CACAO -- From the fastest JIT to JVM

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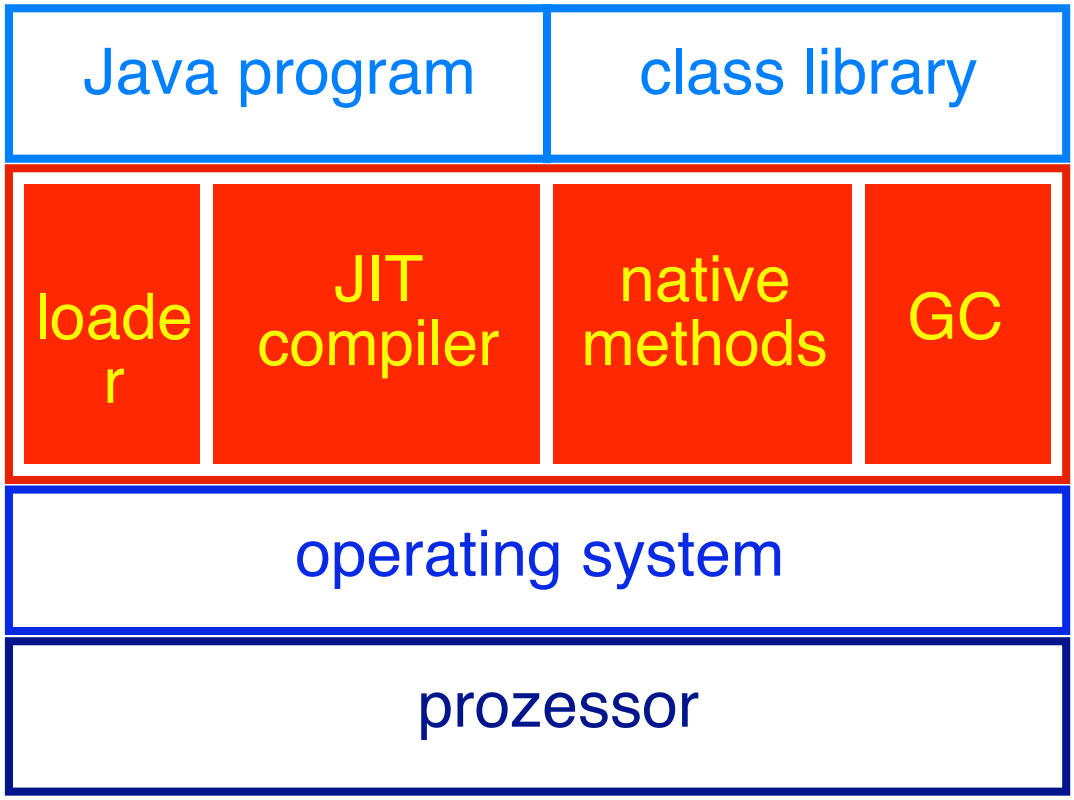
System architecture of CACAO



The Java Virtual Machine

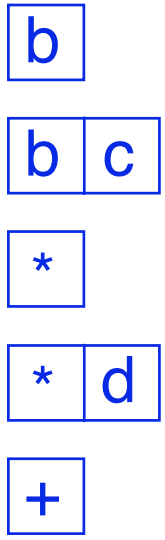
- stack architecture
- typed
- checked
- class files
- constant pool

Stack Architecture

Register Architecture

a = b * c + d

```
iload  b
iload  c
imul
iload  d
iadd
istore a
```




```
mull   b,c,t0
addl   t0,d,a
```

