Seeking the holy Graal

Presenter: David Lucas

Who am I ?

- Over 25 years in software industry
- Working with Java since 1998
- IntelliJ / JetBrains introduced me to Kotlin
- Google made me realize …
  Kotlin is now the new Java
- I am a Kotlin Enthusiast
- Extensive production deployments
- Experience with Make, Ant, Maven, and new to Gradle

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My Agenda

- Not a big fan of polyglot
  (but do realize data scientists care)
- Not a big fan of stored procedures
  (but do realize big data cares)
- My goal is to shrink resource usage for microservices (jar -> exec)
- Alternative for Kotlin Native ?

Goals

- Introduce GraalVM
- Demo some capabilities (js, R, rb, py)
- Demo node polyglot (js, java, R)
- Demo LLVM Interpreter
- Demo JDK 11 Nashorn vs GraalJS
- Demo Script Inspection
- Demo Jar to Native Image
- Summary

GraalVM Intro

ORACLE

- Graal is a highly optimized AOT / JIT compiler
- GraalVM is the combination of many Oracle projects over the last decade
- Focus was on improving performance of resource usage
- Platforms: JVM, Node.js, Native
- True Polyglot Runtime (shared data and functions)
- “Make development more productive and run programs faster anywhere” —@graalvm

http://www.graalvm.org/docs/why-graal/

GraalVM Intro

ORACLE

- Languages: Java, JavaScript
  R, Ruby, Python
- LLVM bit code can be executed
- Generates shared libraries and executables
- Oracle has had a JVM in their database since 2009 for Java Stored Procedures
- Adding support in MySQL
- Twitter in PROD, tweet service in 2017
  (built own includes GraalVM)

http://www.graalvm.org/docs/why-graal/

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GraalVM Intro

ORACLE

- Ahead-Of-Time (AOT) Compilation (static) into Intermediate Representation (IR)
- Convert IR to native in more optimized fashion
  - Speculates results and references
  - De-optimizes and Re-optimizes
  - Snippets (inlining)
- Performs advance escape analysis and initialization before execution
- Details on how it creates a smart IR: http://lafo.ssw.uni-linz.ac.at/papers/2013_Onward_OneVMToRuleThemAll.pdf

