TECHNISCHE UNIVERSITÄT DRESDEN

Faculty of Computer Science · Institute for Computer Engineering

Bump-Pointer Method Caching for Embedded Java Processors

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Itinerary

- Introduction
- Method Cache Design
- Evaluation
- Discussion
- (Multithreading)

Introduction

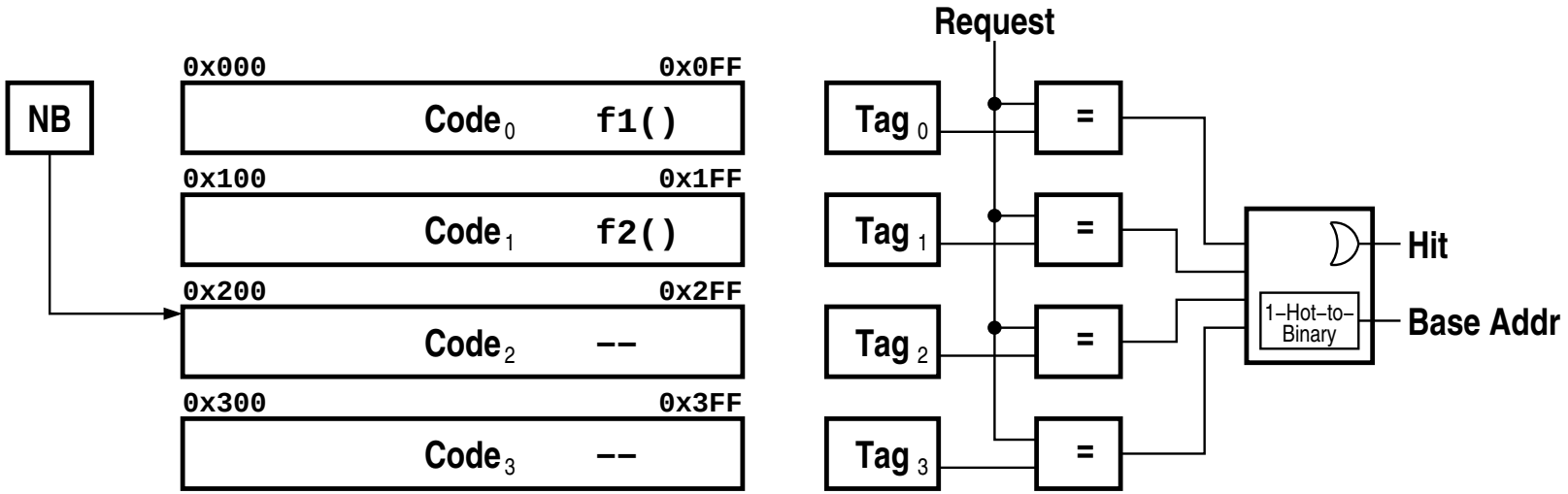
Cache hierarchy

- mandatory to span the performance gap between core and memory.
- accelerates the *common* case.
- complicates the *WCET* analysis.

Java method caches

- feasible as Java methods tend to be small.
- tie predictable costs to method invocations and returns.
- avoid intra-procedural jitter caused by misses.

Blocked Method Cache



Traditional vs. Stack-Based

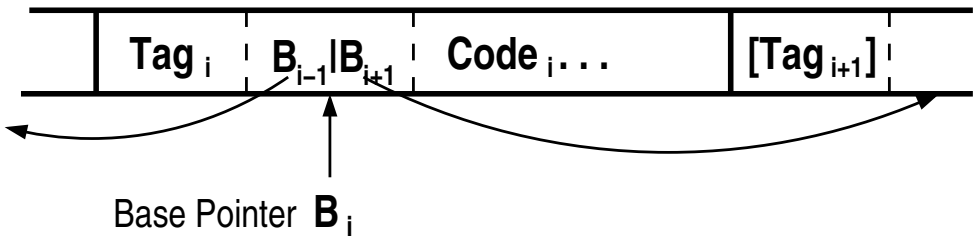
- Traditional cache *often* performs better as thrashing of multiple methods in a loop is avoided:

```
void a() {
  for(;;) {
    b();
    c();
  }
}
```

- Stack-based cache is more predictable as hits only depend on *local* call hierarchy.
- Stack-based cache can be implemented to populate available memory densely through bump-pointer allocation.

