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# Polyglot on the JVM with Graal

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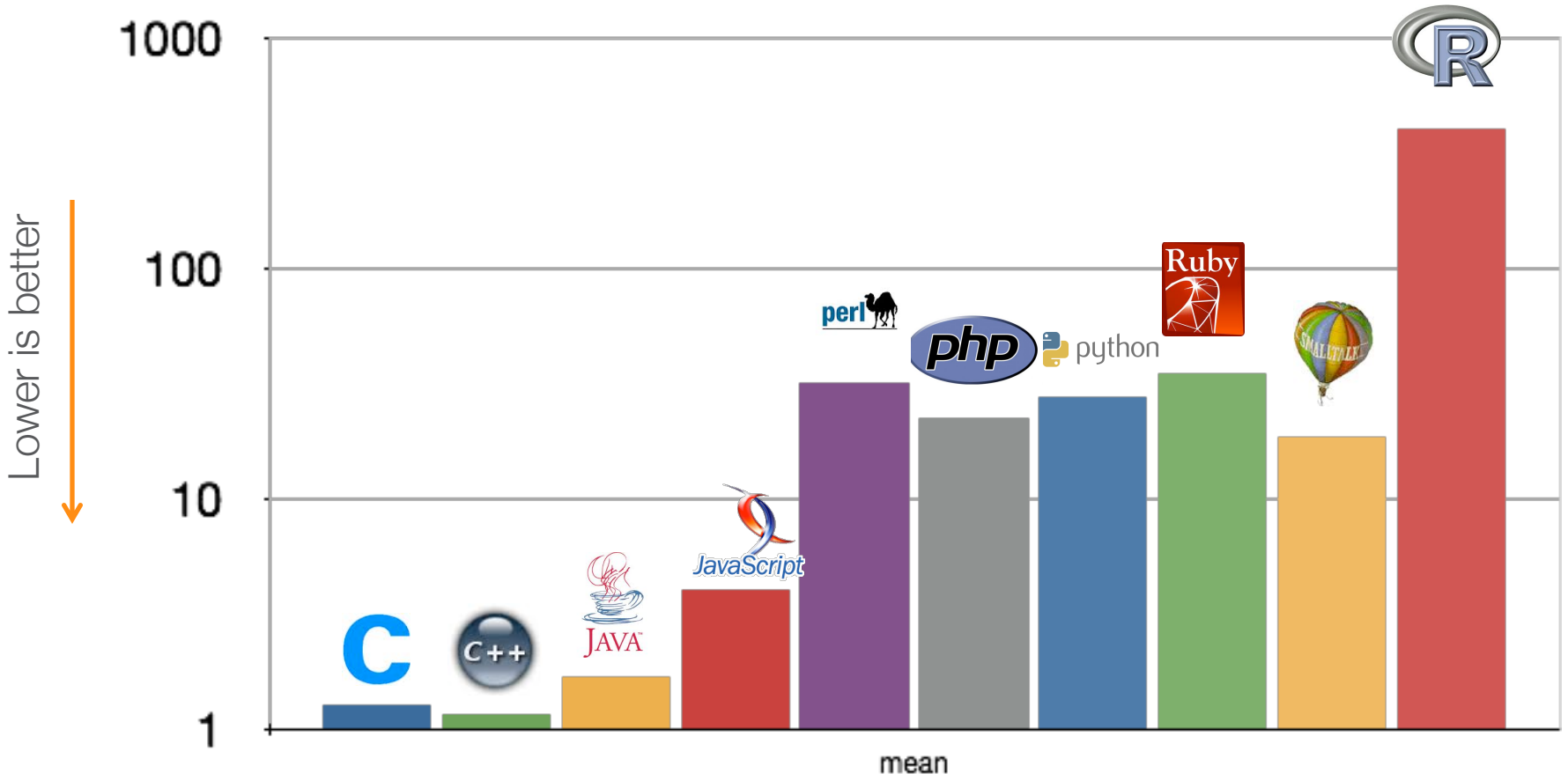
# The World Is Polyglot



