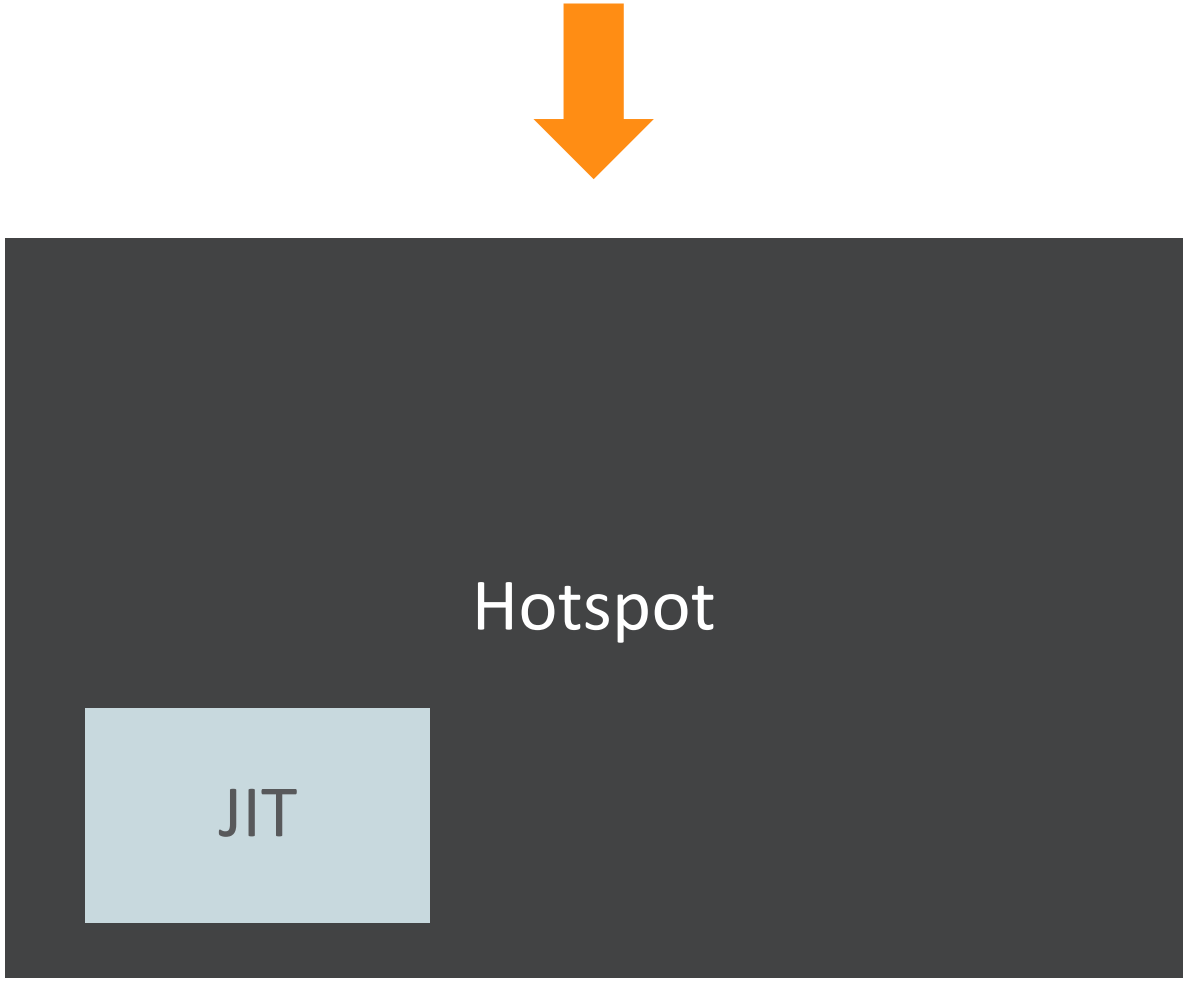
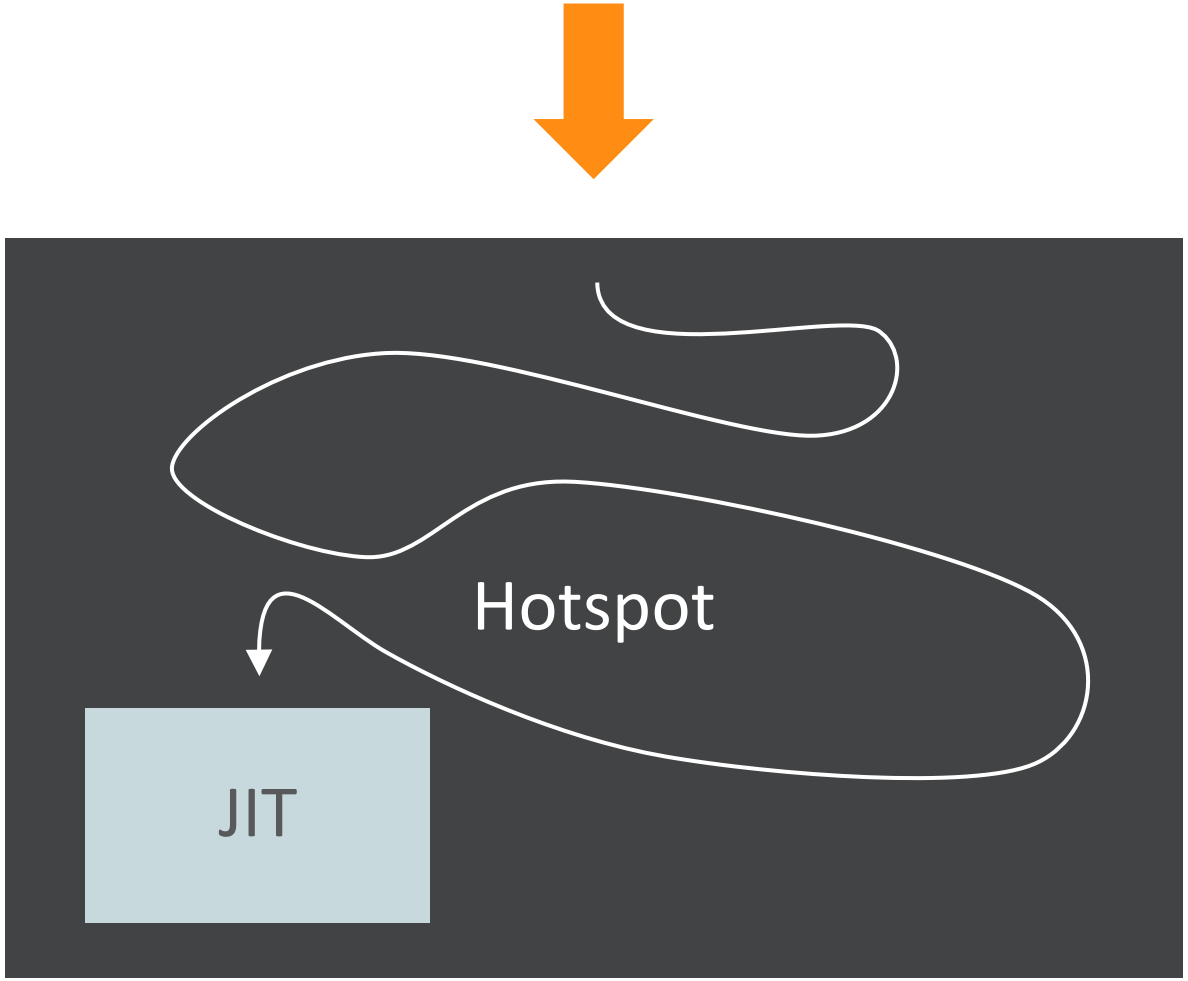
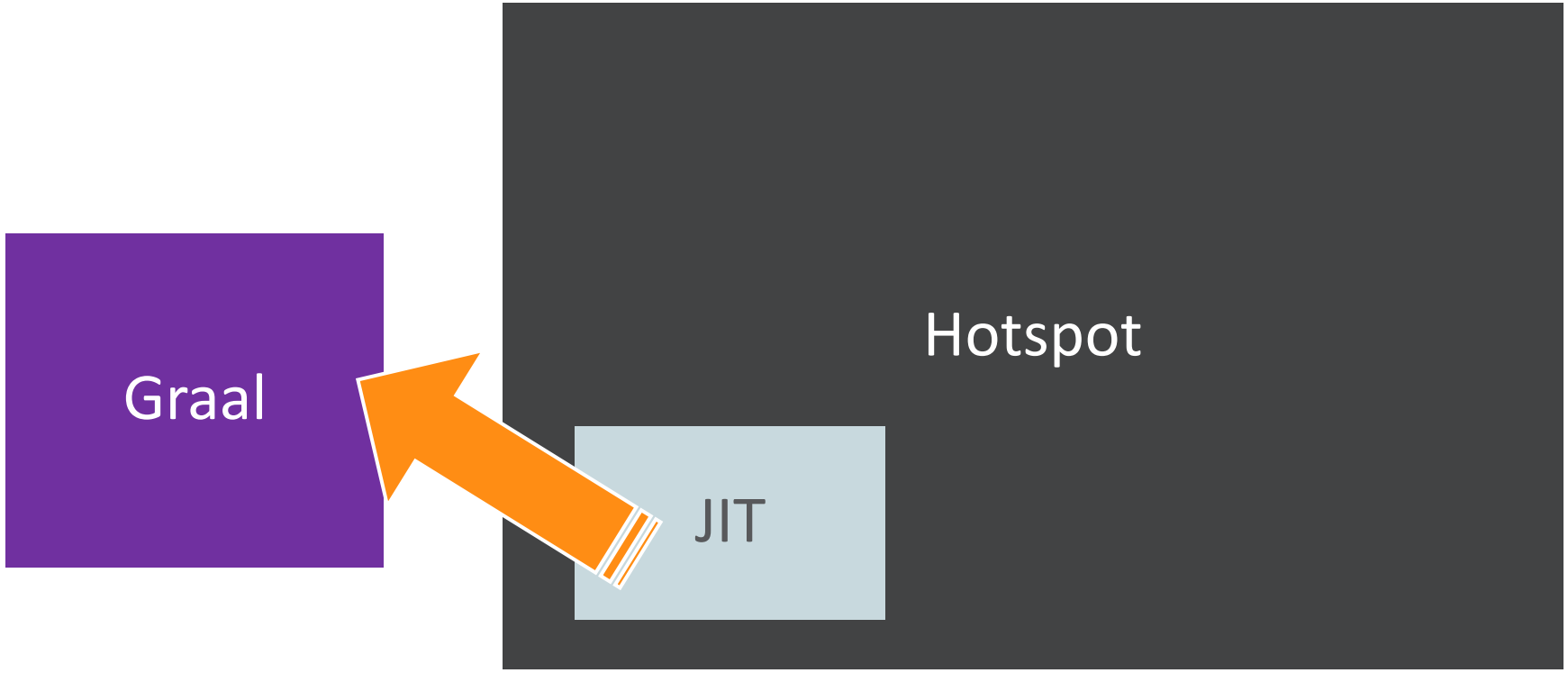
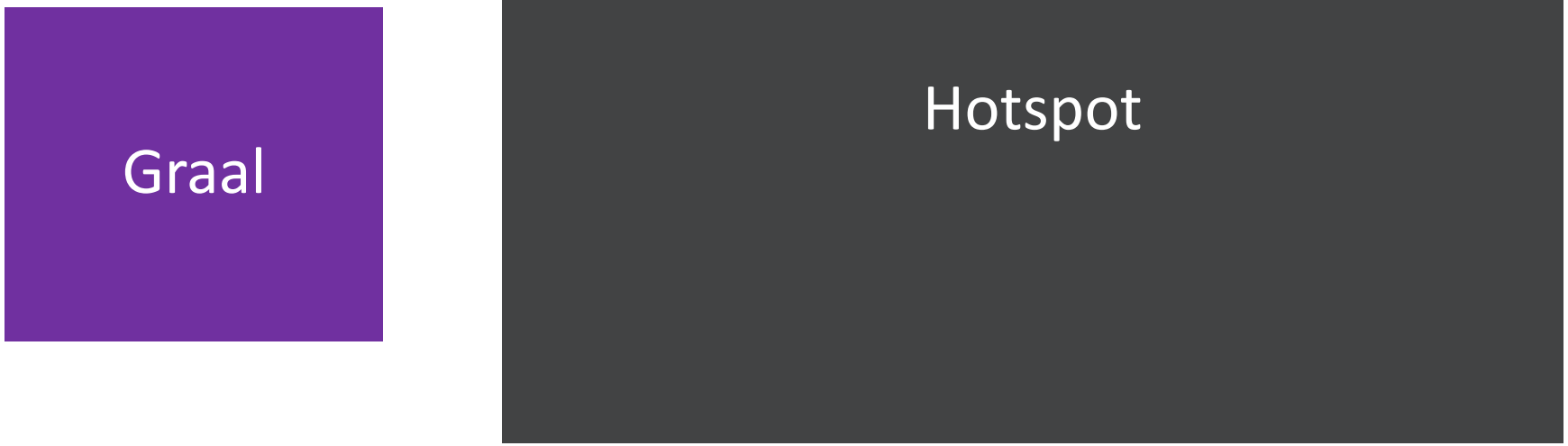
Hotspot