Method Data Layout

Ring Buffer with Method Entries:



Additional State:

- `PB, CB, NB` – registered copies of previous, current and next method base pointer
- `PT, CT, NT` – corresponding registered tags
- `VP` – valid pointer: start of memory area not overridden by farthest extend of call hierarchy

Hits can be distinguished into:

returning	one stack frame is unwound
recursive	re-invocation of calling method
invoking	re-invocation of previously invoked method

Valid Pointer

- is increased on method load beyond it encountering order CB, VP, NB rather than CB, NB, VP:

$$VP - CB \leq NB - CB$$

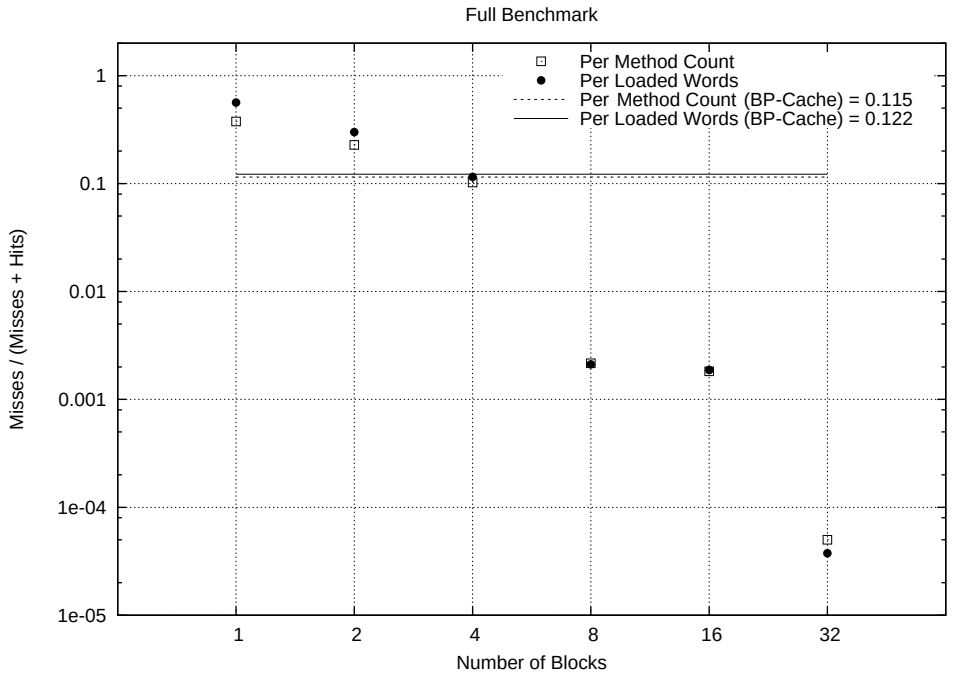
- used to validate returning hits by checking the order VP, PB, CB $\equiv$ CB, VP, PB:

$$VP - CB \leq PB - CB$$

Distance calculation ignores overflows in subtractions.
Re-use of same circuit with single input multiplexor.

Empirical Evaluation

Overall Caffeine Benchmark (without FloatTest):



Discussion

- Hit rates of about 90% comparable to a blocked cache with 4 blocks.
- Sliding window view on cache space is acceptable.
- Larger cache memory is only utilized by multi-slice implementation:
  - Slice size according to average call hierarchy.
  - Slices reduce thrashing in loops.
  - Number of comparators grows with slice number.
  - Slicing and coloring of slices may benefit multithreaded analysis.

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StringTest regularly ran faster when forked into extra Thread.

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StringAtom.execute() ->
    StringBuffer.append() ->
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Cache layout after destructive interruption of forking Thread yielding:

```
System.arraycopy() ->
    String.getChars() ->
        StringBuffer.append() ->
            StringAtom.execute() |
            String.length()
```

Mutual replacement now limited to small methods.

Thank you!