

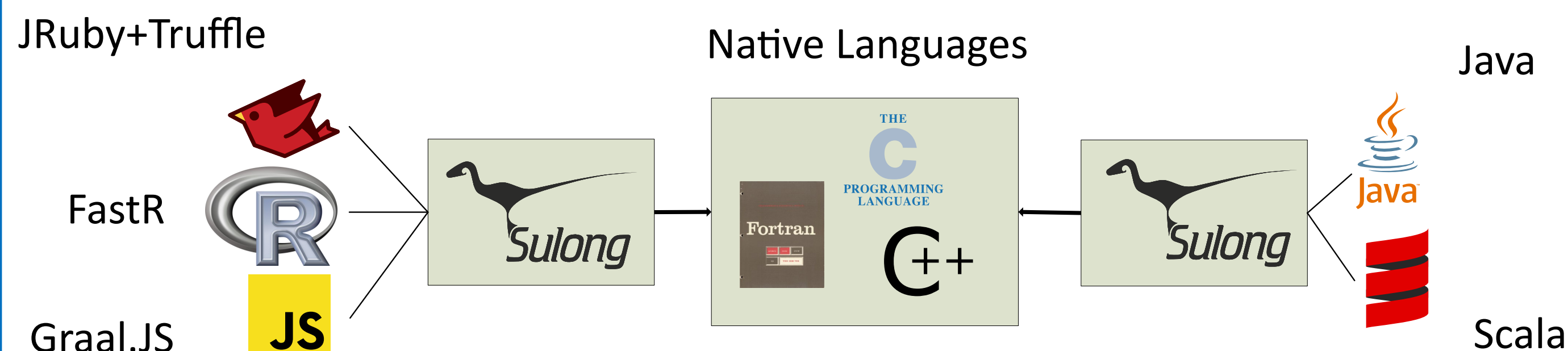
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Motivation

- To execute low-level languages (C, Fortran, C++, ...) from JVM languages, one has to **resort to native interfaces** such as the Java Native Interface (JNI)
- JNI **incurs overhead**, makes **native interoperability complicated**, and **contradicts Java's memory safety guarantees**
- Language boundaries** are an obstacle for optimizations; compilers cannot optimize across language boundaries