Naive translation into native code

a = b * c + d

stack element → stack register

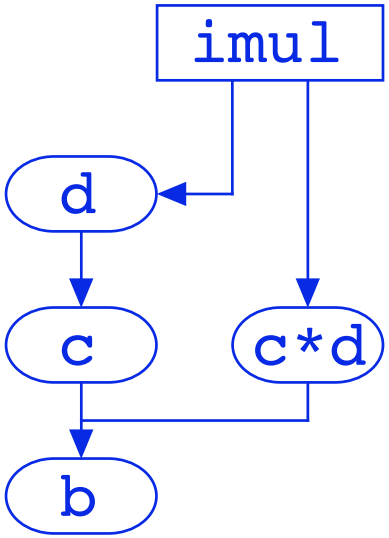
CACAO - Compiler

4+ pass compiler

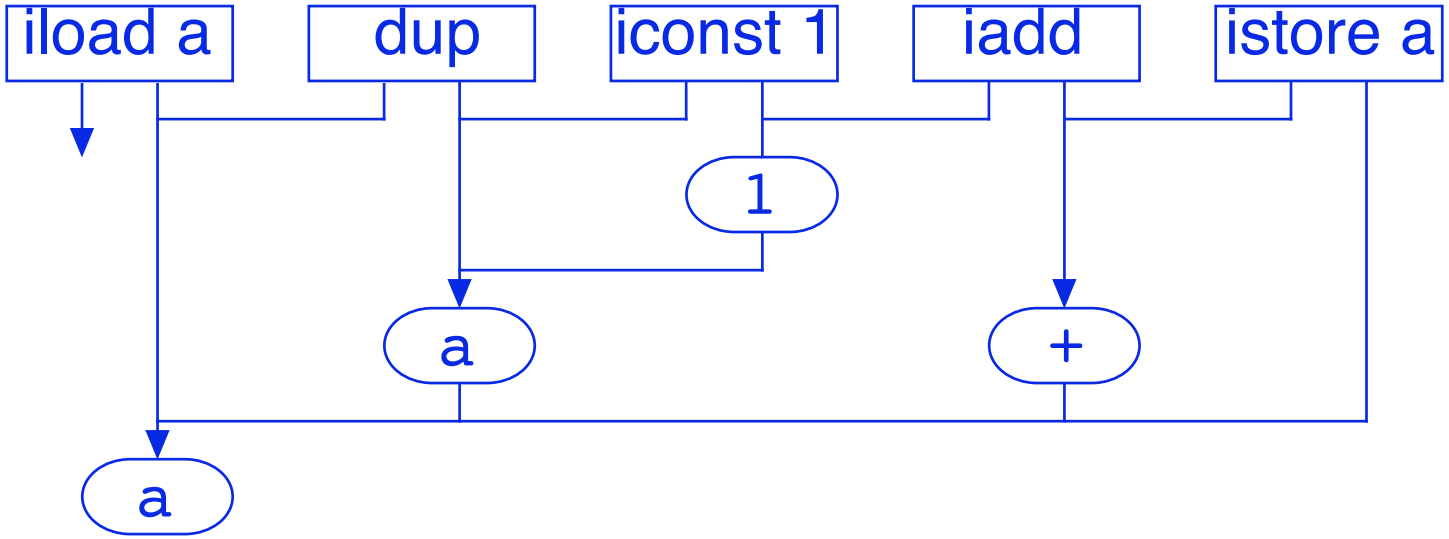
- determines basic blocks
- analyses stack
- allocates registers
- generates native code
- optional loop optimizations and verification

Static stack representation

- stack element contains variable type and index
- types: local, interface, argument, temporary

