GraalVM
Compiler and JVM Research at JKU

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About Me

• Finished Master's studies January 2014
  - Master's Thesis about CACAO VM
  - Supervised by Prof. Krall

• Since March 2014
  - PhD Student, Research & University Assistant
    @ Institute for System Software, JKU Linz

• Working on the Graal Compiler
  - Backend Optimization, Register Allocation
Who Are We?

Institute for System Software

Oracle Labs
Sun/Oracle Collaboration

- Started 2001 by Prof. Hanspeter Mössenböck
  - Sun Microsystems, later Oracle Labs
  - Dynamic compiler and JVM research

- Many artifacts now part of Java
  - Client Compiler: Escape Analysis, Register Allocator, ...
  - JVM Compiler Interface in Java 9

- Current research
  - Graal Compiler
  - Truffle Language Implementation Framework
GraalVM Stack

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HotSpot VM

- Virtual Machine for Java
  - Execute Java Bytecode (class files)
  - Runtime (Garbage Collection, ...)
  - Written in C++

- Execution modes
  - Bytecode Interpreter
    - Immediate start up, slow execution
  - Just-in-Time Compiler (JIT)
    - Important Methods only
    - Slow start up, fast execution

$ java -version
java version "1.8.0"
Java(TM) SE Runtime Environment
Java HotSpot(TM) 64-Bit Server VM
Graal Compiler
Graal Compiler

• JIT Compiler for HotSpot
  - GitHub Project: https://github.com/graalvm/graal-core

• Written in Java
  - IDE support
  - Annotations
  - Meta-programming

• Meta-circular

$ git clone https://github.com/graalvm/graal-core.git
$ cd graal-core
$ mx build
$ mx vm -version

java version "1.8.0"
Java(TM) SE Runtime Environment
Java HotSpot(TM) 64-Bit Server VM (jvmci-0.25)
Java-Level JVM Compiler Interface (JEP 243)

- Compiler **for Java in Java**
- Part of Java 9
  - [http://openjdk.java.net/jeps/243](http://openjdk.java.net/jeps/243)
- Research Artifact → Product
Truffle – Language Implementation Framework

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"Write Your Own Language" (Legacy Approach)

- Parser, Abstract syntax tree (AST) Interpreter
- Write a "real" VM
  - Rewrite in C/C++ (Still using AST interpreter)
  - Add runtime system, Garbage Collection, ...
- People start using it
  - ... and complain about performance
- Define bytecode and write bytecode interpreter
  - Performance is still bad
    - Write a JIT compiler
    - Improve the garbage collector, ...
    - Repeat
“Write Your Own Language” (Truffle Approach)

- Parser, Abstract syntax tree (AST) Interpreter
  - Execute it with Truffle/GraalVM
- People start using it
- ... and it is already fast!

Java (Truffle API)
Speculate and Optimize ...

Node Transitions:
- **U**: Uninitialized Nodes
- **I**: Initialized Nodes
- **G**: Generic Nodes
- **D**: Double
- **S**: String

**Node Rewriting**
- Execute and collect profiling feedback
- Execute until stable

**Compilation using Graal** (Partial Evaluation)

**Truffle**
- Graal
- JVMCI
- HotSpot VM

**AST Interpreter**
- Uninitialized Nodes
- Rewritten Nodes

**Compiled Code**
- Execute compiled code
Truffle Implementations

LLVM IR (C/C++/...) - JKU, Oracle Labs
https://github.com/graalvm/sulong

Smalltalk - JKU (Stefan Marr)
https://github.com/SOM-st/TruffleSOM

Python
Sulon

ZipPy - UCI Irvine
https://bitbucket.org/ssllab/zippy

JavaScript - JKU, Oracle Labs
Not Open Sourced (yet)
Oracle Technology Network
(Technology Preview)

TruffleRuby - JKU, Oracle Labs
https://github.com/graalvm/truelleruby

FastR - JKU, Oracle Labs
https://github.com/graalvm/fastr

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https://github.com/graalvm/truelleruby

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Further Topics

- Language Interoperability
- Native Function Interface
- Substrate VM
  - Paul's Talk

Get in Contact

• Projects, Internships, PhD Positions, ...

• Me
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  - Twitter: @zapstercc

• GraalVM
  - Github: https://github.com/graalvm