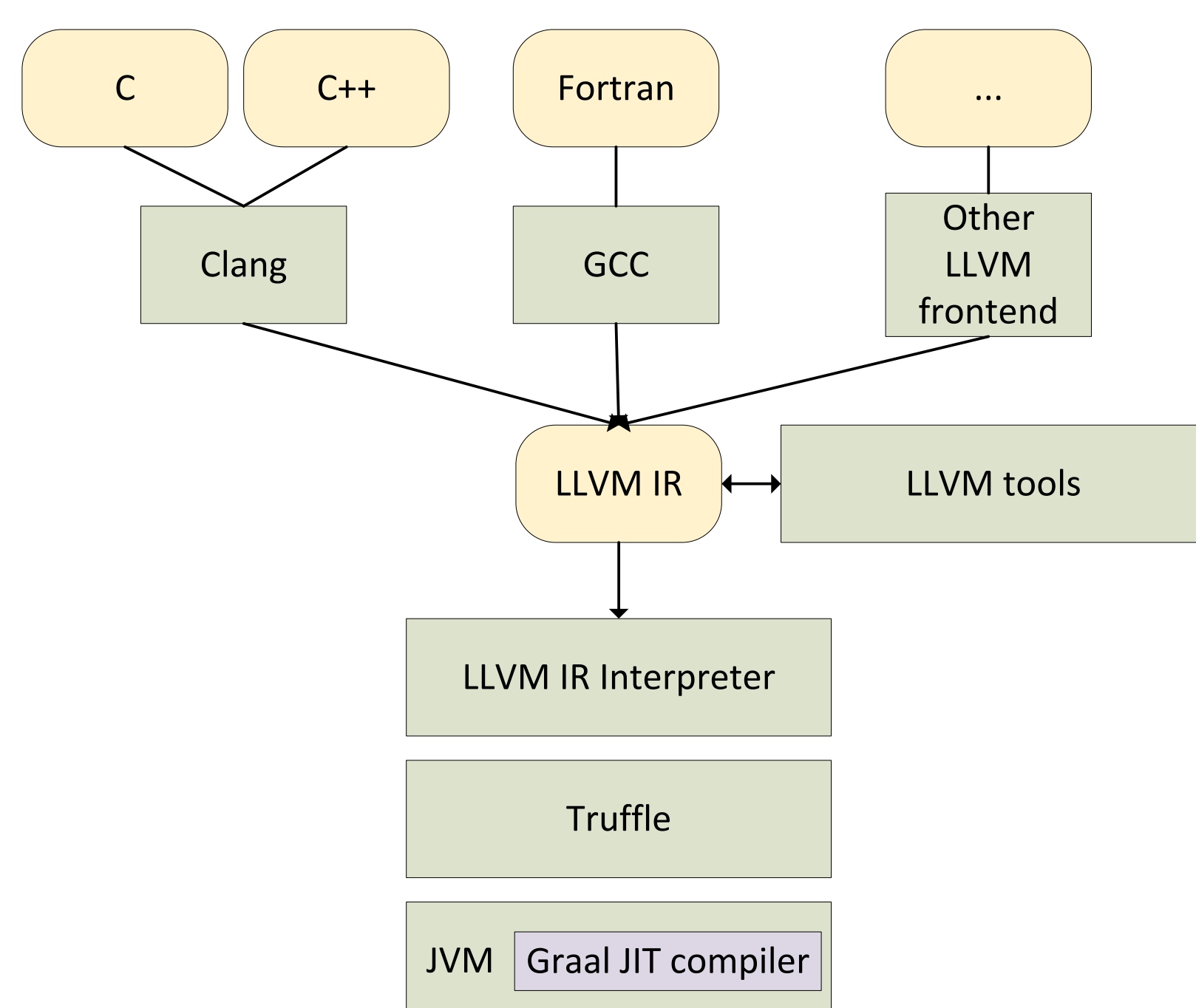
Our Solution: Execute Native Languages on the JVM

- Interpreter for native languages** on top of the JVM to implement **dynamic language's native interfaces** to run **native languages on the JVM**
- Having several languages on the same platform allows **optimizations across language boundaries**



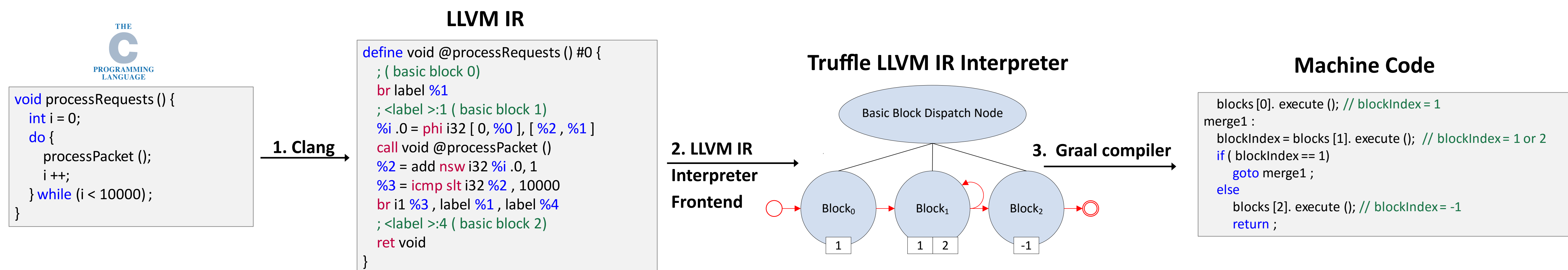
System Overview: Bringing LLVM and the JVM together