http://www.graalvm.org/docs/why-graal/

Java™ Scala Kotlin JS Ruby R python™ C C++

Automatic transformation of interpreters to compiler

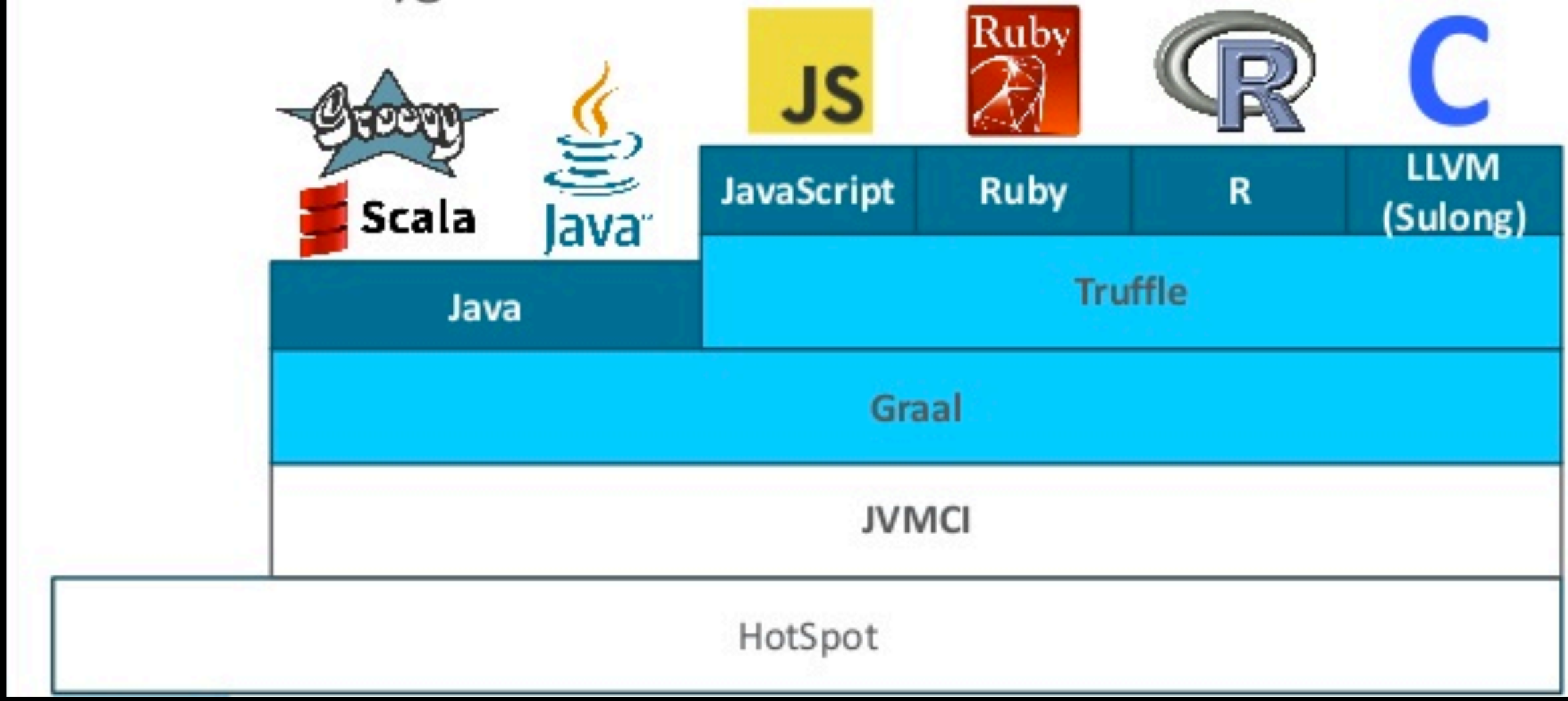
GraalVM™

Embeddable in native or managed applications

OpenJDK™ node.js ORACLE Database MySQL™ standalone >_

https://www.slideshare.net/ThomasWuerthinger/2015-cgo-graal

Graal VM Polyglot



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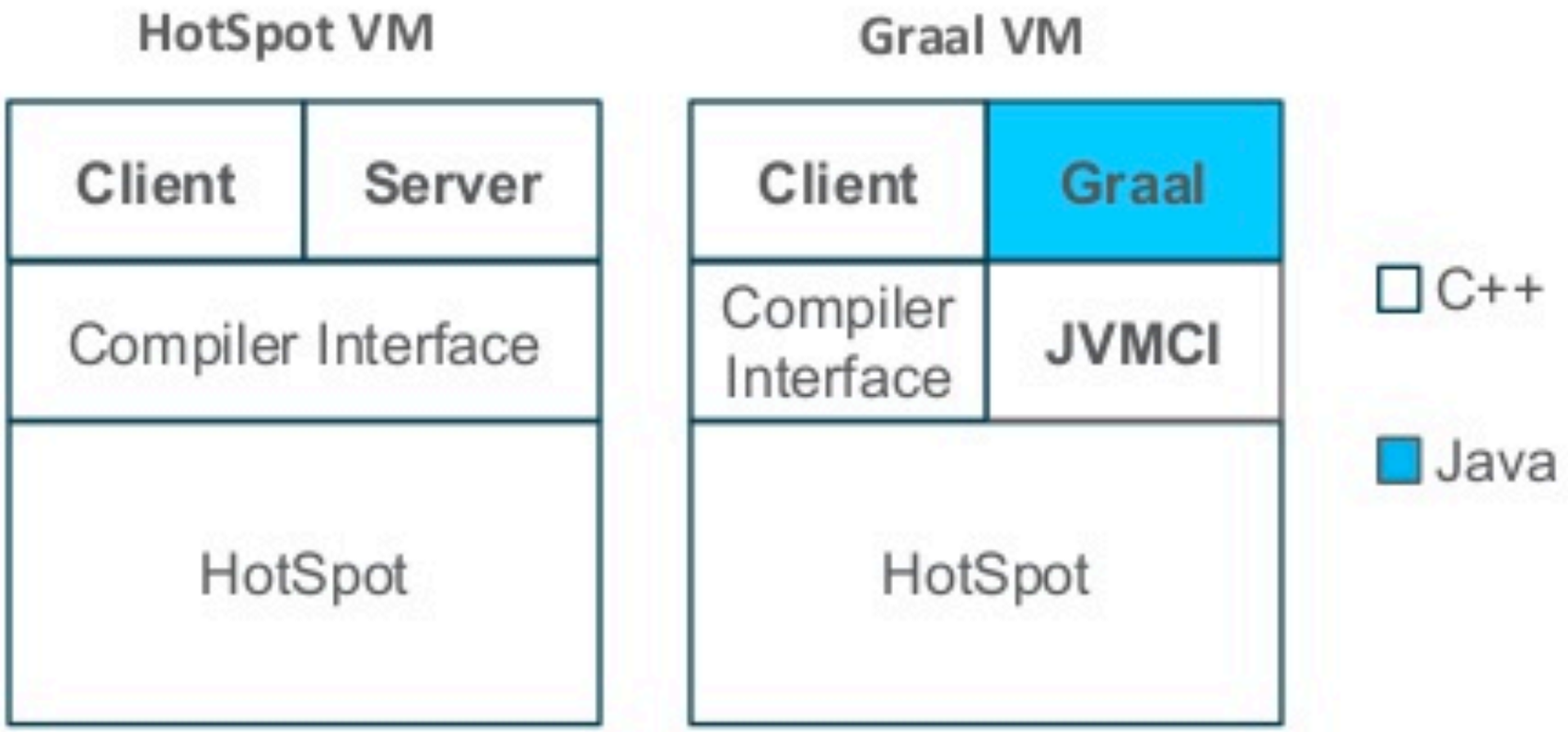
ORACLE

