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Interoperability between Execution Modes on GraalVM

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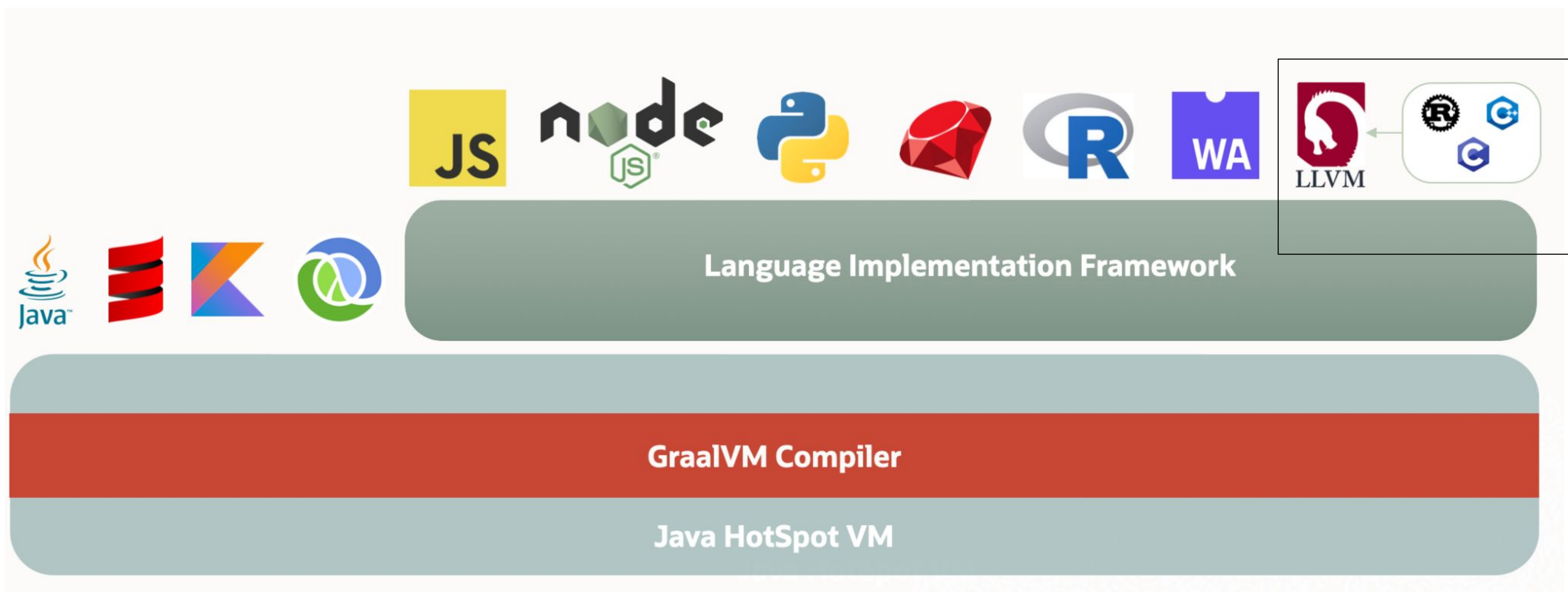
GraalVM

- Polyglot virtual machine
  - No cross-language overhead
- Highly-optimizing JIT-compiler
  - Dynamic and speculative



➔ Execution of C code via clang + LLVM bitcode

Why not only native execution (C code)?