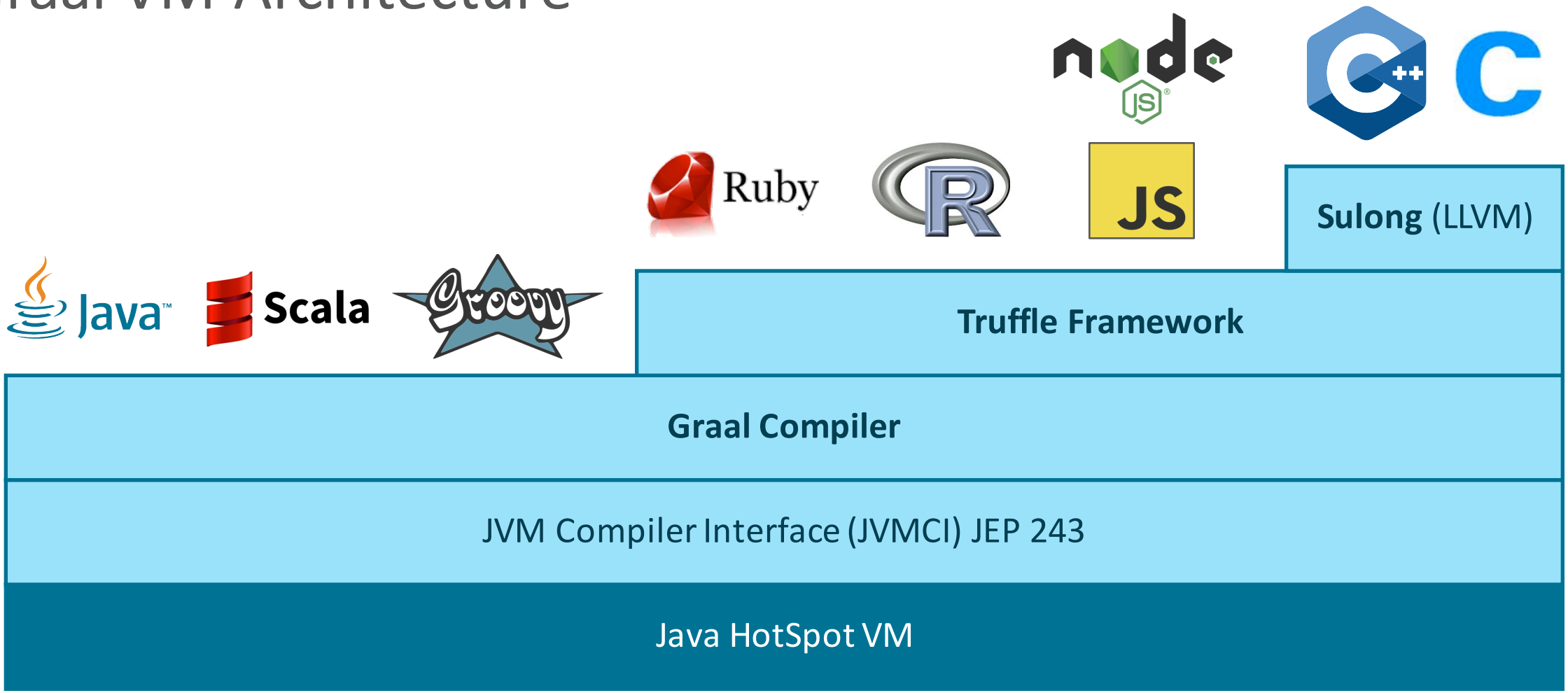
# Graal Vision

**High performance** for all languages

**Zero overhead interoperability** between languages

**Shared infrastructure and tooling** across languages

# Graal VM Architecture



# Graal Compiler Optimizations

inlining, global value numbering, constant folding and propagation, dead code elimination, partial escape analysis, conditional elimination, loop-invariant code motion, core library intrinsifications, invariant reassociation, bounds-checking elimination, read elimination, checkcast elimination, string builder optimizations, test reordering, strength reduction, null check elimination, allocation site merging, speculative guard movement, deoptimization grouping, common subexpression elimination, profile-based devirtualization, class hierarchy analysis, redundant lock elision, tail duplication, path duplication, push-through-phi, de-duplication, alias classification and pointer analysis, induction variable analysis, loop fusion/inversion/unrolling/splitting/unswitching, automatic vectorization, register allocation, instruction selection, peephole optimizations, instruction scheduling, code-block reordering

# Partial Escape Analysis (1)

```
public static Car getCached(int hp, String name) {
    Car car = new Car(hp, name, null);
    Car cacheEntry = null;
    for (int i = 0; i < cache.length; i++) {
        if (car.hp == cache[i].hp &&
              car.name == cache[i].name) {
            cacheEntry = cache[i];
            break;
        }
    }
    if (cacheEntry != null) {
        return cacheEntry;
    } else {

        addToCache(car);
        return car;
    }
}
```