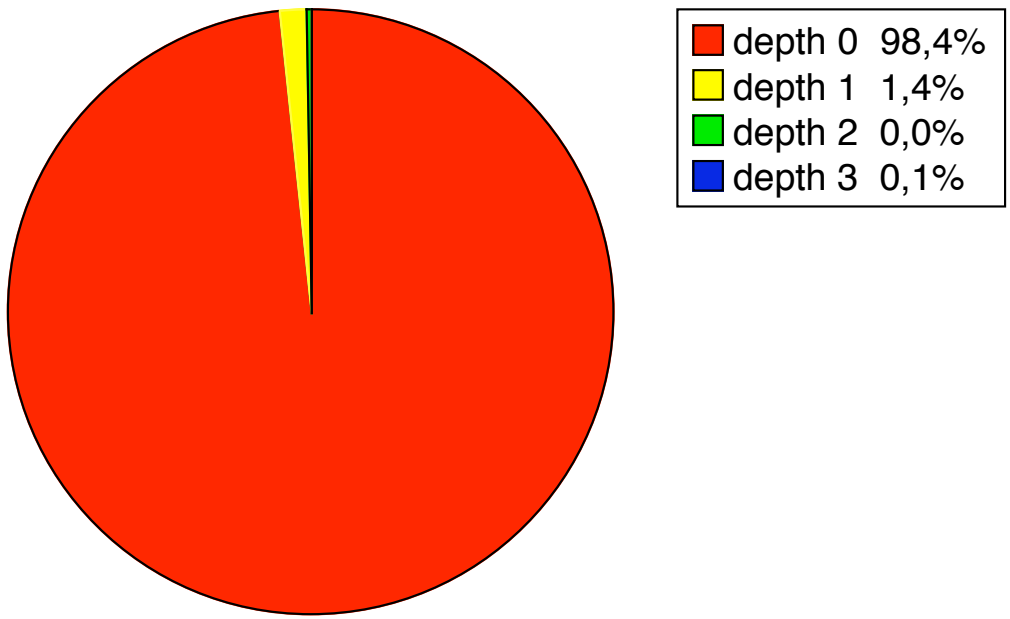


Dependences at store instructions



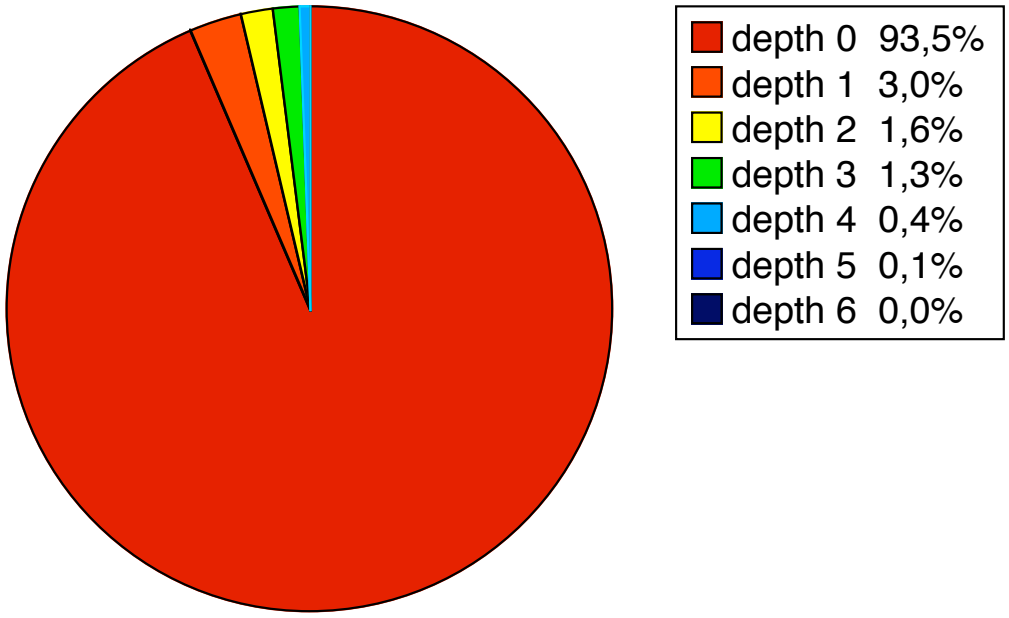
store instructions check stack for copies

Stack depth at store instructions



Fixed register interface for basic blocks

- different register types (`int`, `float`, ...)
- consistent use of saved registers