Python/JS/… pseudo code

```
p = Point(x: 4, y: -3)
diff = calcDiff(p)
```

passing managed (e.g. JS) object to C code

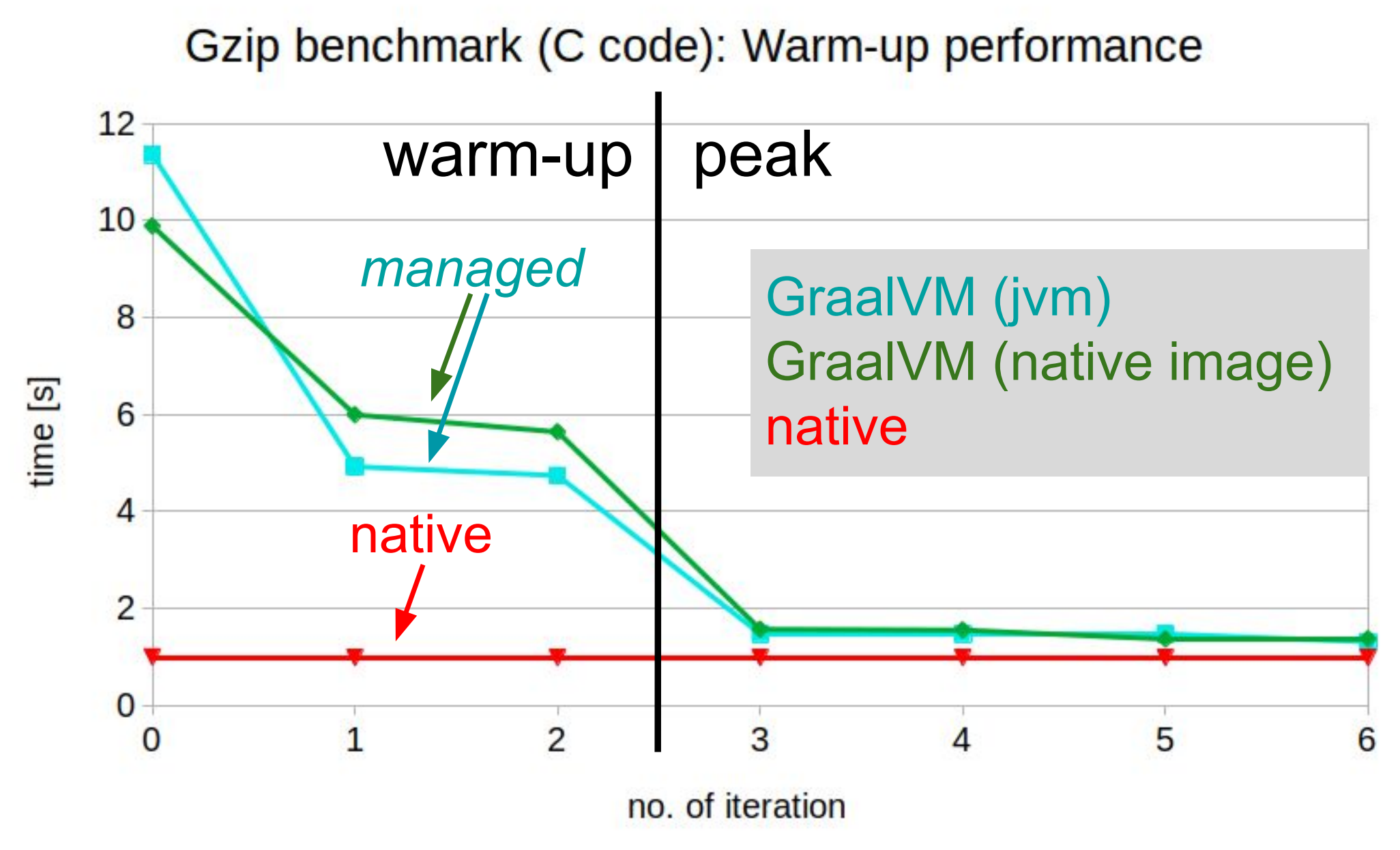
C code

```
double calcDiff(struct Point *p) {
  return sqrt(p->x*p->x+p->y*p->y);
}
```

"ERROR: managed object p not accessible in (natively executed) C code"

- Existing polyglot systems: Overhead for cross-language calls

Why not all functions on GraalVM?