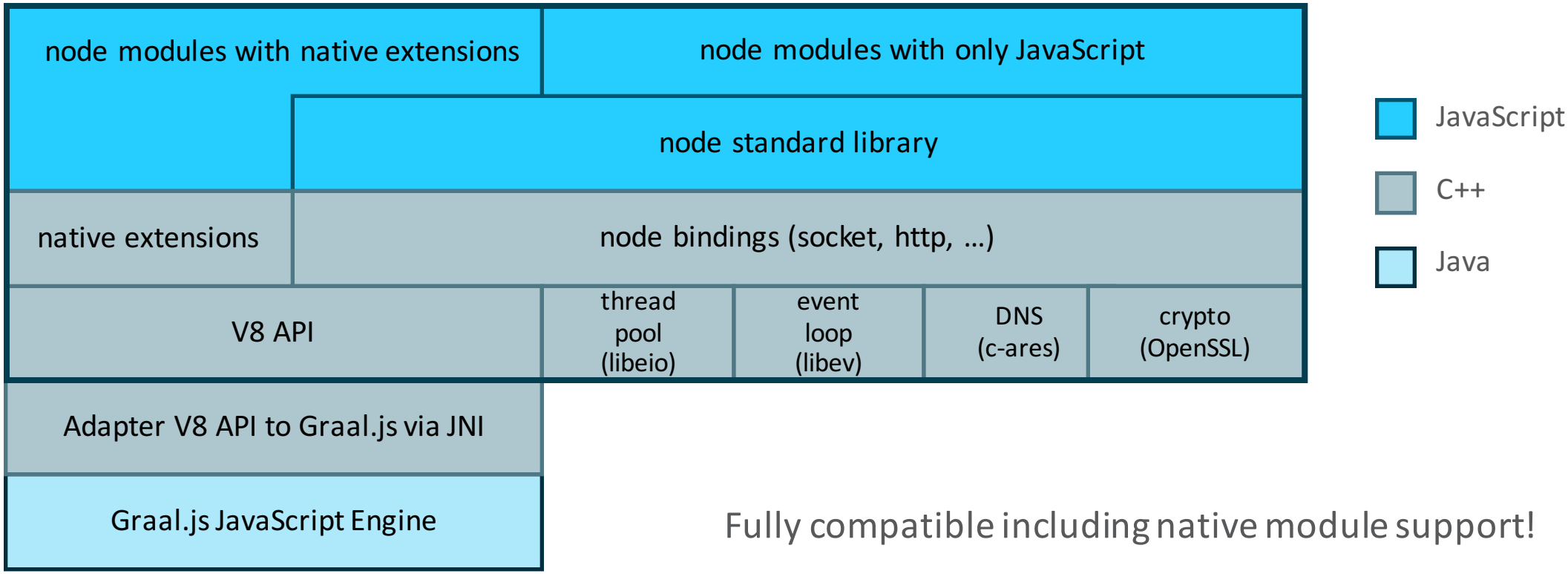
# Partial Escape Analysis (2)

```
public static Car getCached(int hp, String name) {

    Car cacheEntry = null;
    for (int i = 0; i < cache.length; i++) {
        if (hp == cache[i].hp &&
              name == cache[i].name) {
            cacheEntry = cache[i];
            break;
        }
    }
    if (cacheEntry != null) {
        return cacheEntry;
    } else {
        Car car = new Car(hp, name, null);
        addToCache(car);
        return car;
    }
}
```

- `new Car(...)` escapes at:
  - `addToCache(car);`
  - `return car;`
- Might be a very unlikely path
- No allocation in frequent path

# Graal.js Architecture




Fully compatible including native module support!

# Graal OTN Download

- oracle.com/technetwork/oracle-labs/program-languages
- Based on Java 8u92
- Includes a Graal VM technology preview running
  - Java bytecode based languages   
  - JavaScript and node.js  
  - Ruby 
  - R 

# Command Aliases

- graalvm
  - Starts a JVM with Polyglot engine available based on Java 8u92
  - Add –J:-XX:+UseJVMCICompiler for selecting Graal for Java compilations
- js
  - JavaScript engine with full ECMAScript 6 support
- node
  - Running Node.js 6.2.2 with Graal.js replacing V8 as the JavaScript engine
- ruby, irb
  - Running Ruby compatible with version 2.3.1
- R, RScript
  - FastR implementation compatible with GNU R version 3.2.4