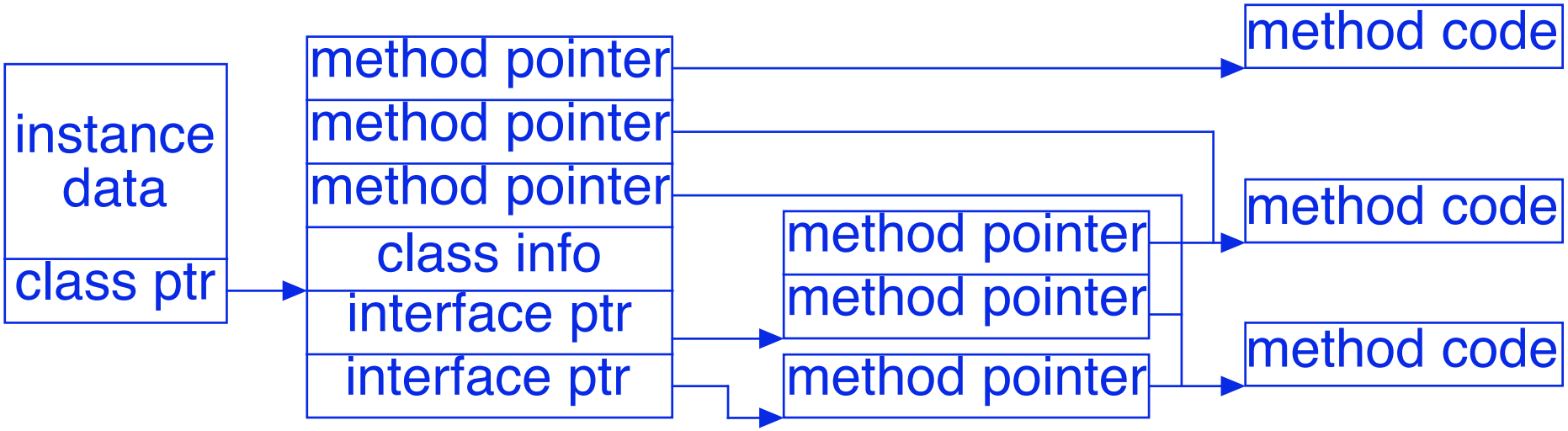


stack depth at basic block boundaries

Register allocation

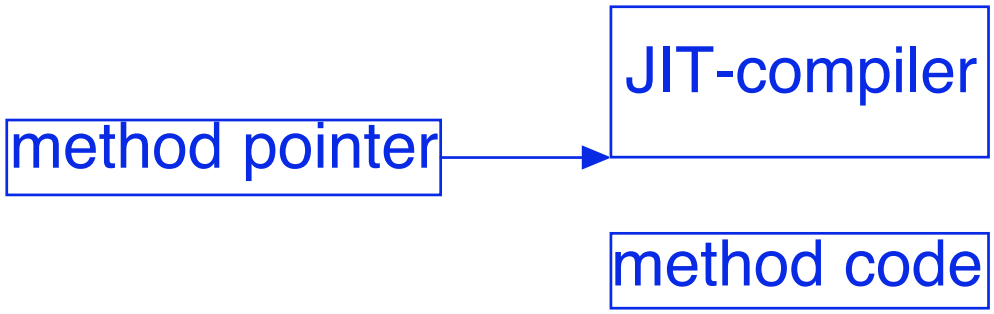
- simple and fast algorithm
- `javac` compiler packs local variables
- fixed register interface for basic blocks
- argument registers are allocated in advance
- registers for local variables are allocated after stack variables