Graal and Graal VM



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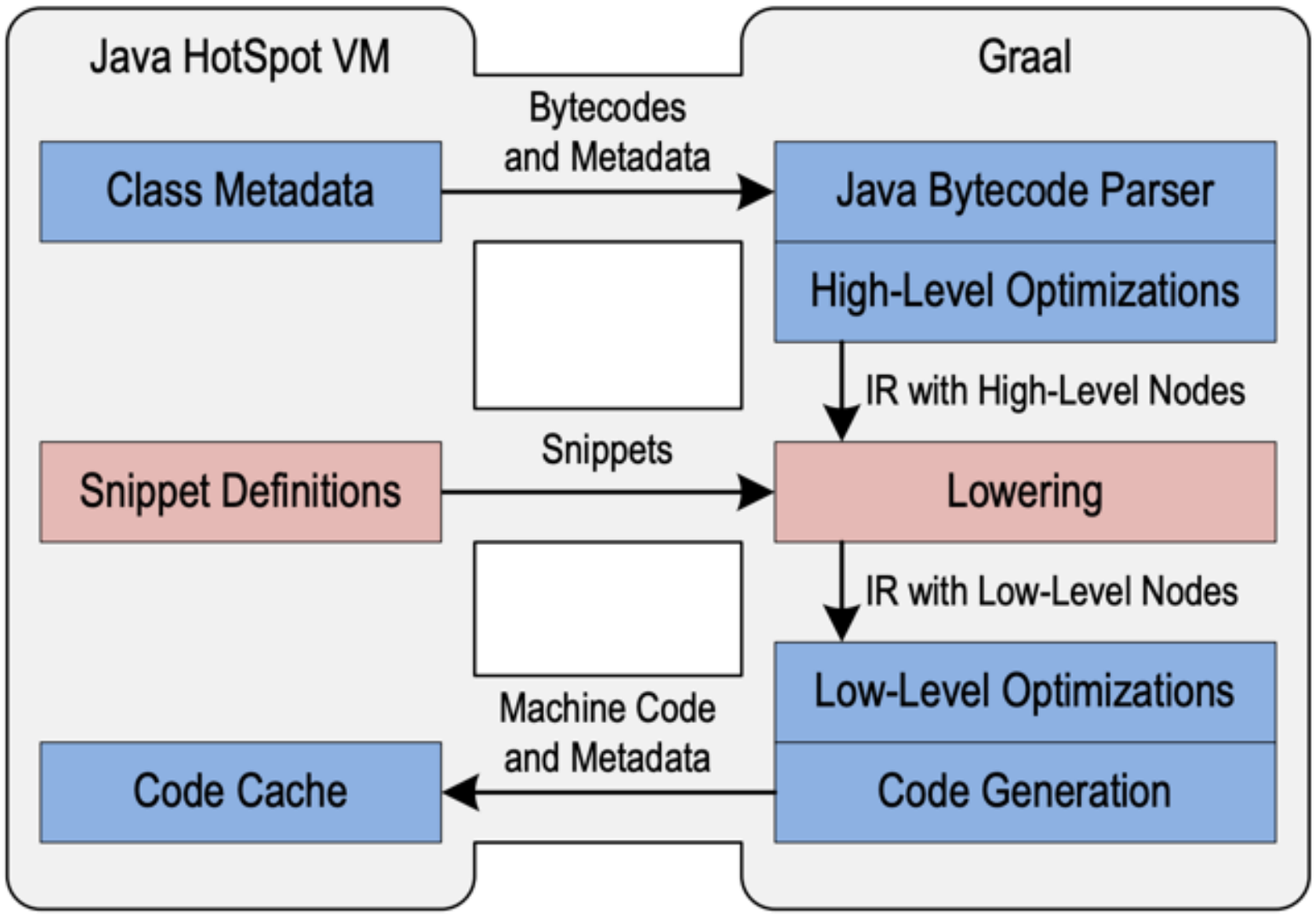
Compiler-VM Separation



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GraalVM API

ORACLE

- Truffle API
  - Declarative
  - AST representation of source code
  - Convert AST into IR
  - Written in Java
- Script Engines use Truffle to create AST
- Truffle AST used to generate IR
- IR used to create byte code or native code

http://www.graalvm.org/docs/why-graal/

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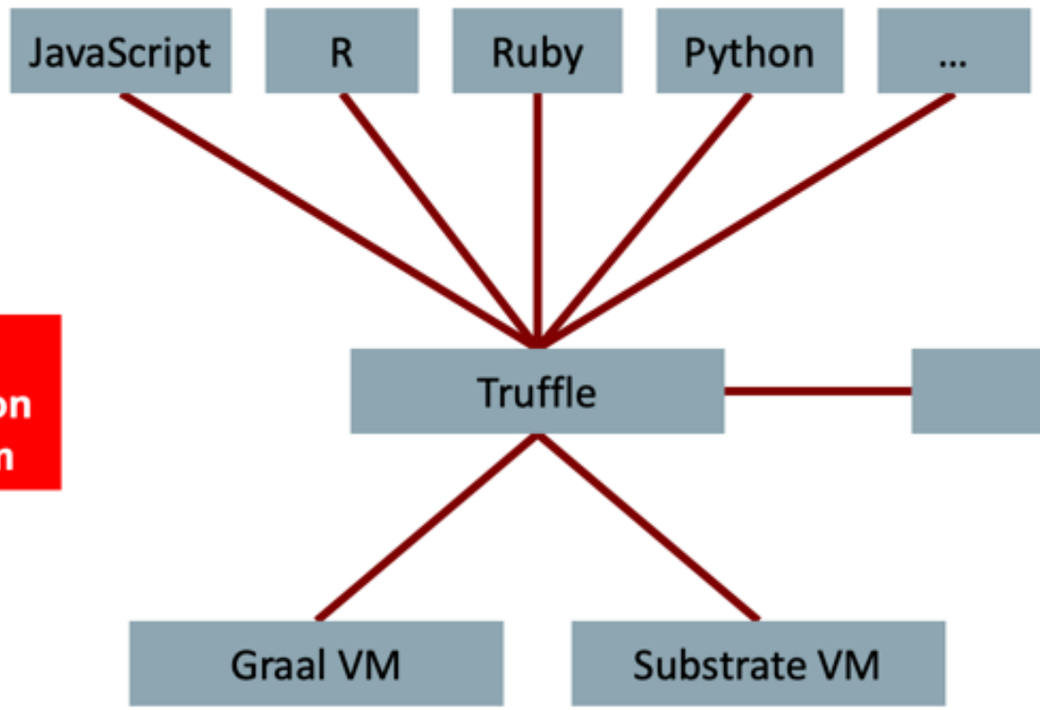
ORACLE

Truffle System Structure

AST Interpreter for every language



Your language should be here!