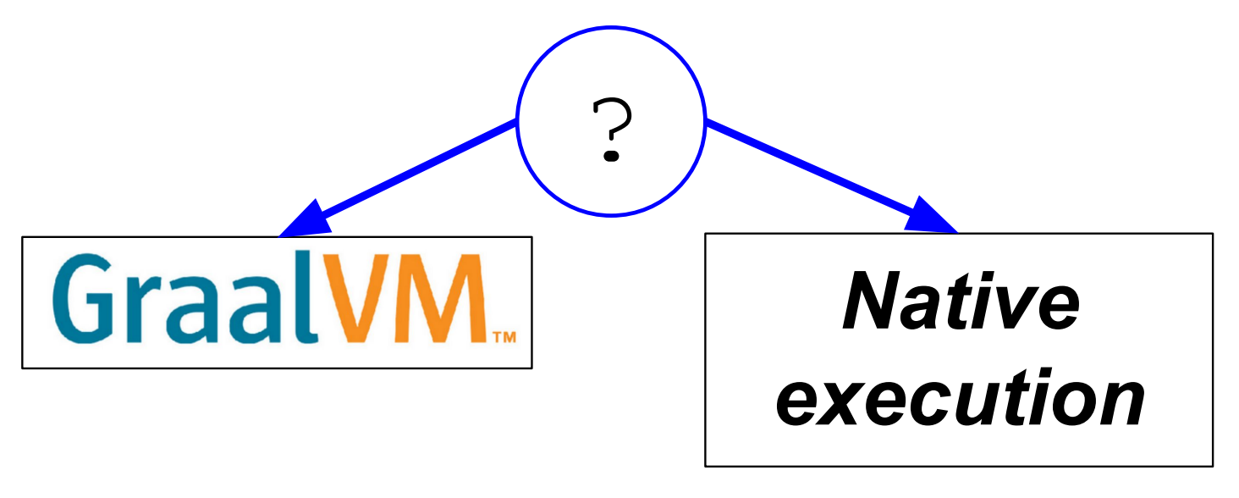


- Slow warm-up for managed execution in GraalVM (due to dynamic compilation)
- Thus: Less managed/more native code improves (warm-up) performance

Our approach: Hybrid execution

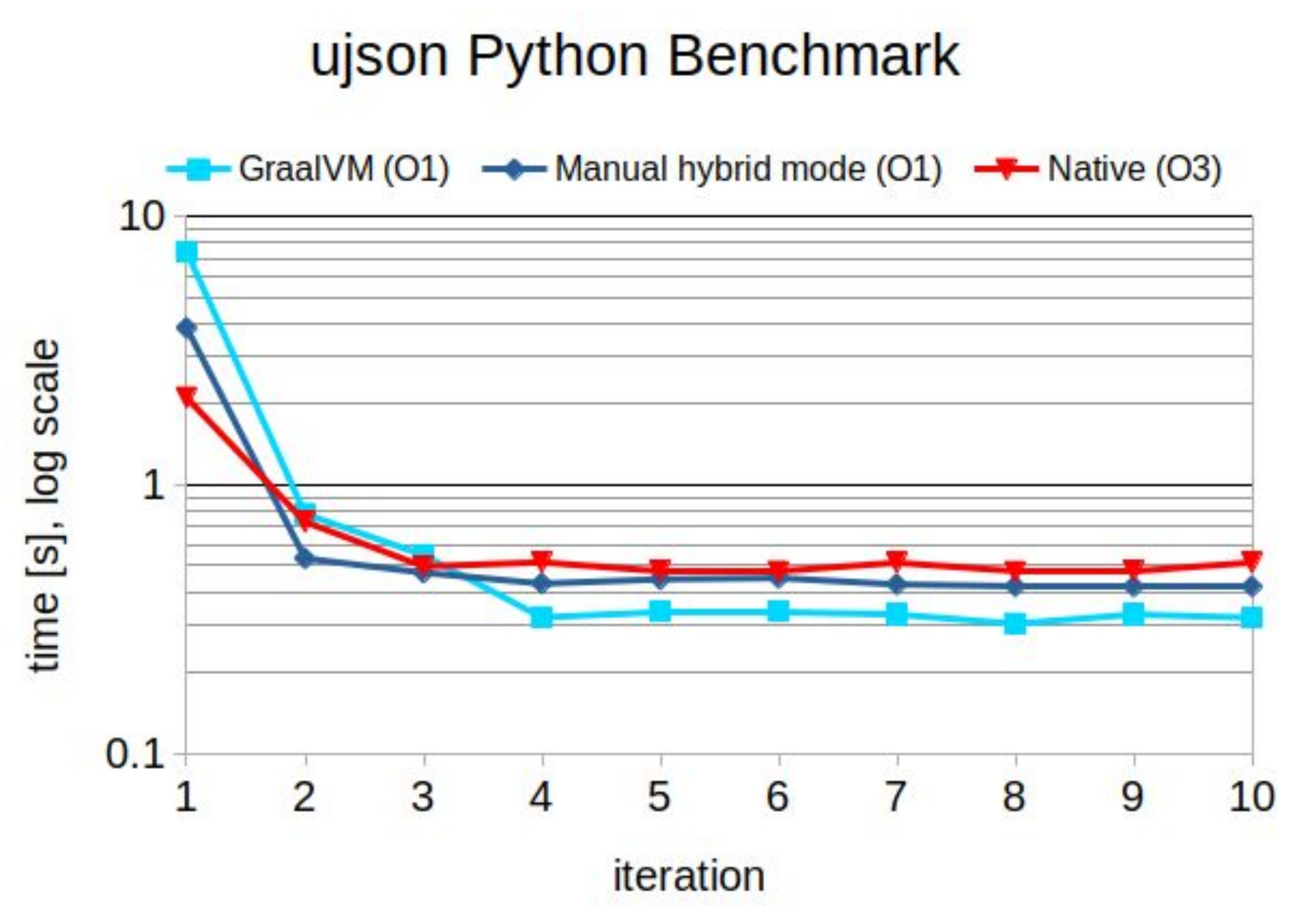
→(let) decide execution mode per callee

```
for each call of C function f:
  decide how f is executed
```