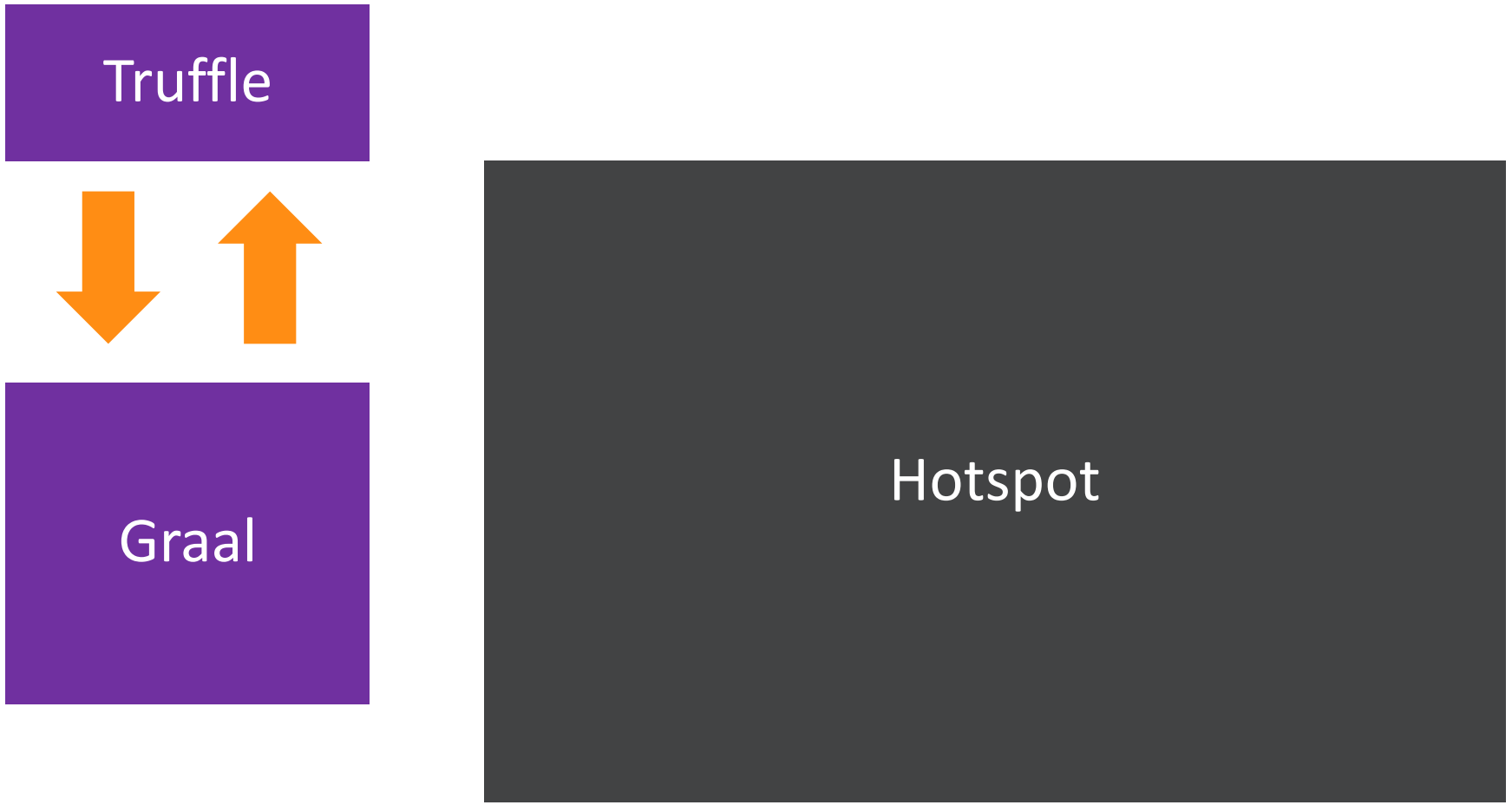
Hotspot











Slightly confusing terminology…

- Graal is a new JIT compiler for the JVM
- Graal VM is the JVM, with Graal, Truffle, and our languages bundled in it
- Truffle uses Graal on your behalf

How we do polyglot in GraalVM

```
Truffle::Interop.eval('application/language', source)

value = Truffle::Interop.import(name)

Truffle::Interop.export(name)
```

```
Interop.eval('application/language', source)

value = Interop.import(name)

Interop.export(name)
```

```ruby
puts Truffle::Interop.eval('application/javascript', '14 + 2')
# 16
```

JavaScript

Ruby

```ruby
puts Truffle::Interop.eval('application/javascript', '14 + 2')
# 16
```

```
Truffle::Interop.eval('application/javascript', "
  function add(a, b) {
    return a + b;
  }

  Interop.export('add', add.bind(this));
")

add = Truffle::Interop.import('add')

puts add.call(14, 2)
# 16
```

Ruby

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Truffle::Interop.eval('application/javascript', "
  function add(a, b) {
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JavaScript

```
function add(a, b) {
  return a + b;
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puts add(14, 2)
# 16
```

JavaScript

```
function add(a, b) {
  return a + b;
}
```

Ruby

```
puts add(14, 2)
# 16
```

```
function Point(x, y) {
  this.x = x;
  this.y = y;
}

function random_points(n) {
  points = [];
  for (i = 0; i < n; i++) {
    points[i] = new Point(Math.random(), Math.random())
  }
  return points;
}

points = random_points(100)

point = points[0]
puts point.x, point.y
# 0.642460680339328
# 0.116305386298814
```

JS

```
function Point(x, y) {
  this.x = x;
  this.y = y;
}

function random_points(n) {
  points = [];
  for (i = 0; i < n; i++) {
    points[i] = new Point(Math.random(), Math.random())
  }
  return points;
}
```

Ruby

```
points = random_points(100)

point = points[0]
puts point.x, point.y
# 0.642460680339328
# 0.116305386298814
```

Performance

```ruby
def clamp(num, min, max)
  [min, num, max].sort[1]
end

def cmyk_to_rgb(c, m, y, k)
  Hash[{
    r: (65535 - (c * (255 - k) + (k << 8))) >> 8,
    g: (65535 - (m * (255 - k) + (k << 8))) >> 8,
    b: (65535 - (y * (255 - k) + (k << 8))) >> 8
  }.map { |k, v| [k, clamp(v, 0, 255)] }]
end

benchmark do
  cmyk_to_rgb(rand(255), rand(255), rand(255), rand(255))
end
```

```ruby
def clamp(num, min, max)
  [min, num, max].sort[1]
end

def cmyk_to_rgb(c, m, y, k)
  Hash[{
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  }.map { |k, v| [k, clamp(v, 0, 255)] }]
end

benchmark do
  cmyk_to_rgb(rand(255), rand(255), rand(255), rand(255))
end
```
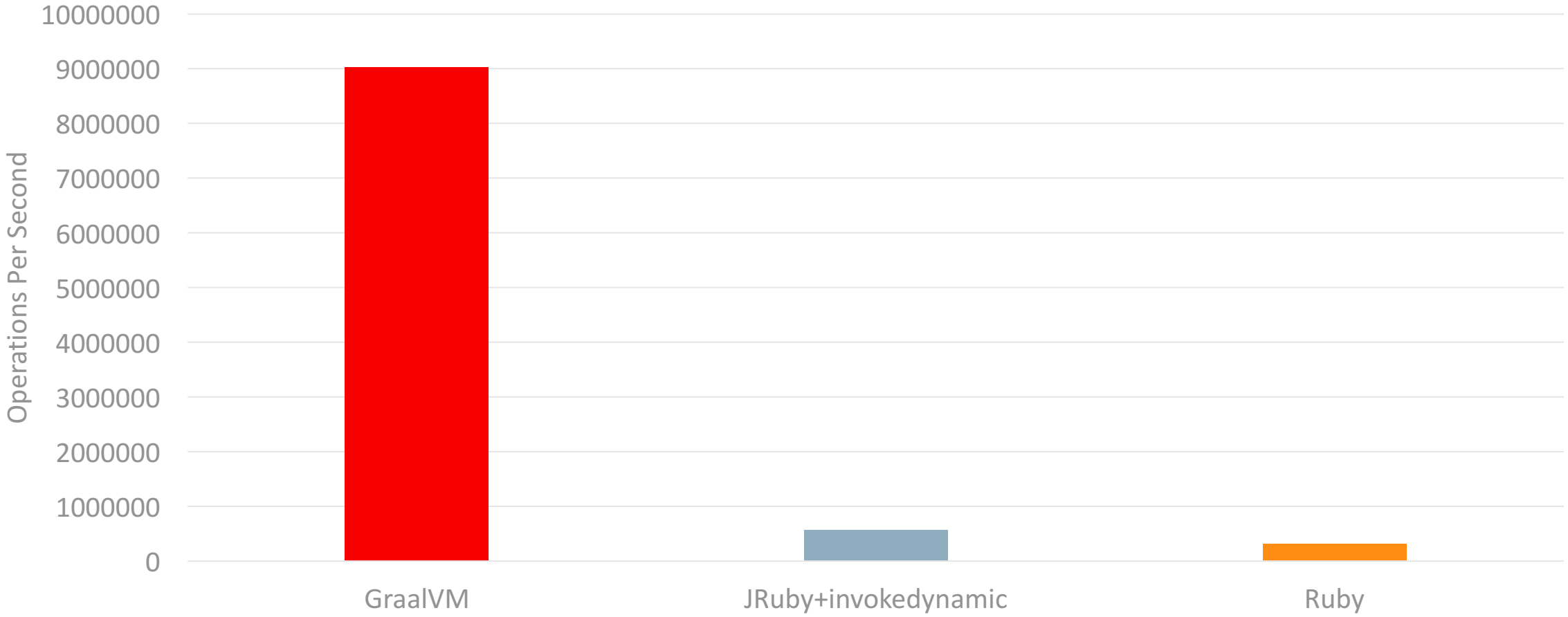
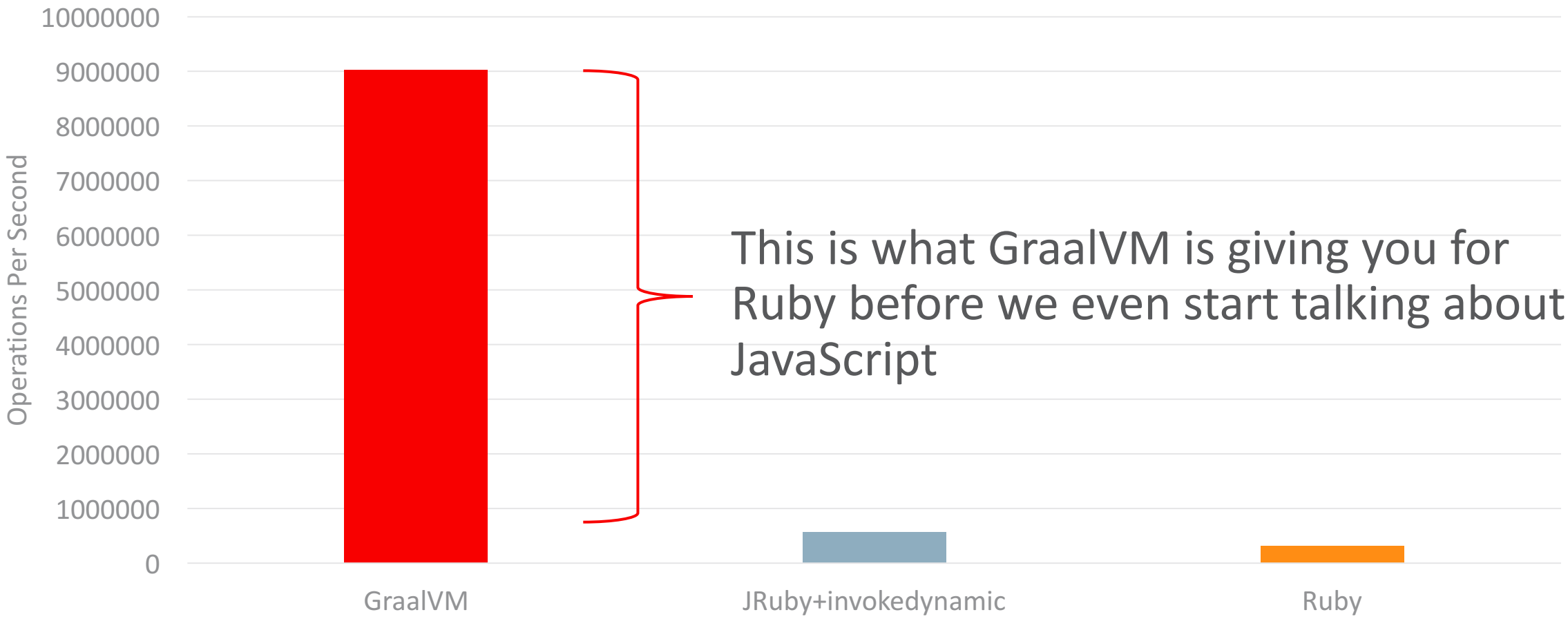