Common API separates language implementation and optimization system

Language agnostic dynamic compiler

Integrate with Java applications

Low-footprint VM, also suitable for embedding

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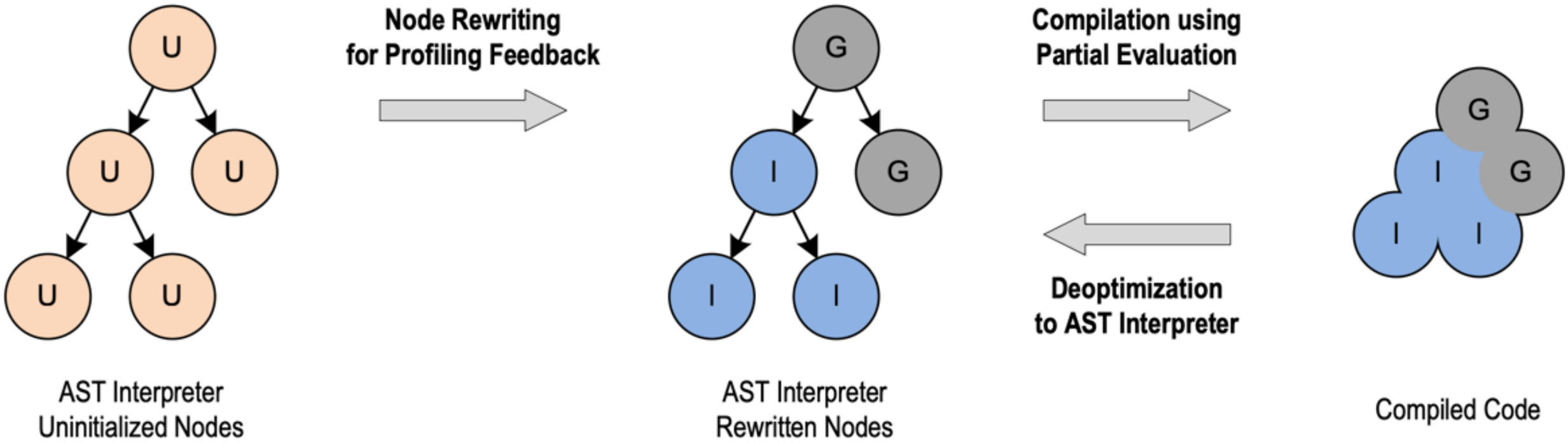
Truffle Approach



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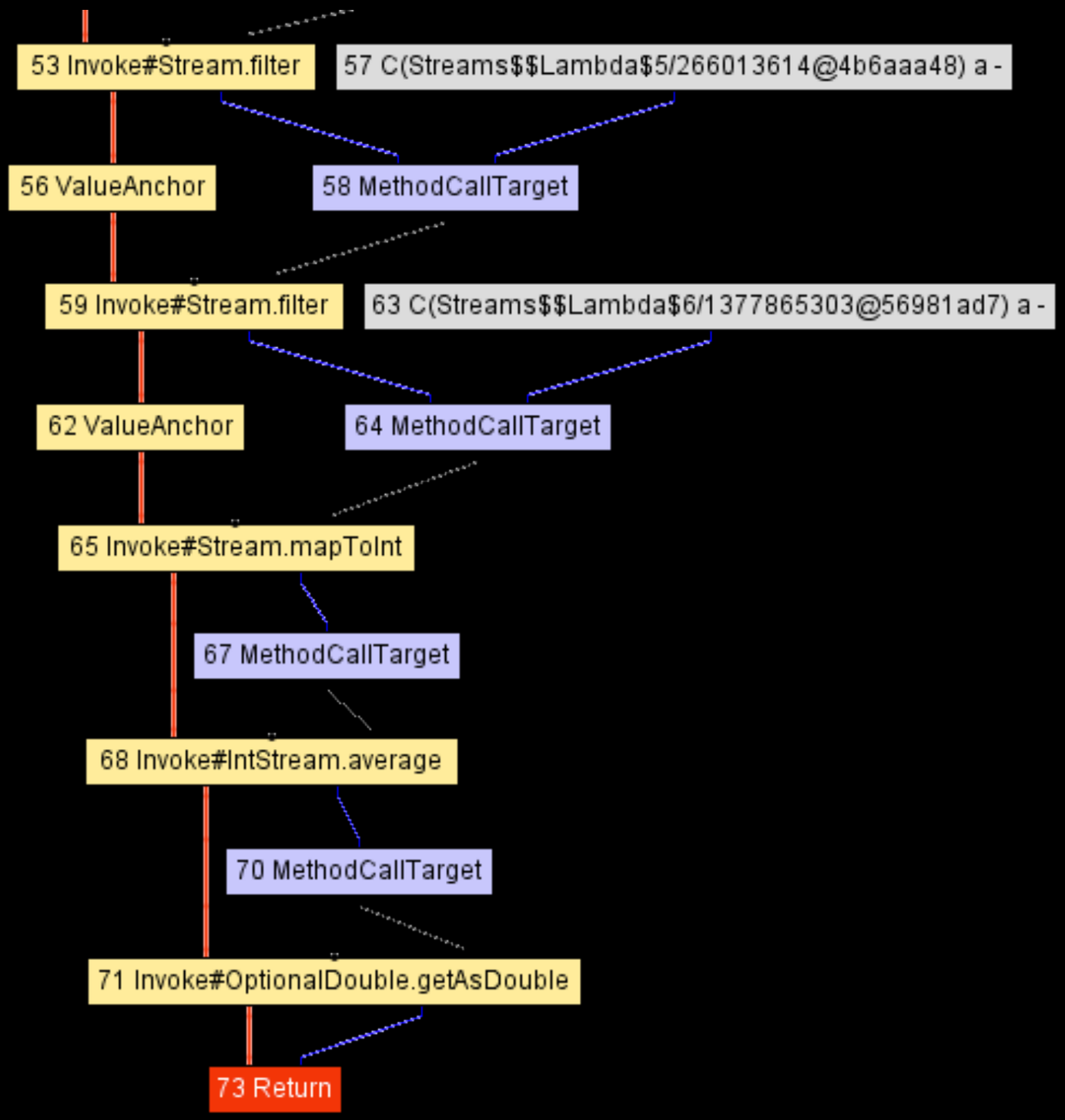
GraalVM
Intermediate Representation (IR)