- Clang and GCC** compile **native languages to LLVM IR**
- LLVM IR** is a machine-specific, low-level intermediate format
- LLVM IR interpreter** bases on the Truffle language implementation framework
- Truffle interpreters are **Abstract Syntax Tree (AST) interpreters**
- Truffle uses **the Graal JIT compiler** for efficient compilation



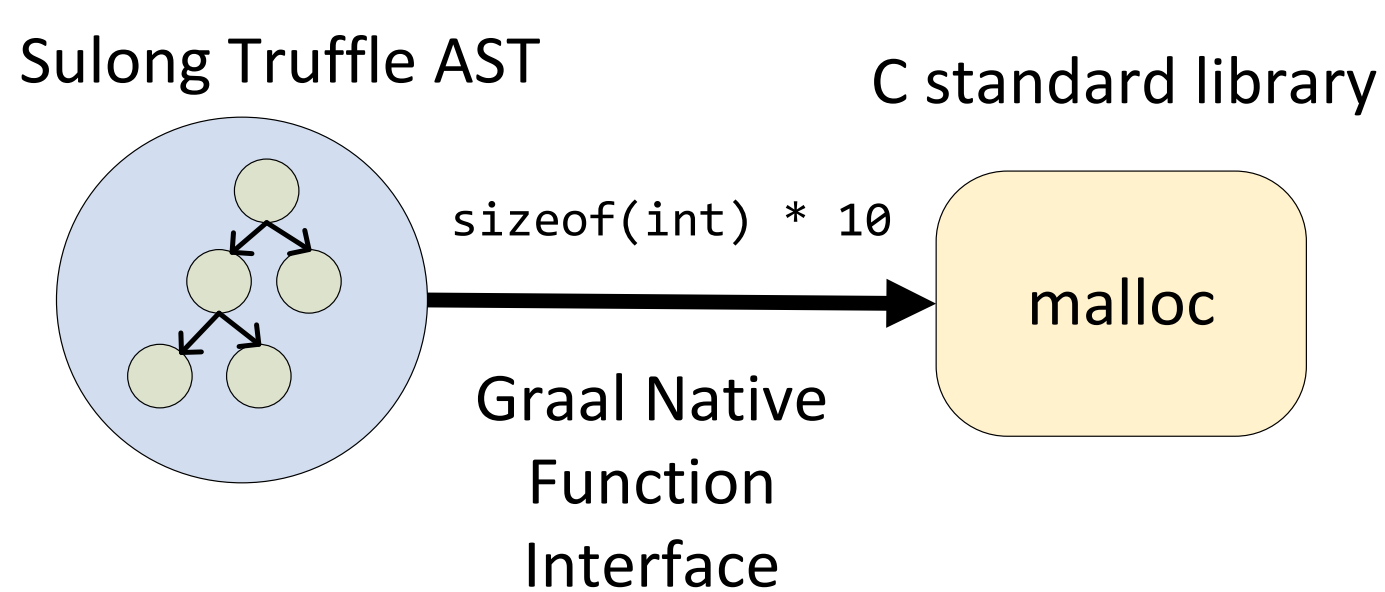
Interpretation and Dynamic Compilation of LLVM IR

1. **Compile C/C++/Fortran Program** to LLVM IR
2. Execute **LLVM IR** with the **Truffle LLVM IR Interpreter**
3. Compile frequently executed functions to machine code by **unrolling the interpreter loop**