Warms up and then reports iterations per second

Random inputs stop the whole thing being totally optimised away

`clamp` in Pure Ruby



`clamp` in Pure Ruby



```ruby
require 'v8'

context = V8::Context.new

$clamp = context.eval("
  function clamp(num, min, max) {
    if (num < min) {
      return min;
    } else if (num > max) {
      return max;
    } else {
      return num;
    }
  }
  clamp;
")

def cmyk_to_rgb(c, m, y, k)
  Hash[{
    r: (65535 - (c * (255 - k) + (k << 8))) >> 8,
    g: (65535 - (m * (255 - k) + (k << 8))) >> 8,
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  }.map { |k, v| [k, $clamp.call(v, 0, 255)] }]
end
```

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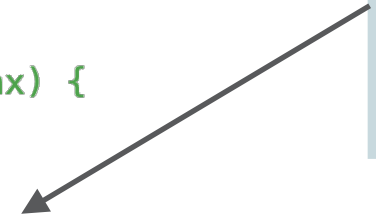
  }.map { |k, v| [k, $clamp.call(v, 0, 255)] }]
end
```

Not only have we rewritten in JavaScript, but the JavaScript code is simpler than the Ruby



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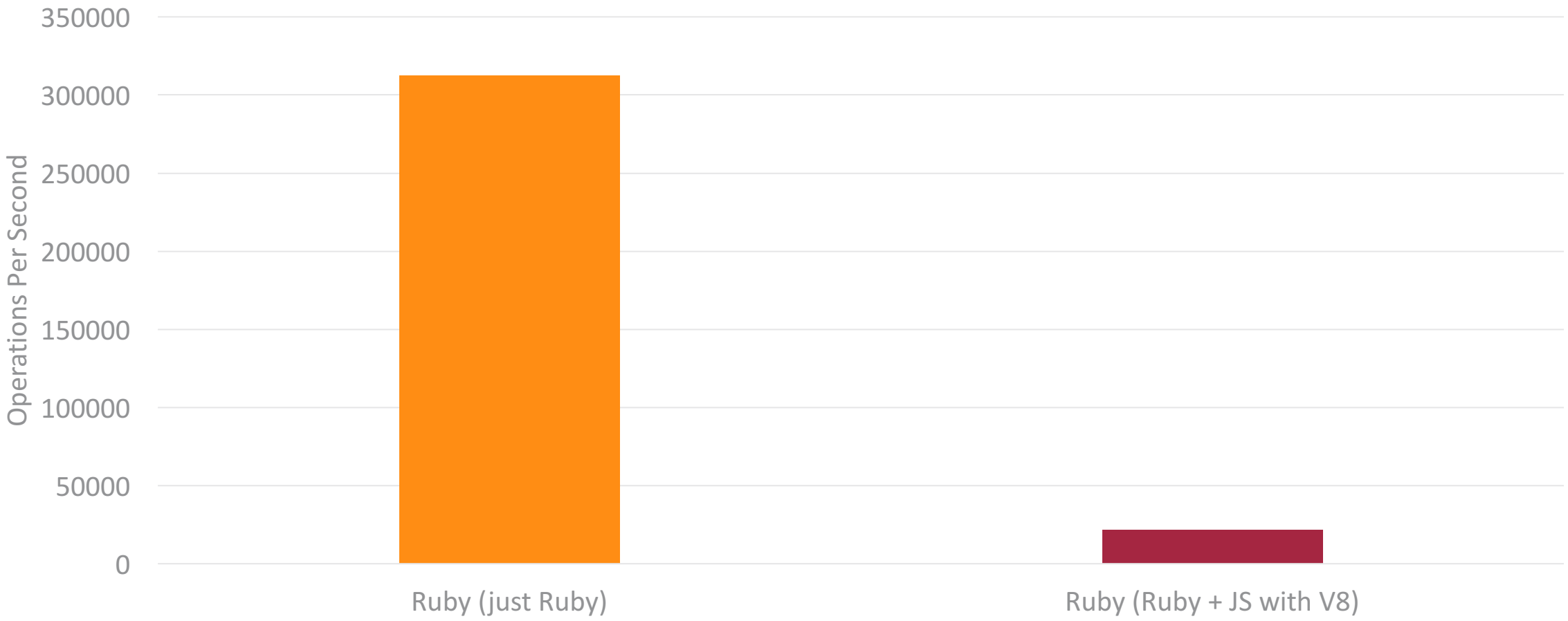
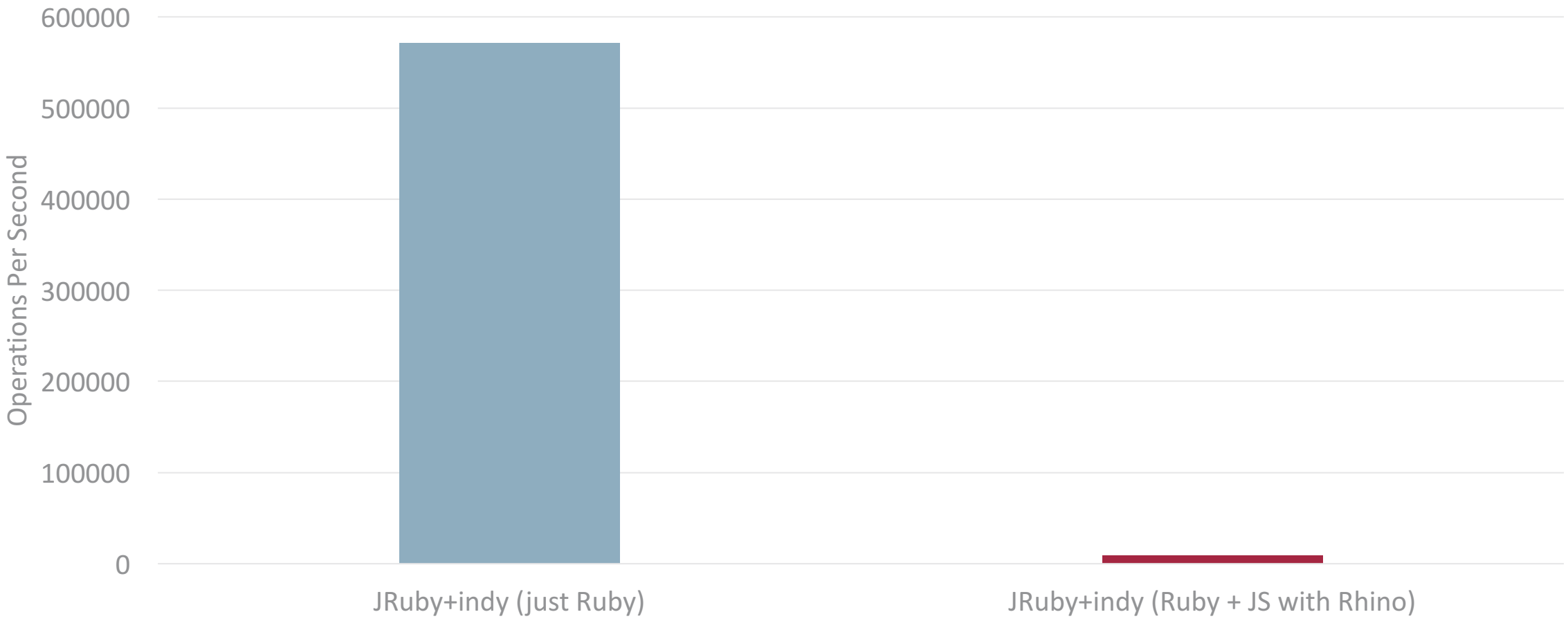
`clamp` in Ruby and JavaScript with V8



```
require 'rhino'

context = Rhino::Context.new
```

`clamp` in Ruby and JavaScript with JRuby and Rhino



```
factory = javax.script.ScriptEngineManager.new
engine = factory.getEngineByName 'nashorn'
bindings = engine.createBindings