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Substrate VM

Static Analysis and Ahead-of-Time Compilation using Graal

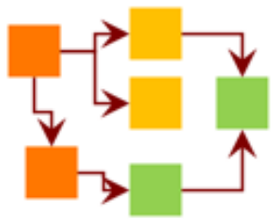
Static Analysis

Java Application

JDK

Substrate VM

All Java classes from application, JDK, and Substrate VM



Reachable methods, fields, and classes

Ahead-of-Time Compilation

Machine Code

Initial Heap

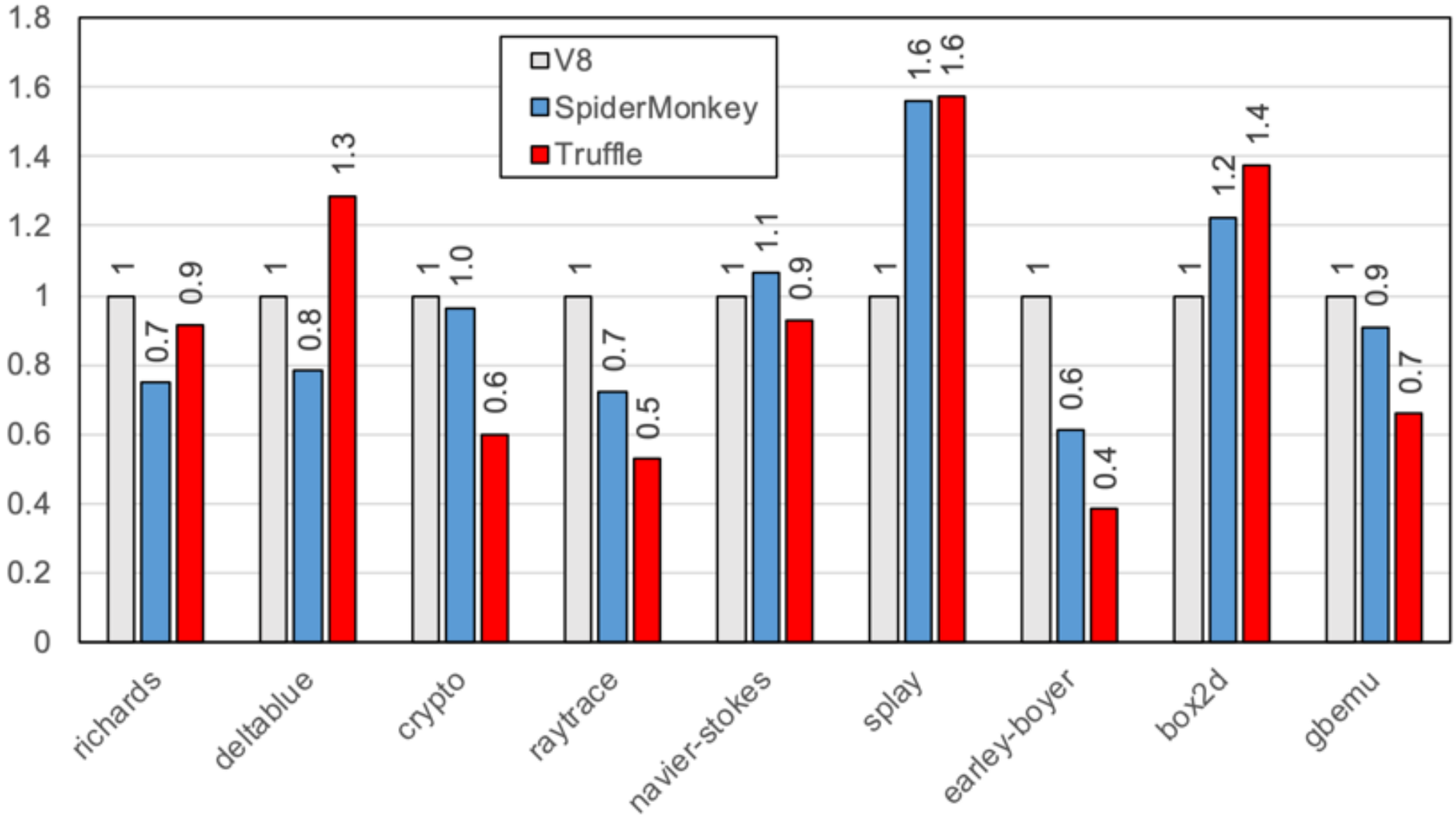
