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Evaluation of the runtime performance of control flow structures for dynamic dispatch in Java

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Motivation:

Frequent dynamic dispatch in Java programs

- ⇨ Efficient implementation crucial
- ⇨ Which bytecode control structure is the most efficient to implement dynamic dispatch ?

Methodology:

- A benchmark suite to time control structures for dynamic dispatch in Java under varying conditions:
 - Different control structures
 - Different numbers of possible receiver types (static)
 - Different patterns of runtime receiver types (dynamic)
 - Different execution environments

Java benchmarks are generated for each combination of control structure and number of possible types
 ⇨ 220+ variants

Type ID pattern files are generated, representing the order in which types occur at runtime
 ⇨ Control & repeatability
 ⇨ 60+ variants

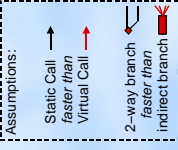
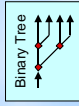
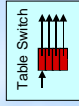
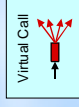
We time the execution of each benchmark on all patterns that apply to it, on various execution environments:

- Java Virtual Machines:
 - SUN HotSpot Server [HSS]
 - SUN HotSpot Client [HSC]
 - IBM JIT
- Hardware platforms:
 - Intel Pentium III [P3]
 - SUN UltraSparc III [U3]
 - Intel Celeron)
 - (AMD Athlon)

⇨ Bench × pattern × JVM × platform = 21,000 data points

Control structures:

We generate different control structures for polymorphic calls:



For comparison we also run benchmarks without any call:

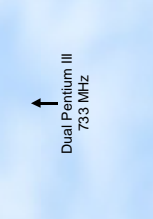
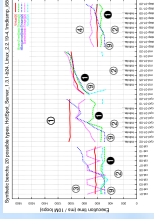
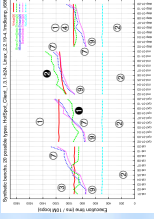
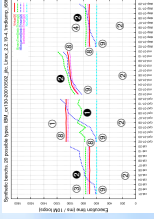


Some results:

- Virtual calls tend to be more expensive than other structures
- Virtual calls on P3 are sensitive to execution patterns
- Virtual calls on constant patterns tend to be efficient on P3 and U3
- Virtual calls with stepped patterns behave well on P3 but not on U3
- Virtual calls on U3 are insensitive to execution patterns, except for the constant pattern
- Virtual calls on U3 tend to be costly
- Switches on HSC behave like if sequences
- Switches on IBM behave like virtual calls
- If sequences are the best when only the first few ifs are exercised, except in some cases for HSS on U3

- Binary trees are significantly faster than virtual calls in most cases
- When binary trees are slower than virtual calls, the difference generally remains small

- All control structures, except virtual calls, speed up when the number of possible types is small



Conclusion:

- Performance of dynamic dispatch varies greatly across VMs and execution patterns
- Dynamic dispatch in current VMs can be significantly improved at compile time
- Much better implementations are possible for small numbers of possible receiver types, if sequences for up to ≈4, binary tree dispatch up to ≈8