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

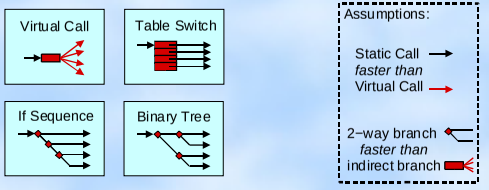
Type ID pattern files are generated, representing the order in which types occur at runtime
- ➪ Control & repeatability
- ➪ 60+ variants

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)

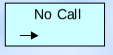
➪ Bench × pattern × JVM × platform ≃ 21,000 data points

Control structures:

We generate different control structures for polymorphic calls:



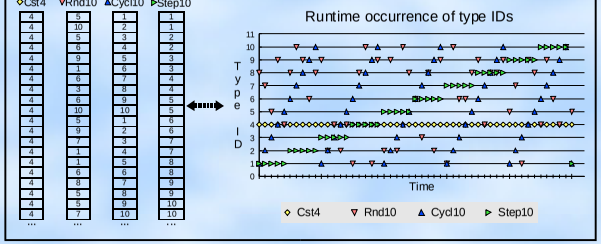
For comparison we also run benchmarks without any call:



Type ID Patterns:

	◇ Constant	▽ Random	△ Cyclic	▷ Stepped
Polymorphism	None	High	High	High
Variability	None	High	High	Low
Predictability	100%	None	Average	High
Frequency	Very common	Uncommon	Uncommon	Common

Implementation: x,000 iterations over a 10Kint array −> x0,000,000 calls



Some results:

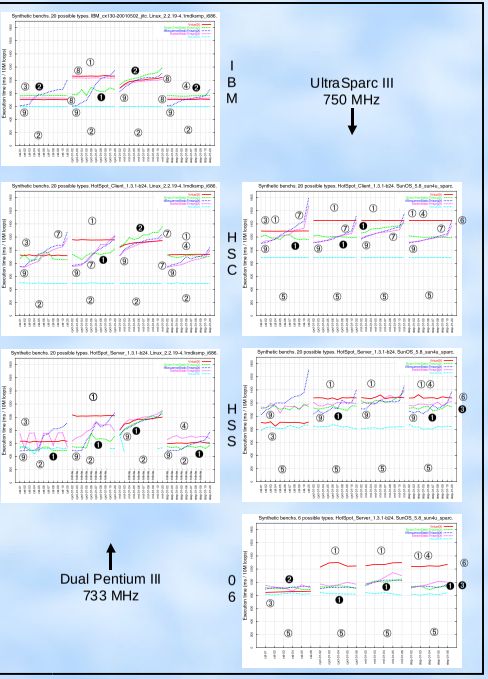
① Virtual calls tend to be more expensive than other structures
② Virtual calls on P3 are sensitive to execution patterns
③ Virtual calls on constant patterns tend to be efficient on P3 and U3
④ Virtual calls with stepped patterns behave well on P3 but not on U3
⑤ Virtual calls on U3 are insensitive to execution patterns, except for the constant pattern
⑥ Virtual calls on U3 tend to be costly

⑦ Switches on HSC behave like if sequences
⑧ Switches on IBM behave like virtual calls

⑨ If sequences are the best when only the first few ifs are exercised, except in some cases for HSS on U3

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

❸ 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