DWARF Info

ELF / MachO Binary

Application running without dependency on JDK and without Java class loading

https://www.slideshare.net/ThomasWuerthinger/2015-cgo-graal

Performance: JavaScript



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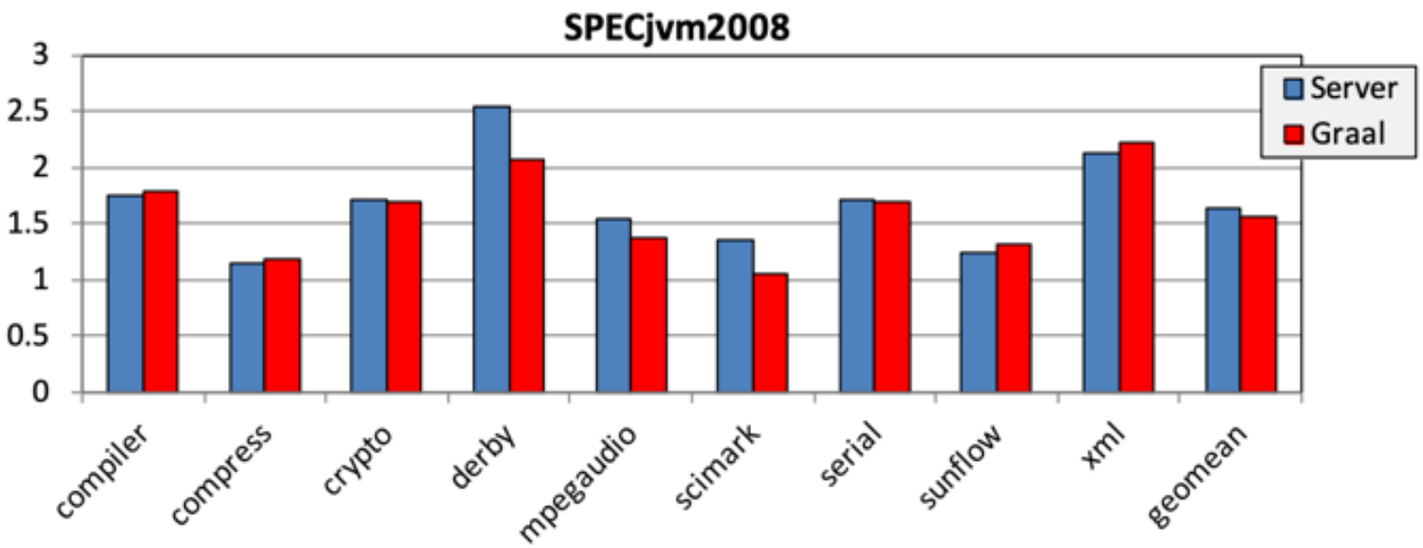
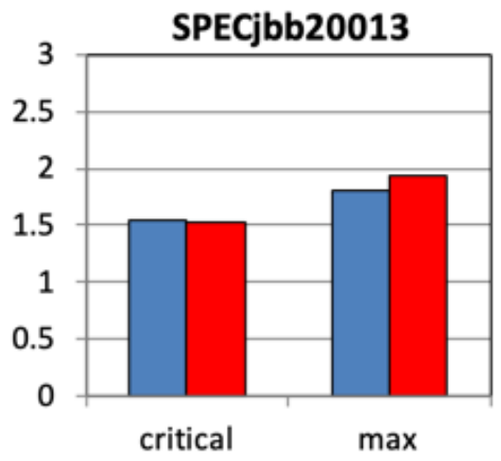
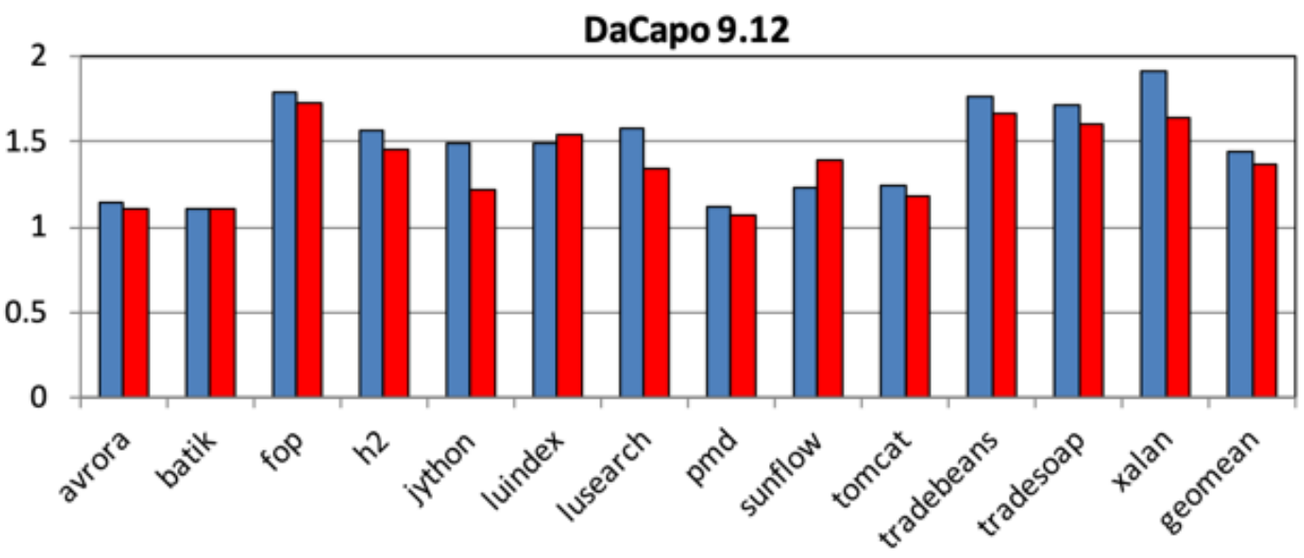
Graal Benchmark Results