$clamp = engine.eval("
  function clamp(num, min, max) {
    if (num < min) {
      return min;
    } else if (num > max) {
      return max;
    } else {
      return num;
    }
  }
", bindings)

def cmyk_to_rgb(c, m, y, k)
  Hash[{
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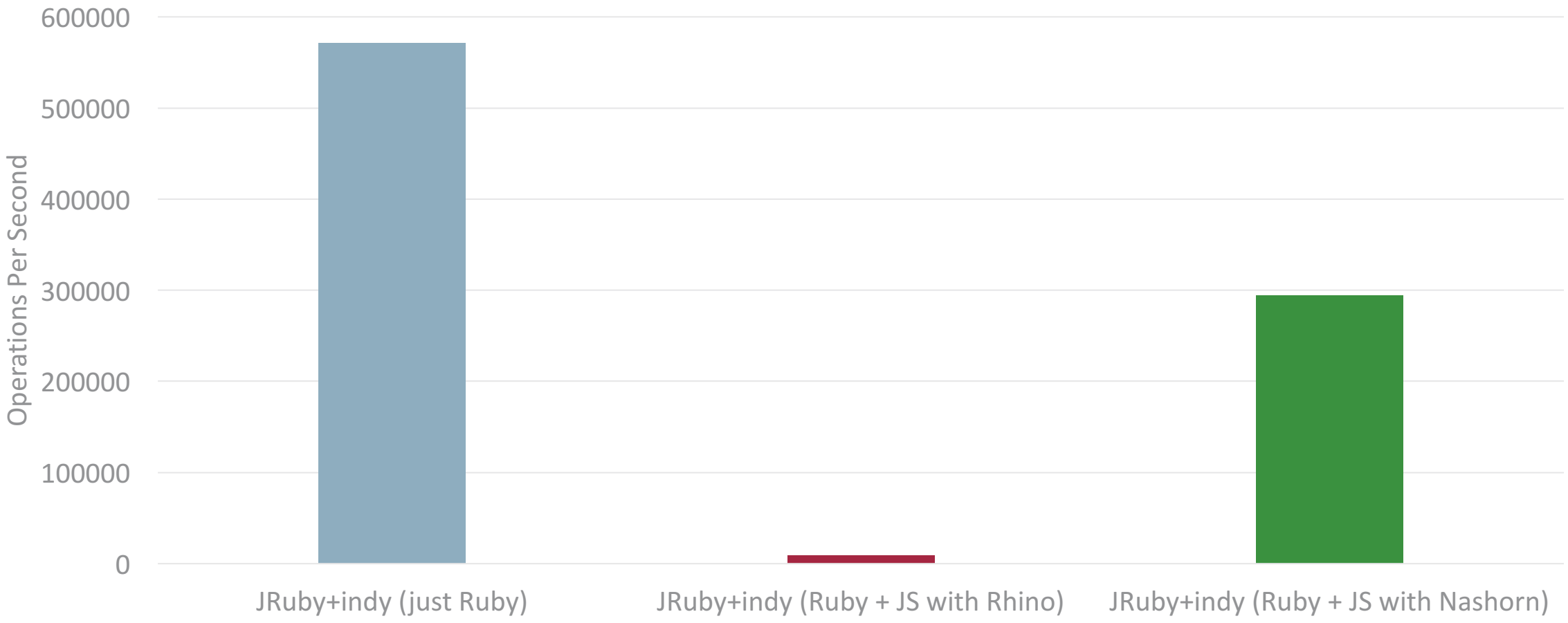
  }.map { |k, v| [k, $clamp.call(v, 0, 255)] }]
end
```

`clamp` in Ruby and JavaScript with JRuby and Nashorn



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  } else {
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}
```

```
def cmyk_to_rgb(c, m, y, k)
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  }.map { |k, v| [k, clamp(v, 0, 255)] }]
end
```
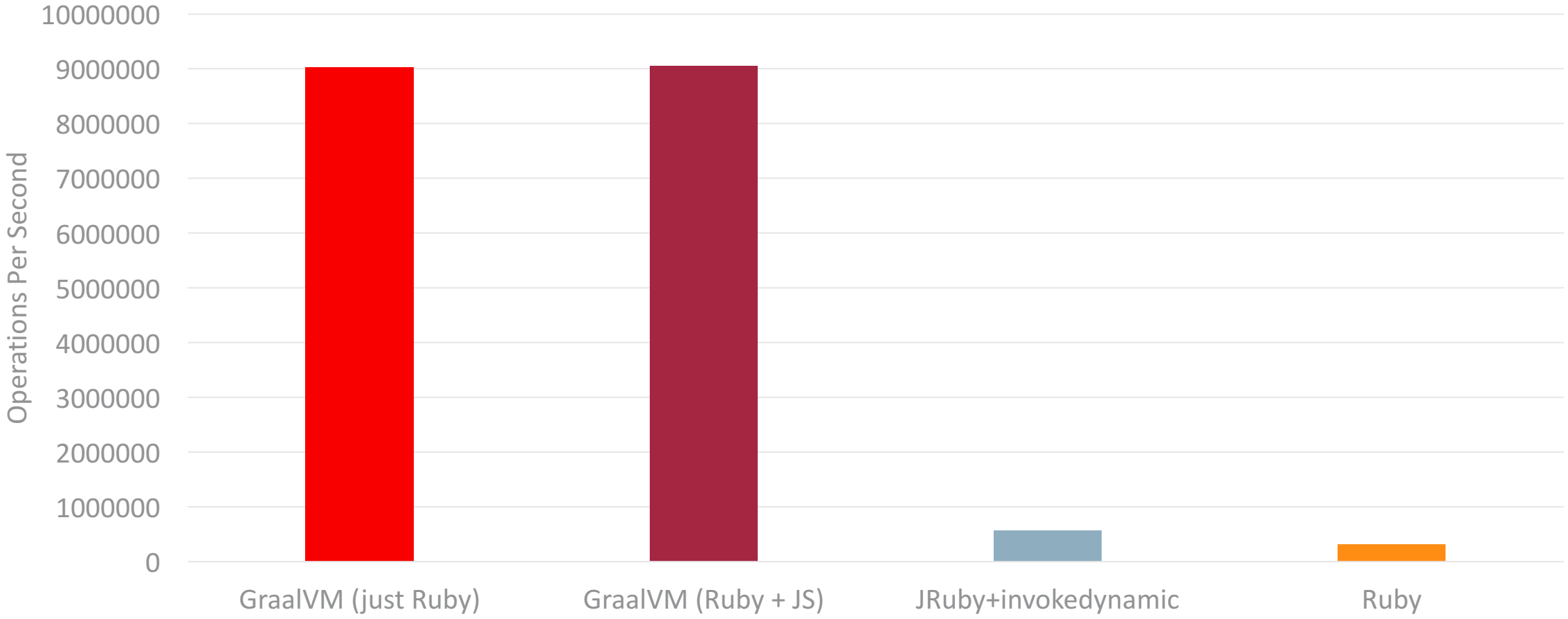
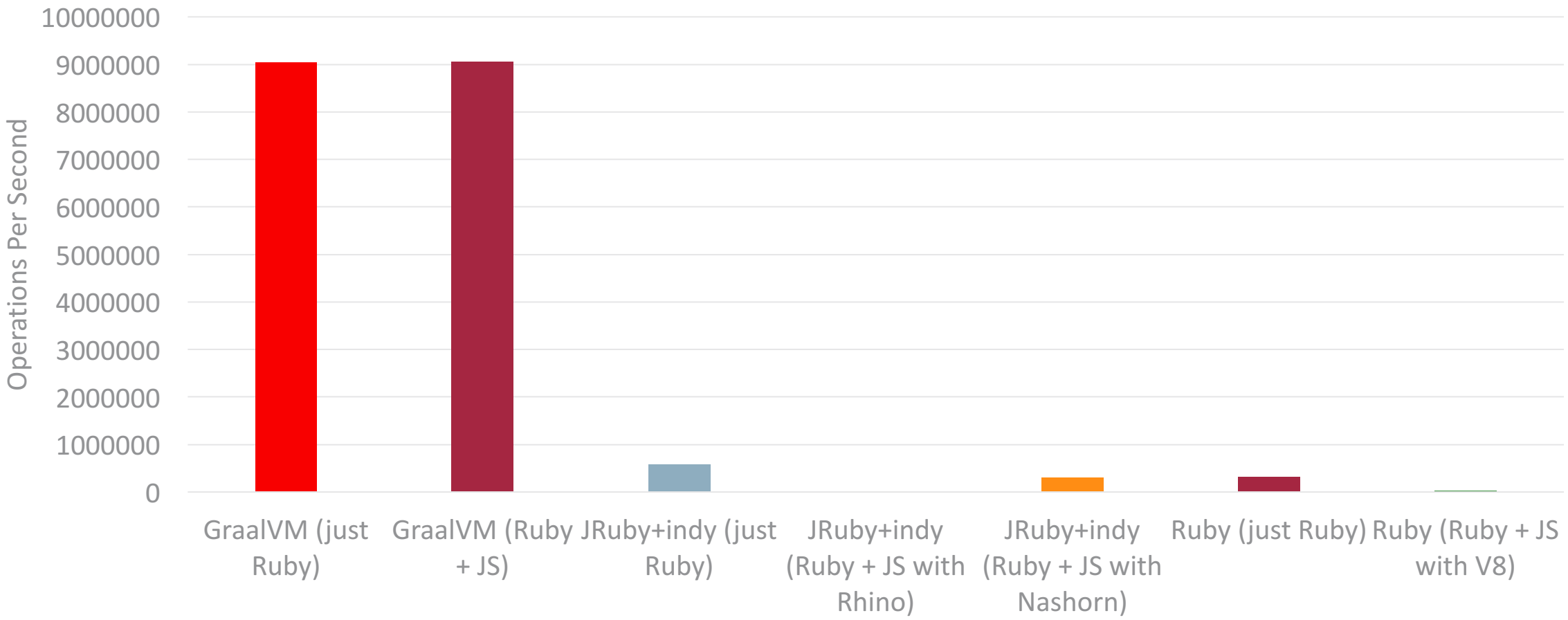
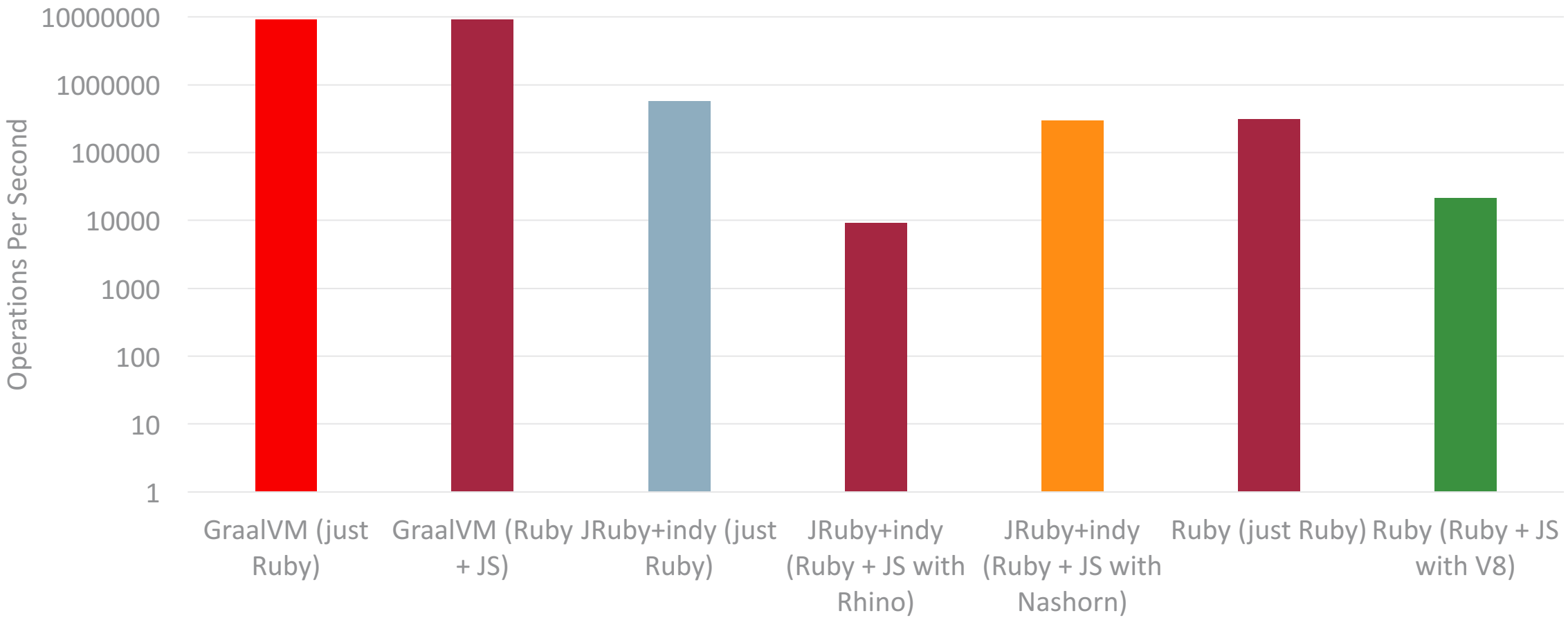