- e.g. Python/numpy:
  - Few functions access managed objects
  - Majority of C code can be run without GraalVM
- Goal: automatic decision at run time (based on call frequency, function size, managed accesses)

Current state: Results and restrictions



- Benchmark: JSON parser written in Python and C
- Forcing 3 (leaf) functions to run natively already improves warm-up (1.7x) performance
- Restrictions in current state
  - Manual decision how a callee is run (GraalVM/native)
  - Pure functions only

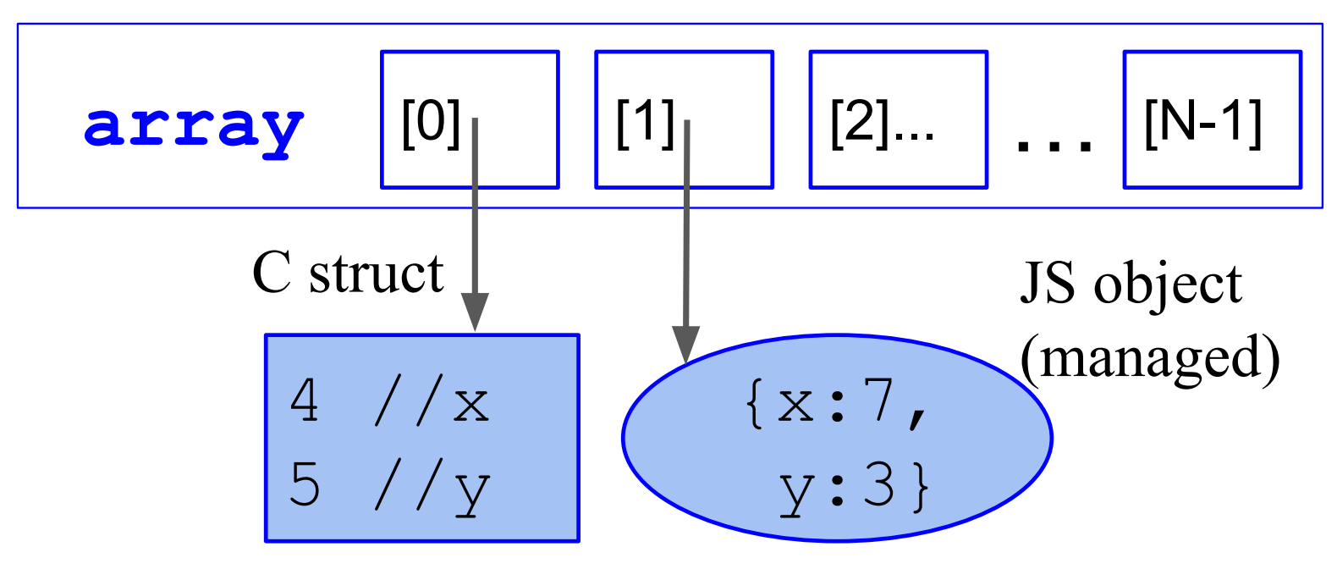
GraalVM: all (Python/C) functions run on GraalVM, inlining enabled.
Manual hybrid mode: 3 often called C functions are executed natively, all others on GraalVM. No inlining.
Native: GraalVM accesses natively compiled C code (no polyglot access possible)

Arising problems for switching the execution mode

No possibility to statically detect managed access

- Native execution whenever possible
- However: Managed access must be done on GraalVM
- Statically undecidable if native function accesses managed objects (cf. example below) → switch at run time necessary!

```
struct Point* array[] = …
for(int i=0; i < N; i++) {
  sumY += array[i]->y;
}
```



Functions with side effects on global variables

- Native globals cannot store GraalVM data
- GraalVM globals cannot be accessed from native code
- Enabling both global types at the same time lets globals exist twice →Might/Will lead to inconsistency for impure functions!

```
static int nElems;

void  add(...) {nElems++;...}

void* remove() {nElems--;...}
```

Instruction	Execution mode	native value of ***nElems***	GraalVM value of ***nElems***	correct value of ***nElems***
…	…	0	0	0
`add(...)`	GraalVM	0 ⚠	1	1
`remove()`	native	-1 ⚠	1 ⚠	0

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