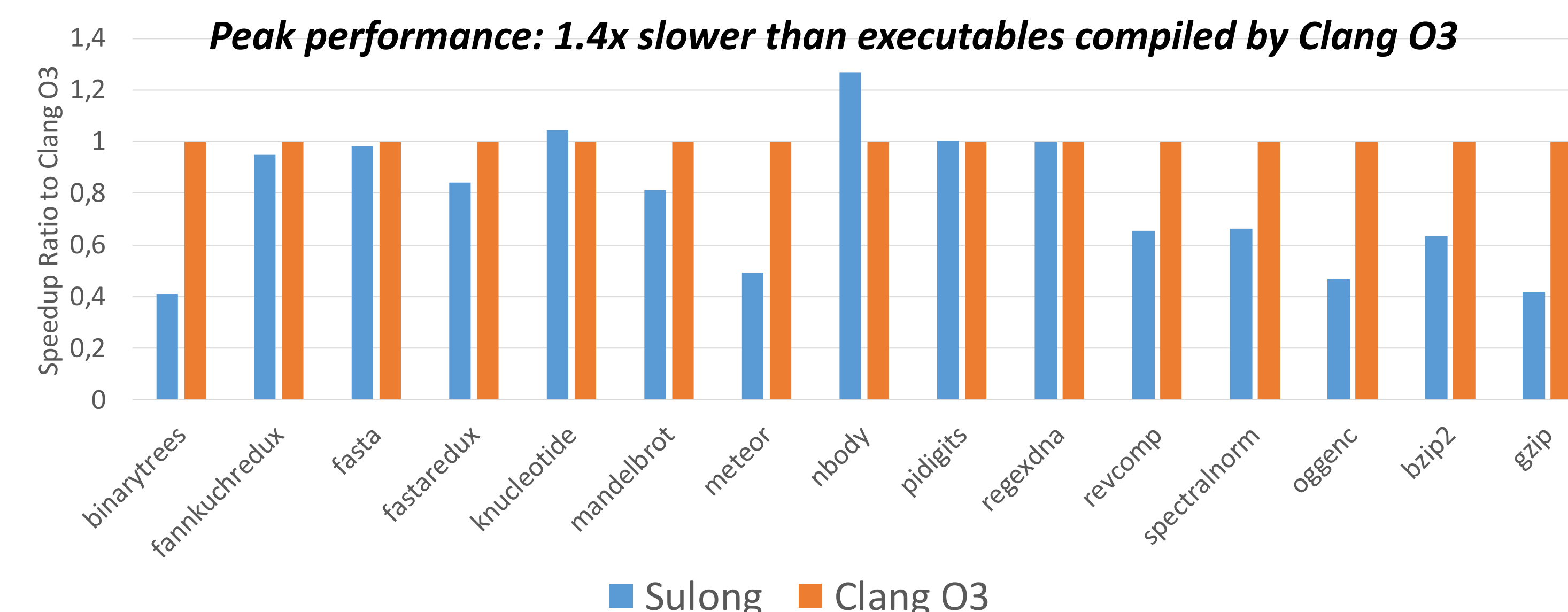
Native Calls

- Graal Native Function Interface (NFI)** to call native functions
- Direct calls** from compiled Java code to native functions!
- Sulong allocates and accesses **unmanaged memory to avoid conversion** and marshalling of data



Grimmer, M., et al. "An efficient native function interface for Java." *Proceedings of PPPJ'13*.

Performance Evaluation: C Benchmarks

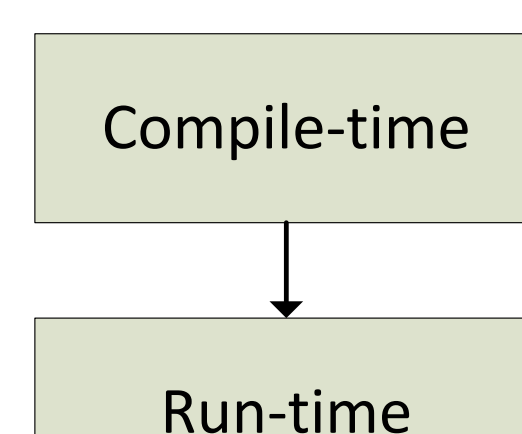


Static Optimizations

- Problem:** Java compilers do not optimize accesses to unmanaged memory
- Solution:** Use LLVM's static optimization tool to promote memory accesses to local variables



LLVM



Dynamic Optimizations

- Problem:** Static compilers cannot react to changes in program behavior
- Solution:** Profile in the interpreter and exploit profiling data during compilation through speculative optimizations

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