`clamp` in Ruby and JavaScript with GraalVM



`clamp` in all configurations

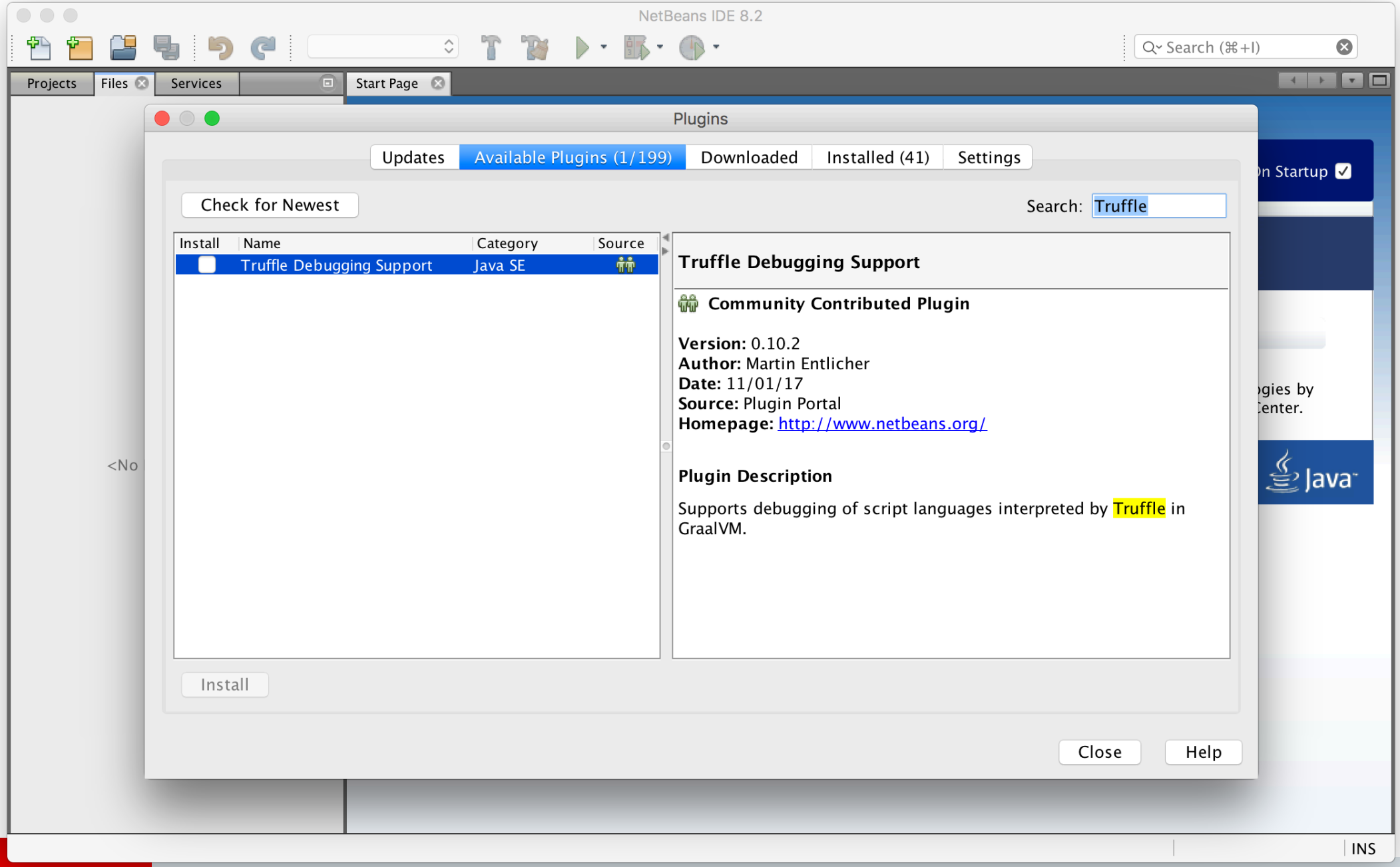


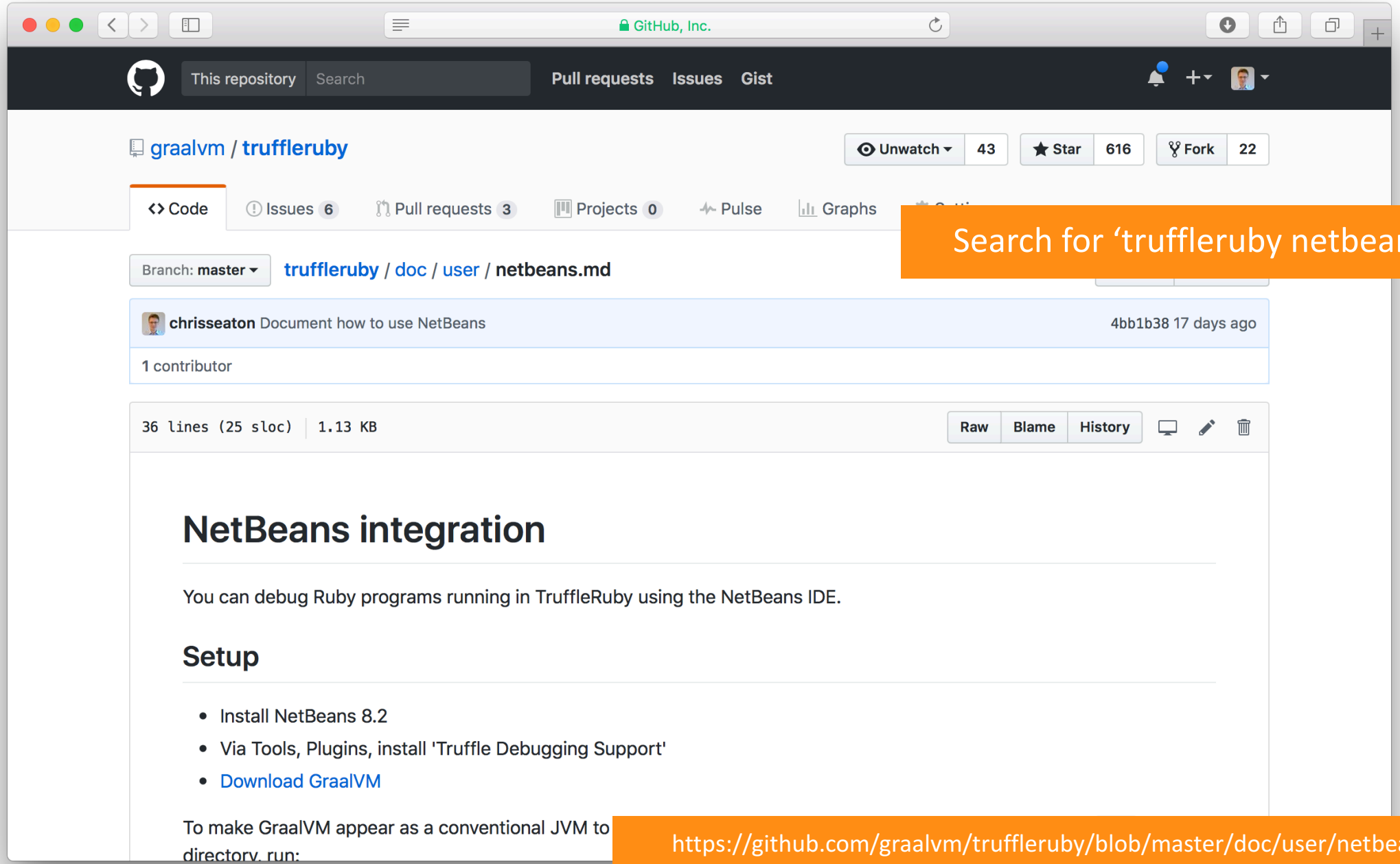
`clamp` in all configurations



GraalVM and NetBeans

NetBeans 8.2

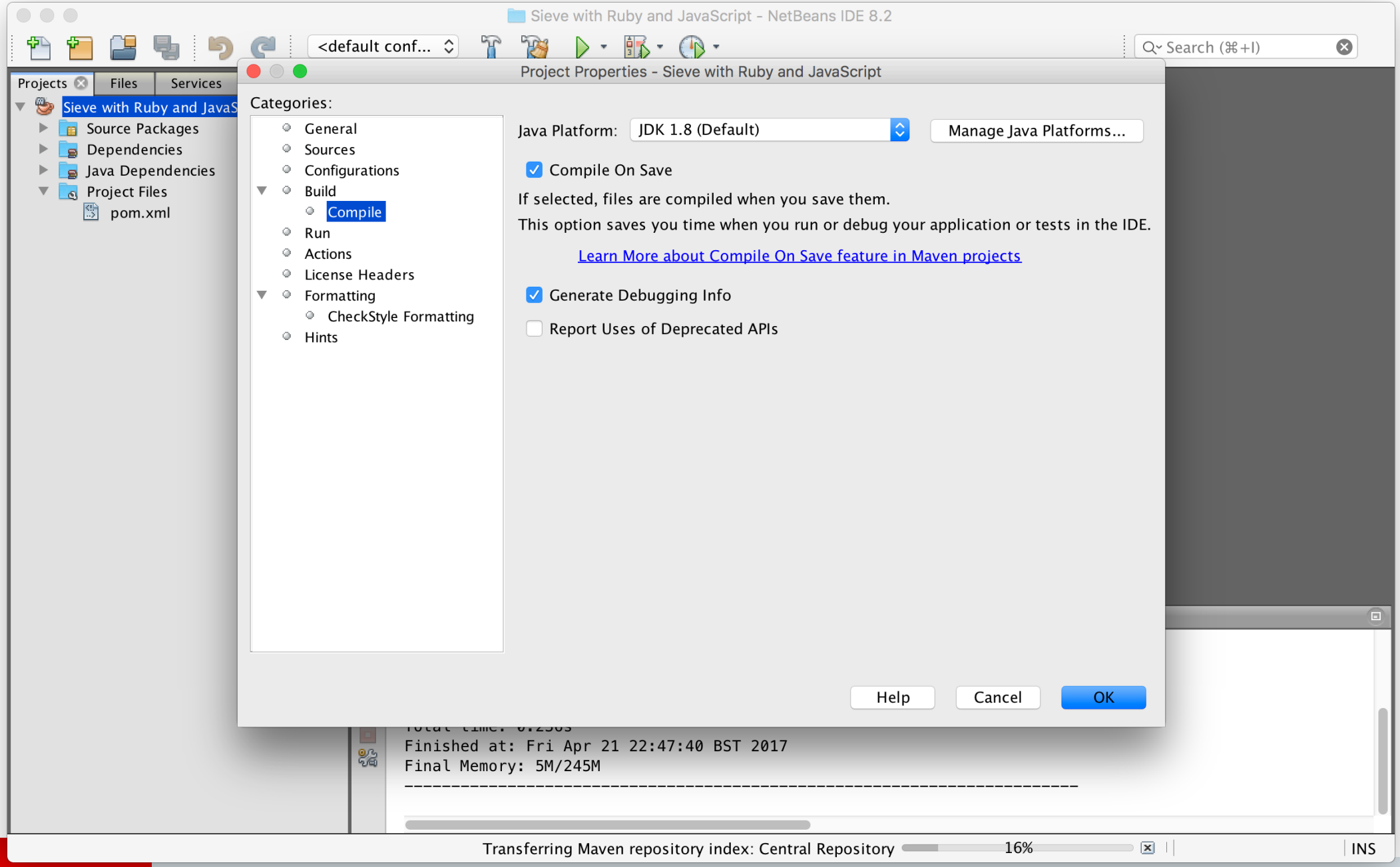


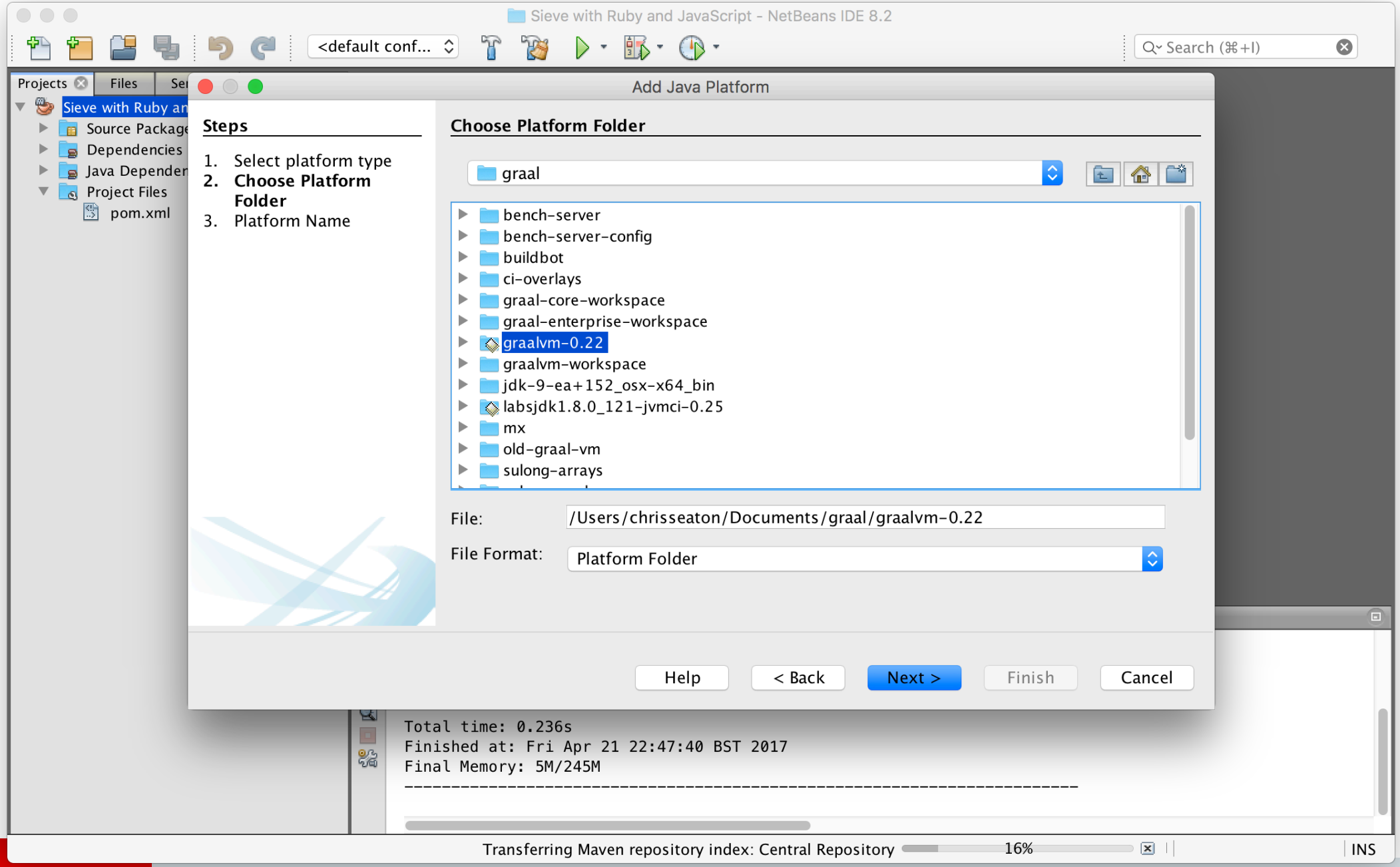


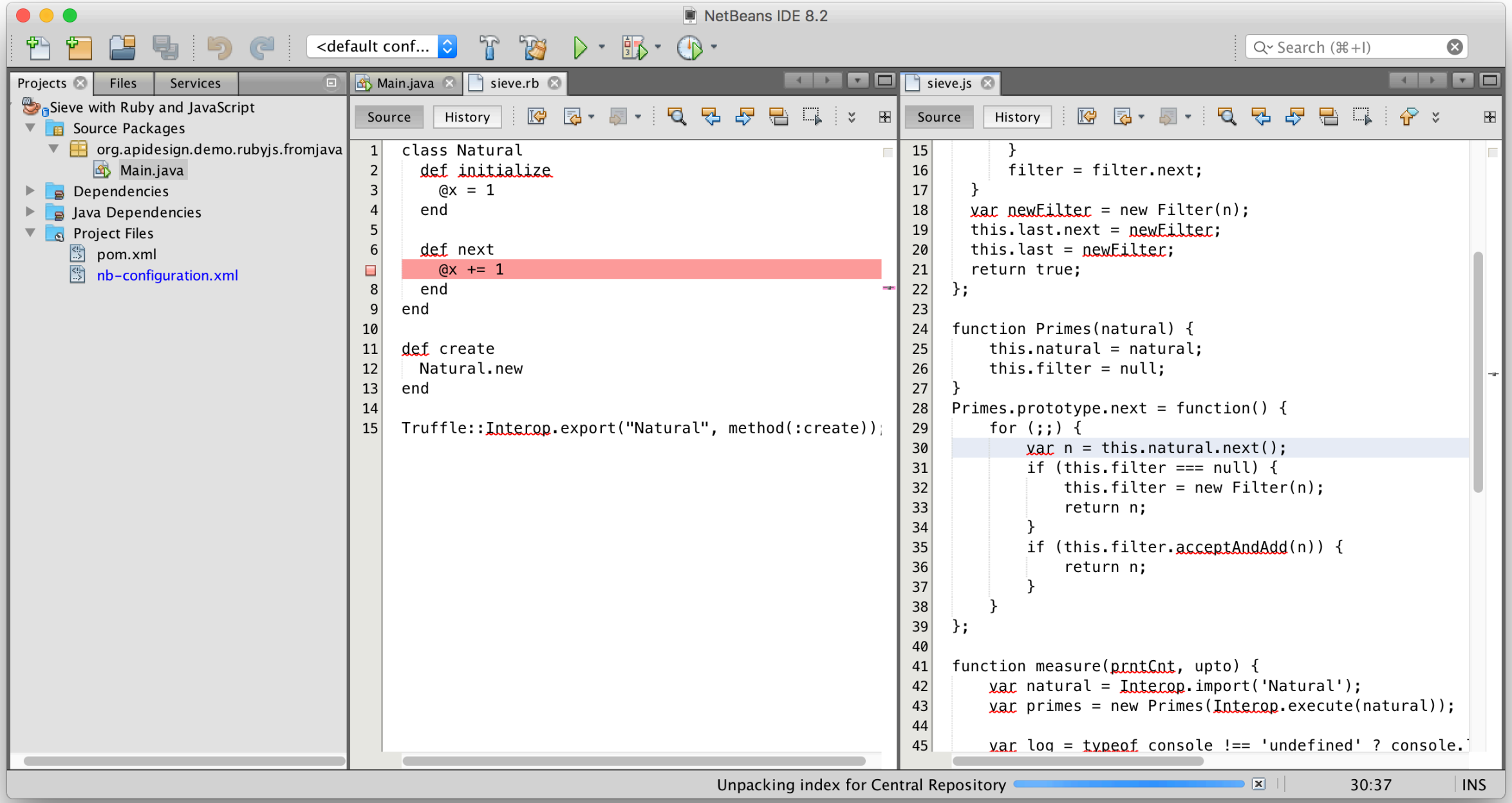
Search for ‘truffleruby netbeans’

https://github.com/graalvm/truffleruby/blob/master/doc/user/netbeans.md

git clone https://github.com/jtulach/sieve.git

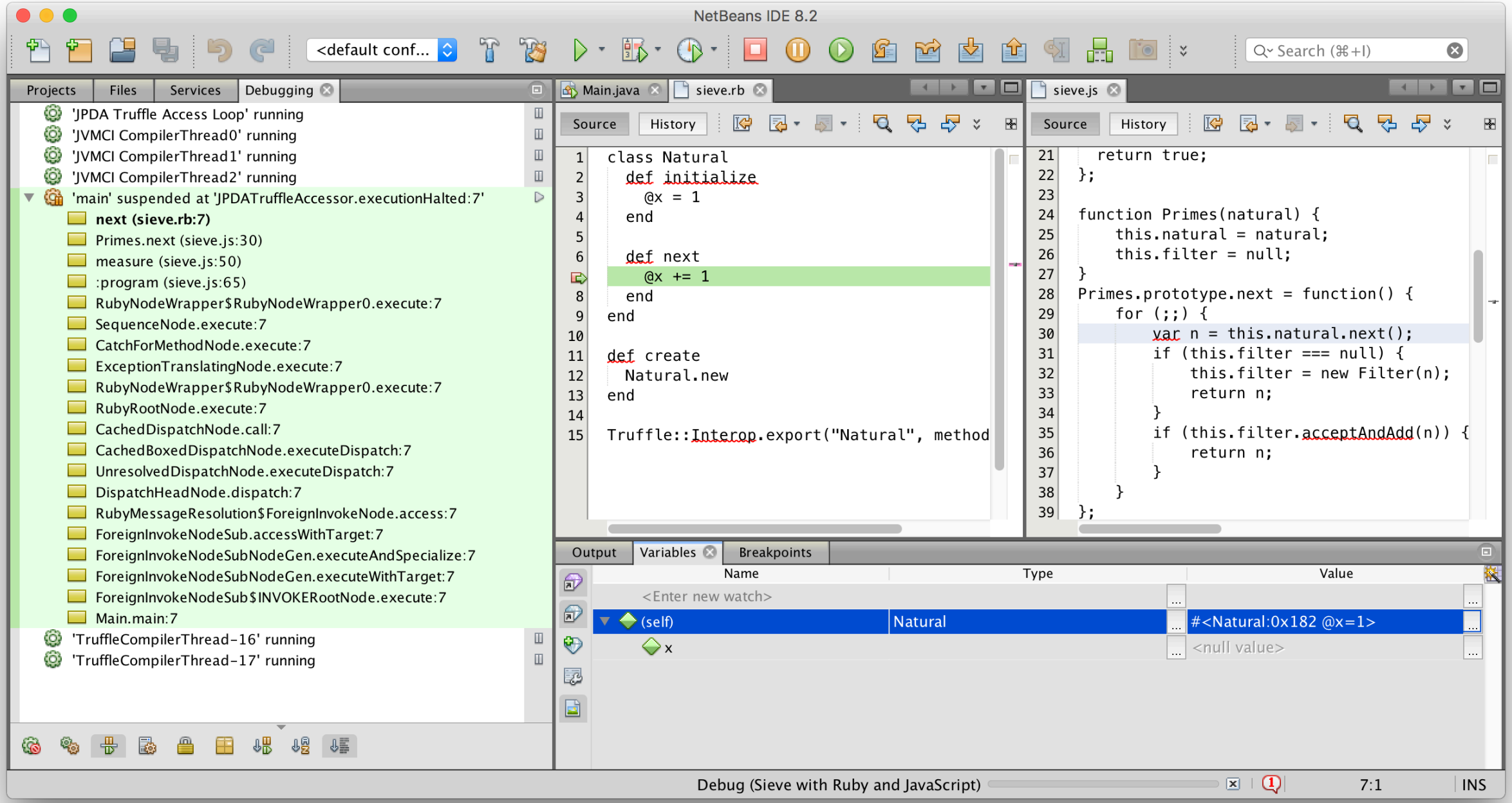






```ruby
class Natural
  def initialize
    @x = 1
  end

  def next
    @x += 1
  end
end

def create
  Natural.new
end

Truffle::Interop.export("Natural", method(:create));
```

```javascript
      }
      filter = filter.next;
  }
  var newFilter = new Filter(n);
  this.last.next = newFilter;
  this.last = newFilter;
  return true;
};

function Primes(natural) {
    this.natural = natural;
    this.filter = null;
}
Primes.prototype.next = function() {
    for (;;) {
        var n = this.natural.next();
        if (this.filter === null) {
            this.filter = new Filter(n);
            return n;
        }
        if (this.filter.acceptAndAdd(n)) {
            return n;
        }
    }
};

function measure(prntCnt, upto) {
    var natural = Interop.import('Natural');
    var primes = new Primes(Interop.execute(natural));
```

