Interleaving with Coroutines
A Practical Approach to Avoid Memory Stalls

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1. Index joins in database systems
- Databases use index structures for random data access:
  - Sorted arrays with binary search
  - Tree structures

![Index lookups ⇒ irregular memory access patterns](image)
- Index lookups ⇒ irregular memory access patterns
- Index join: a sequence of independent index lookups

**Irregular memory accesses + independent lookups**

2. Irregular memory access ⇒ wasted cycles
- Index lookups are sensitive to index size
- ...regardless of the index structure

![Index join execution breakdown](image)

**Memory stalls: up to 85% of total cycles**

3. Interleaved execution of lookups
- Consecutive lookups with 3 cache misses each

![Interleaved Execution](image)

- Overlap memory access with independent instructions from other lookups
- Transfer execution control upon cache miss

**Execute independent instructions instead of stalling**

4. Interleaved execution with coroutines
- Coroutines: functions that suspend and resume their execution

![Control transfer](image)
- Binary search as a coroutine:
  1. `size = array.size()`, `low = 0`
  2. `while size >= 2 do`
  3. `half = size / 2`
  4. `probe = low + half`
  5. `size = half`
  6. `prefetch(&array[probe])`
  7. `suspend()`
  8. `v = array[probe]` original cache miss
  9. `low = v < value ? probe : low`
  10. `return low`

**Minimal and non-intrusive code changes**

5. Interleaved vs non-interleaved execution

![Index join on sorted array (10K binary searches)](image)

**Interleaved execution ⇒ runtime oblivious to array size**

6. Multithreaded interleaved execution

- Multithreaded (MT) index join on sorted array (10K binary searches)
- + Hyperthreading (HT) + Interleaved Execution (C)

![Speedup over Baseline](image)

**Interleaved execution scales better**

Parts of this work have been published at PVLDB 11(2) under the title
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