# Demo

# Sulong


- Enable LLVM bitcode as just another ”Truffle language”
- Why?
  - Particular interest in running C, C++, and Fortran programs.
  - High-performance native extensions for managed languages.
  - Low overhead of security-related instrumentations such as bounds checks.
  - Apply dynamic optimization techniques to static context.

```
FUNCTION add(x, y)
  INTEGER :: add
  INTEGER :: a
  INTEGER :: b
  add = a + b
  RETURN
END FUNCTION
```

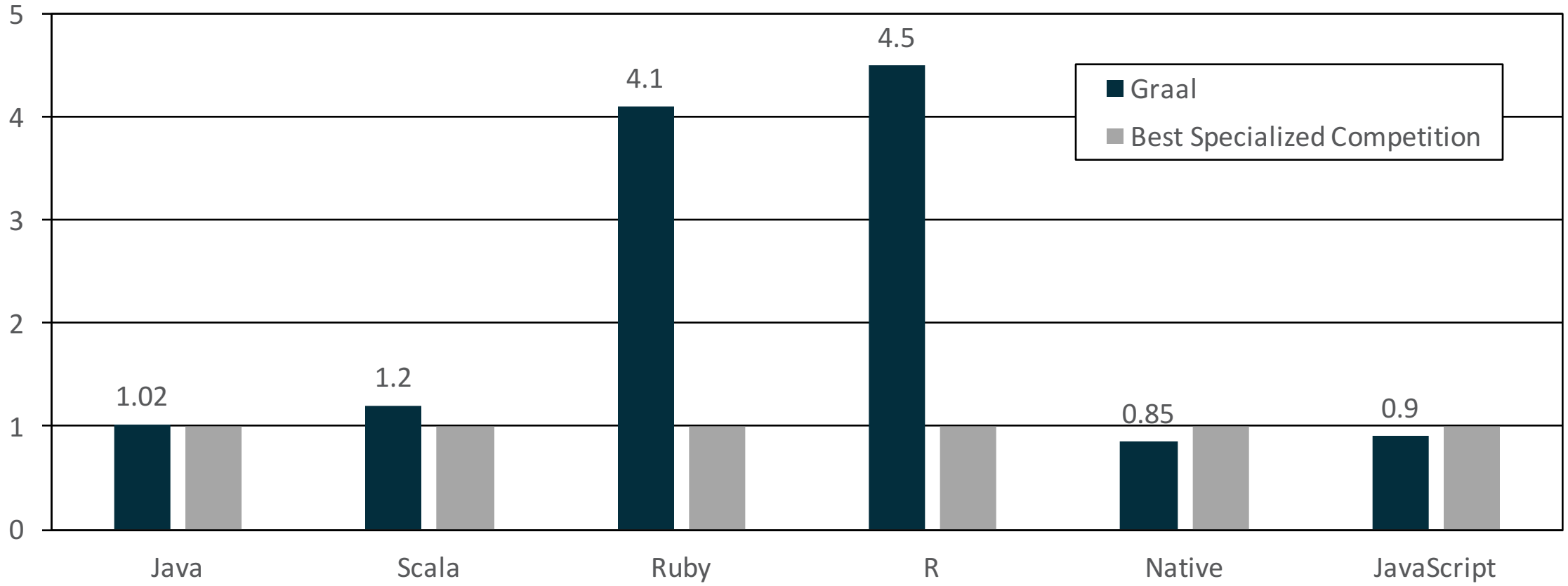
LLVM frontend

```
define i32 @add(i32 %x, i32 %y) #0 {
  %1 = alloca i32, align 4
  %2 = alloca i32, align 4
  store i32 %x, i32* %1, align 4
  store i32 %y, i32* %2, align 4
  %3 = load i32* %1, align 4
  %4 = load i32* %2, align 4
  %5 = add nsw i32 %3, %4
  ret i32 %5
}
```

Graal VM
via Truffle

# Performance Estimates

**Speedup, higher is better**




**Composite performance on 64-bit x86 on well-known benchmark suites relative to recent versions of: HotSpot/Server, JRuby, GNU R, LLVM, V8**

# Open Source

- github.com/graalvm/
- graal-core: dynamic compiler technology
- truffle: language implementation framework
- fastr: implementation of the R runtime
- sulong: execution of LLVM-based languages
- rubytruffle: implementation of the Ruby runtime
- simplelanguage: example language for getting started

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# Q/A

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

github.com/graalvm

gitter.im/graalvm

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