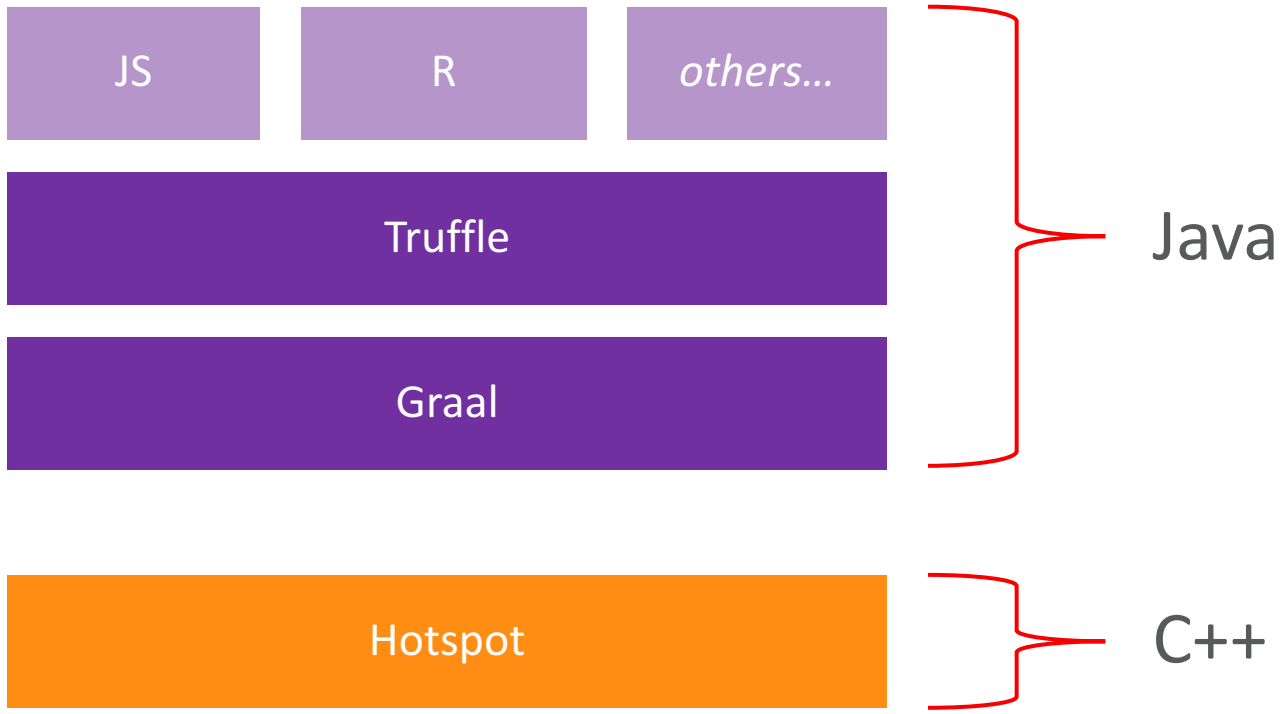


How to use GraalVM

GraalVM – everything in one package today

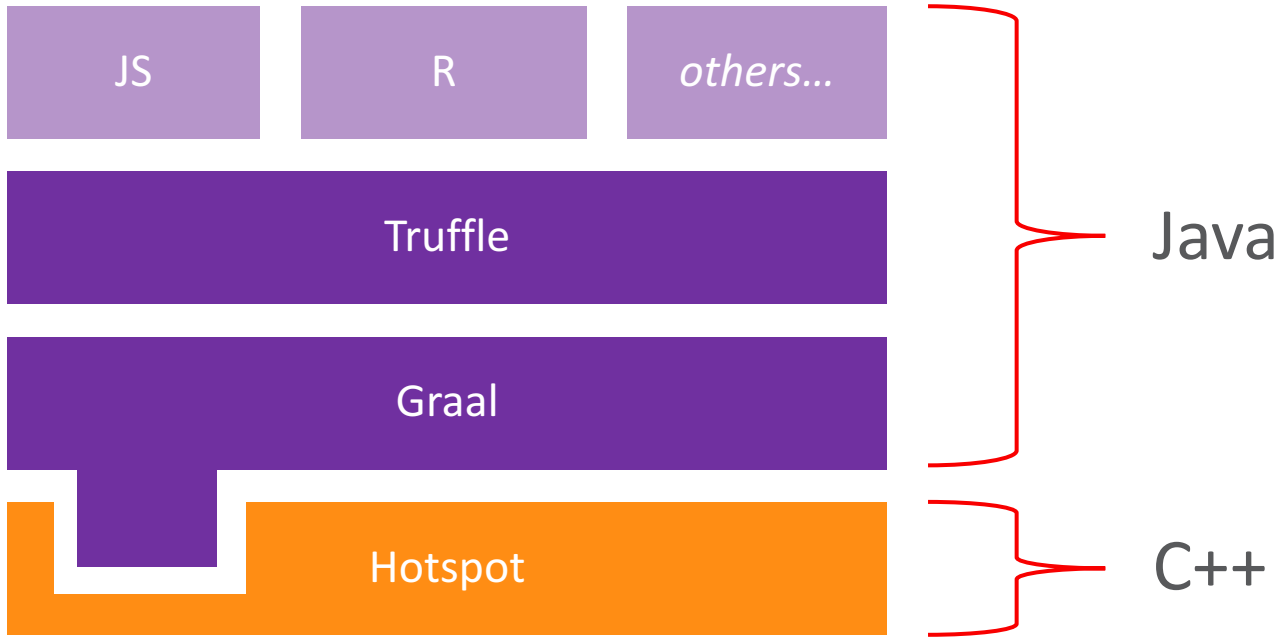
- Includes:
  - JVM (RE or DK)
  - Java
  - JavaScript
  - Ruby
  - R
  - More in the future
- Binary tarball release
- Mac or Linux

Java 9 – runs on an unmodified JVM



Java 9 – runs on an unmodified JVM

JVMCI
(JVM Compiler Interface)