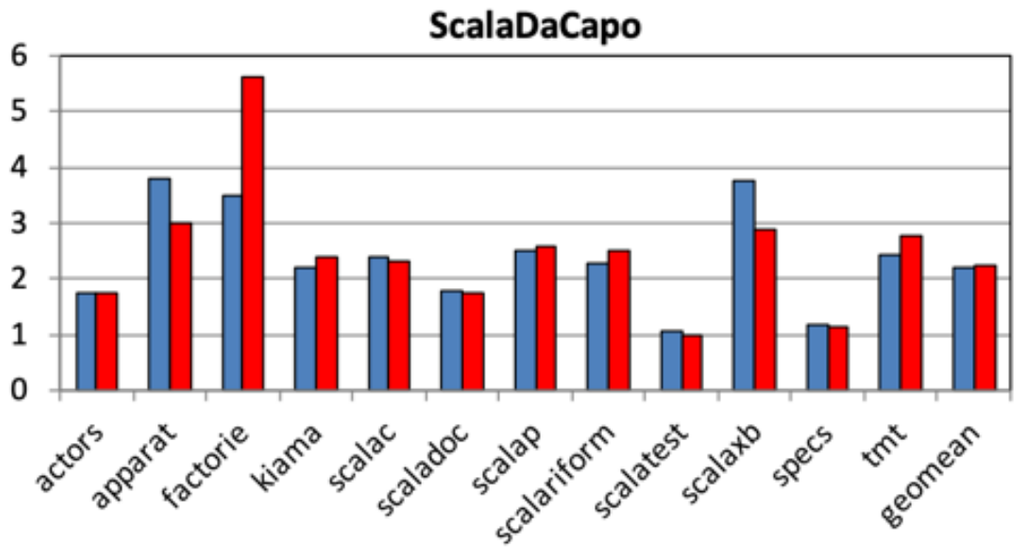




Higher is better, normalized to Client compiler.

Results are not SPEC compliant, but follow the rules for research use.





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GraalVM Setup

- GraalVM CE (Linux and Mac)
  http://www.graalvm.org/downloads/
- GraalVM EE (has Windows Preview)
  https://www.oracle.com/technetwork/oracle-labs/program-languages/downloads/index.html
- Follow installation instructions
- Add GRAALVM_HOME to your PATH
- verify

```
> java -version
openjdk version "1.8.0_192"
OpenJDK Runtime Environment (build 1.8.0_192-20181024123616.buildslave.jdk8u-src-tar--b12)
GraalVM 1.0.0-rc10 (build 25.192-b12-jvmci-0.53, mixed mode)
```

http://www.graalvm.org/docs/getting-started/

GraalVM Layout

Typical JDK Structure

```
.
├── bin
├── demo
├── include
├── jre
├── lib
├── man
└── sample
```

- https://docs.gradle.org/current/userguide/organizing_gradle_projects.html

GraalVM Layout

New Members

```
R                jarsigner        jhat             jstatd           policytool       serialver
Rscript          java             jinfo            jvisualvm        polyglot         servertool
appletviewer     javac            jjs              keytool          rake             testrb
extcheck         javadoc          jmap             lli              rdoc             tnameserv
gem              javah            jps              native-image     ri               truffleruby
graalpython      javap            jrunscript       native2ascii     rmic             unpack200
gu               jcmd             js               node             rmid             wsgen
idlj             jconsole         jsadebugd        npm              rmiregistry      wsimport
irb              jdb              jstack           orbd             ruby             xjc
jar              jdeps            jstat            pack200          schemagen
```

- https://docs.gradle.org/current/userguide/organizing_gradle_projects.html

GraalVM Tooling

- Graal Updater: installs components (languages)
- Scripts can use Chrome Inspector (—inspect)
- Native Image: convert jar to exec or shared library
  - creates Substrate JVM
  - native-image -
    H:ReflectionConfigurationFiles=graal_config.js
    on x.jar # provides explicit class loading

https://docs.gradle.org/current/release-notes.html

GraalVM DEMO

- examples/build.sh will pull down some git repos and place in tmp folder
- it also creates a docker image for Linux demo
- examples can run from Mac or Linux
- this is a subset of GraalVM samples