CACAO's object and class representation



Just-in-time compilation

translation done during method invocation

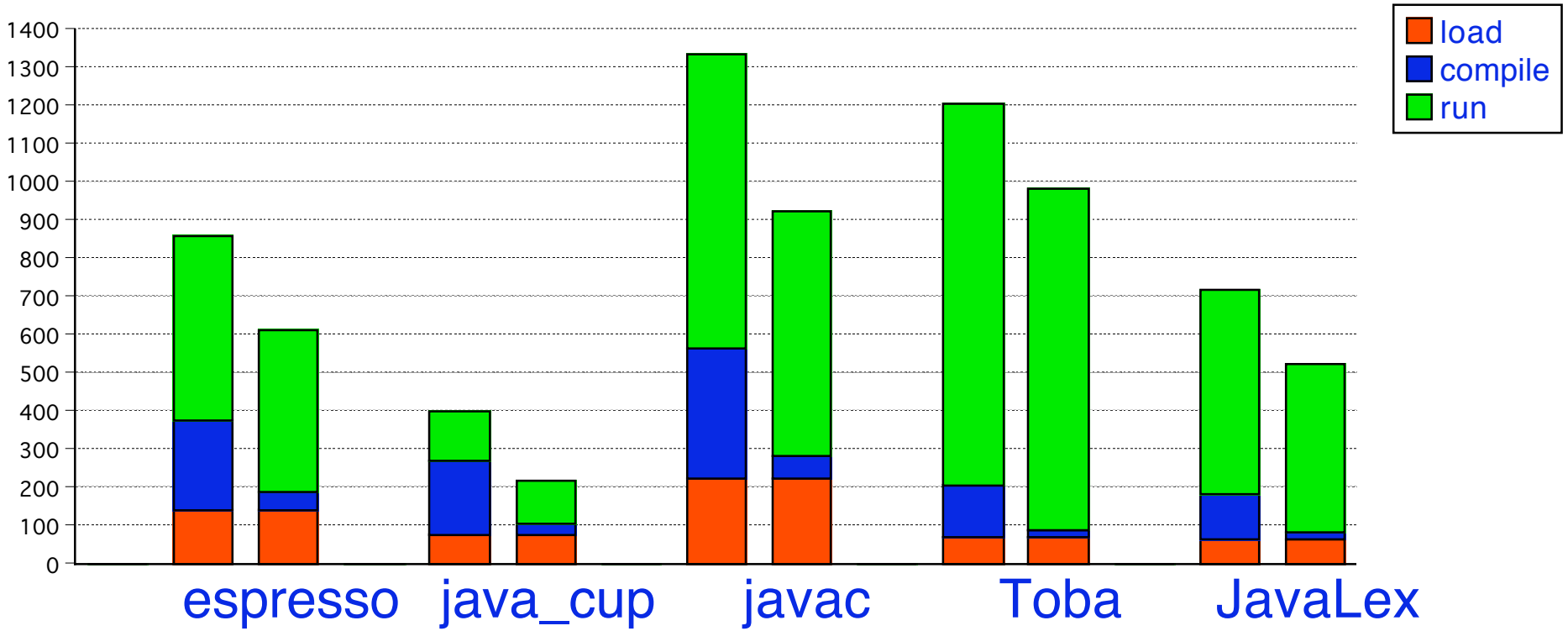


static methods are called using adress constants

Run time type checks

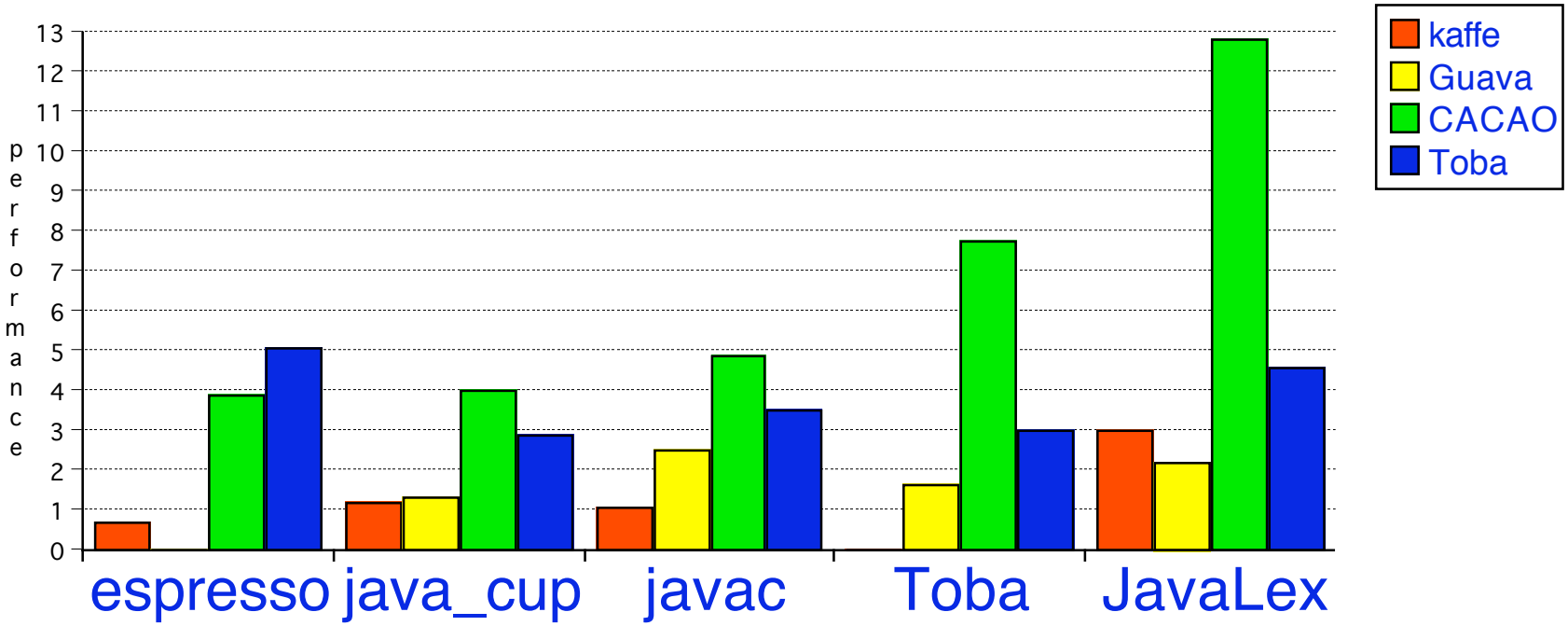
- relative tree numbering for classes
- interface hierarchy stored as pointer matrix
- run time type check done in four machine instructions