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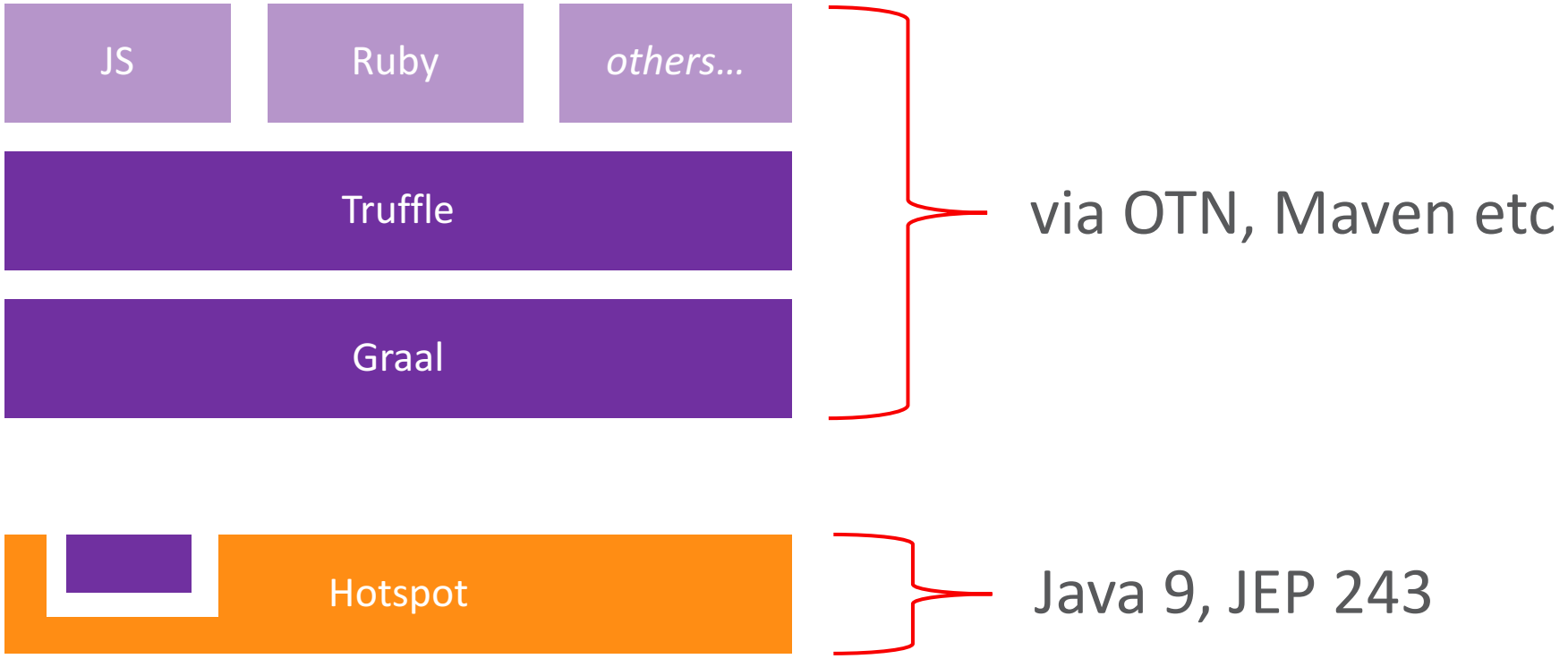
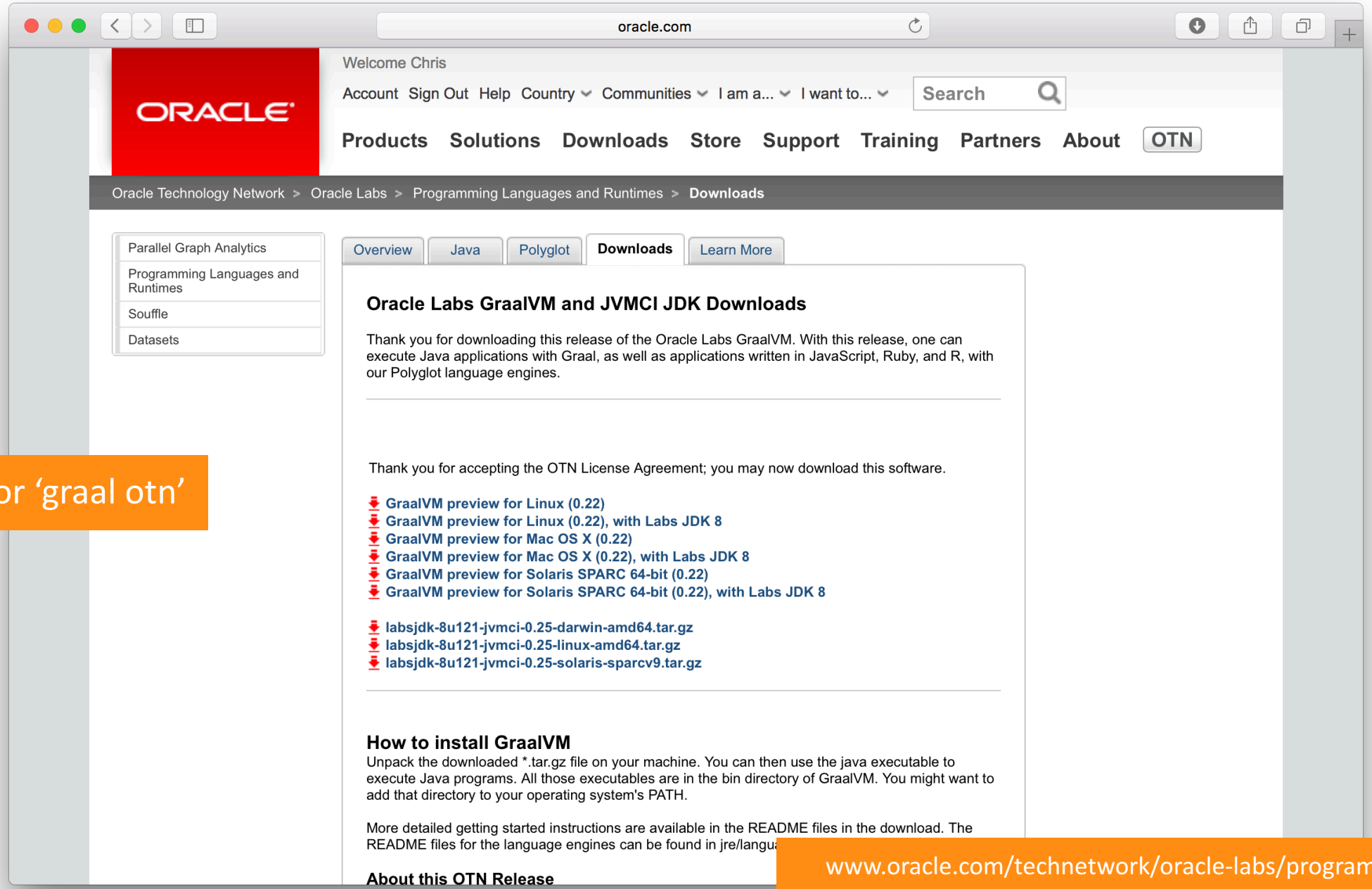
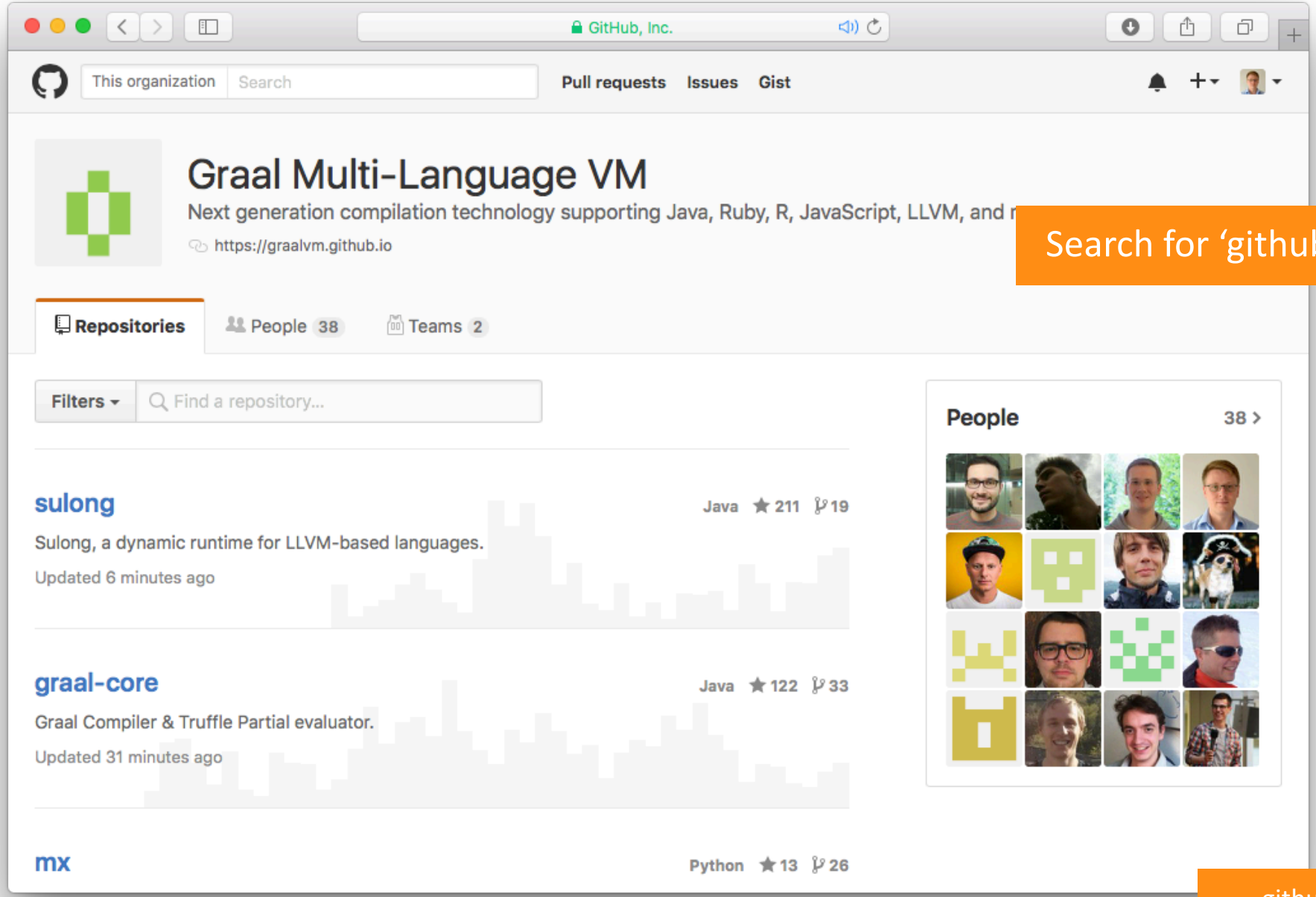


Where to find more information



Search for ‘graal otn’

www.oracle.com/technetwork/oracle-labs/program-languages



Search for ‘github graalvm’

github.com/graalvm

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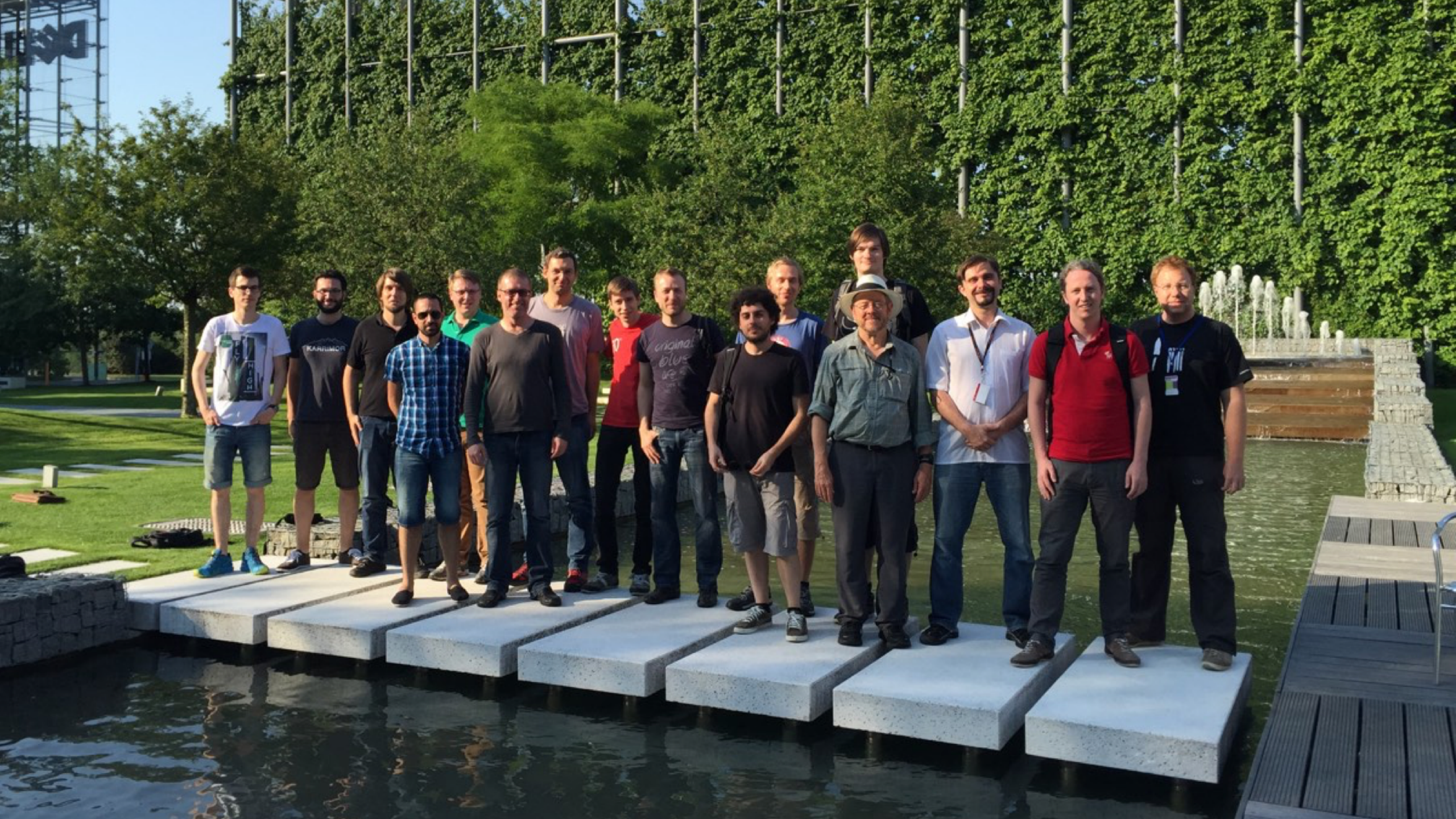
@chrisgseaton

github.com/graalvm

gitter.im/graalvm/graal-core

Search ‘otn graalvm’



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Michael Van De Vanter
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Christian Wimmer
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Oracle Interns
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Miguel Garcia
Shams Imam
Alexey Karyakin
Stephen Kell
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Julian Lettner
Joe Nash
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Alumni
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Michael Haupt
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Floréal Morandat

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Prof. Jan Vitek
Tomas Kalibera
Petr Maj
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Prof. Duncan Temple Lang
Nicholas Ulle

University of Lugano, Switzerland
Prof. Walter Binder
Sun Haiyang
Yudi Zheng

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