GraalVM DEMO Verify

- verify GraalVM on MAC
- export PATH= ...
- ga install R ruby python
- cd examples/hello-poly
- javac HelloPolyglotWorld.java
- java HelloPolyglotWorld

GraalVM DEMO FizzBuzz

- Shell into Linux Docker Image
- docker run -p3000:3000 -it graalvm-demo:0.01 bash
- source environment
  . /dockerjava/setup-gvm.env
- add experimental languages
  ga install R ruby python
- cd /dockerjava/graalvm-ten-things
- which java && which R && which ruby && which graalpython
- js fizzbuzz.js
- graalpython fizzbuzz.py
- Rscript fizzbuzz.r
- ruby fizzbuzz.rb

GraalVM DEMO Polyglot Node.js

- node --jvm polyglot.js
- which npm
- npm init
- npm install
- node --jvm polyglot.js
- Linux: curl http://localhost:3000/ # hard to see
- Mac: open http://localhost:3000/

GraalVM DEMO LLVM

- ls -l gzip.*
- clang -c -emit-llvm gzip.c
- file gzip.bc
- echo "HELLO WORLD" | lli gzip.bc -f -c - | zcat -

GraalVM DEMO Streams

- cd ../streams-example
- /opt/graalvm-ce-1.0.0-rc10/bin/java -jar target/benchmarks.jar mapReduce -f1 -wi 4 -i4
- /usr/lib/jvm/java-11-openjdk-amd64/bin/java -jar target/benchmarks.jar mapReduce -f1 -wi 4 -i4

GraalVM DEMO JDK 11 JS

- cd ../streams-example/test
- mvn clean install
- /opt/graalvm-ce-1.0.0-rc10/bin/java -jar target/benchmarks.jar mapReduce -f1 -wi 4 -i4
- /usr/lib/jvm/java-11-openjdk-amd64/bin/java -jar target/benchmarks.jar mapReduce -f1 -wi 4 -i4

Adding some Ketchup

- So what about a complicated server ???
- Native can handle runtimes that have explicit resolution of types and dependencies
- Spring-FU project is working to create a functional API that avoids annotations, reflection, and runtime
- Working with Graal team to improve both
- https://spring.io/blog/2018/10/02/the-evolution-of-spring-fu

Spring FU (kofu)

```
import org.springframework.fu.kofu.web.server
import org.springframework.fu.kofu.webApplication
import org.springframework.web.reactive.function.server.ServerRequest
import org.springframework.web.reactive.function.server.ServerResponse.ok

val app = webApplication {
    beans {
        bean<SampleService>()
        bean<SampleHandler>()
    }
    server {
        port = if (profiles.contains("test")) 8181 else 8080
        router {
            val handler = ref<SampleHandler>()
            GET("/", handler::hello)
            GET("/api", handler::json)
        }
        codecs {
            string()
            jackson()
        }
    }
}
data class Sample(val message: String)
class SampleService {
    fun generateMessage() = "Hello world!"
}
class SampleHandler(private val sampleService: SampleService) {
    fun hello(request: ServerRequest)= ok().syncBody(sampleService.generateMessage())
    fun json(request: ServerRequest) = ok().syncBody(Sample(sampleService.generateMessage()))
}
fun main() {
    app.run()
}
```

GraalVM DEMO kofu

- Mac shell:
  cd tmp/spring-fu/samples/kofu-reactive-minimal
- ./gradlew build
- java -jar build/libs/kofu-reactive-minimal.jar
- cat ./build.sh
- ./build.sh

GraalVM Notes

- Static / declarative dependencies works
- Dynamic dependencies need work (logging)
- Definitely adds new scripting capabilities
- Brings a new AOT / JIT compiler to the table
- Static initialization and optimization saves in startup time
- Memory requirements are reduced

GraalVM Notes

- Native works as long as static dependencies are identified
- Frameworks need to change how they do some things to work with Graal engine
- Spring FU is pushing to improve Graal
- Anyone can write a new scripting language and leverage the entire GraalVM ecosystem

GraalVM Summary

- Technology to keep an eye on
- Depends on goals
  - If you are in to polyglot…
  - Alternative to Node.js
  - Multi-platform support
  - Ready for production, maybe for Twitter
- Extensible
- Flexible
- Open Source
- I get to use Kotlin more
- Enterprise Edition provides even more

GraalVM Resources

- https://www.graalvm.org
- https://www.slideshare.net/ThomasWuerthinger/2015-cgo-graal
- https://www.slideshare.net/ThomasWuerthinger/2014-0424-graal-modularity
- https://www.slideshare.net/ThomasWuerthinger/graal-truffle-ethdec2013
- https://medium.com/graalvm/stream-api-performance-with-graalvm-be6cfe7fbb52
- https://medium.com/graalvm/graalvm-ten-things-12d9111f307d
- https://medium.com/graalvm/under-the-hood-of-graalvm-jit-optimizations-d6e931394797
- https://github.com/oracle/graal

Questions ?

https://github.com/lseinc/seeking-graal-cm19.git

Don’t forget to fill
out the survey!

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Thank You !

https://github.com/lseinc/seeking-graal-cm19.git

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