Performance comparison



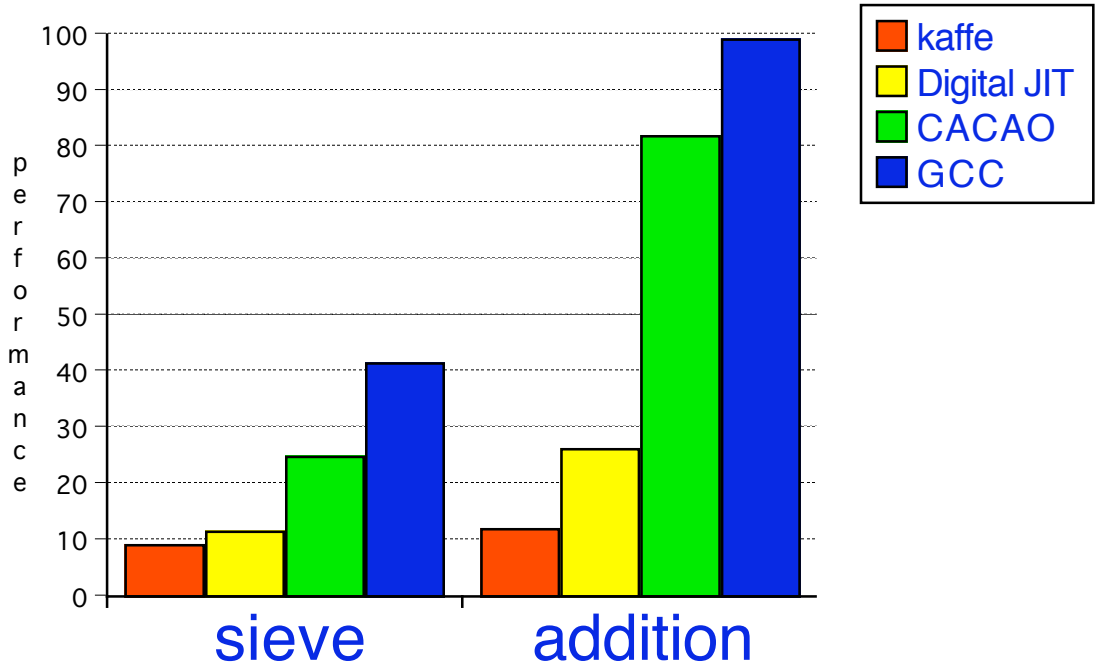
load/compile/run times in milliseconds

Performance comparison



performance relative to JDK-interpreter

Performance comparison



performance relative to JDK-interpreter

Conclusion

main reasons for CACAO's efficiency

- efficient just-in-time compilation
- efficient use of machine registers
- efficient object and class representation
- efficient synchronization
- fast exception handling and run time type check

`http://www.cacaojvm.org/`