Efficient SIMD Vectorization for Hashing in OpenCL

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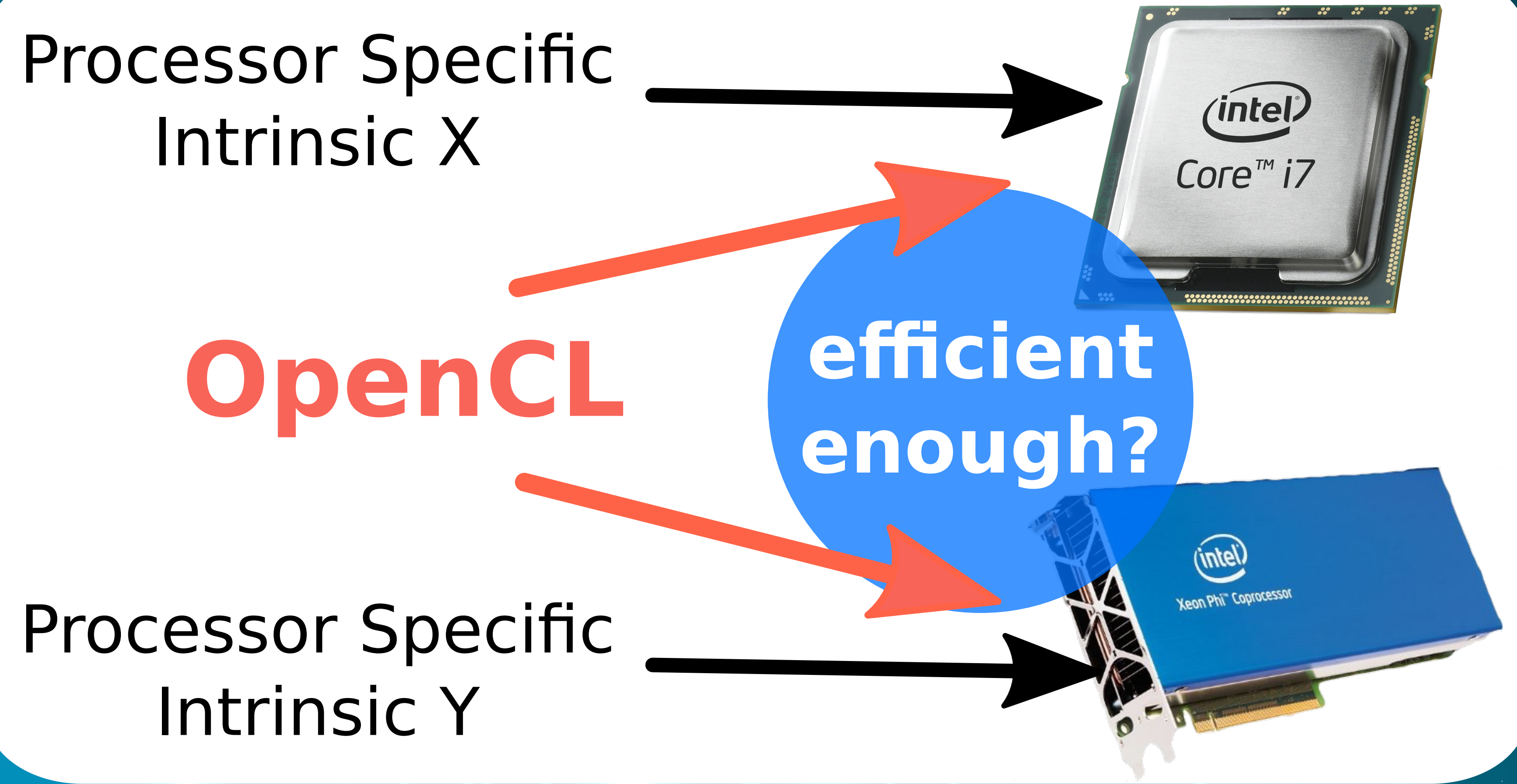
Abstract

Hashing is at the core of many efficient database operators such as hash-based joins and aggregations.

Significant speedup was shown for vectorized hash table operations using processor specific low-level intrinsics.

We present portable and vectorized hashing primitives using the parallel programming framework OpenCL.



Processor Specific Intrinsic X

OpenCL

efficient enough?

Processor Specific Intrinsic Y

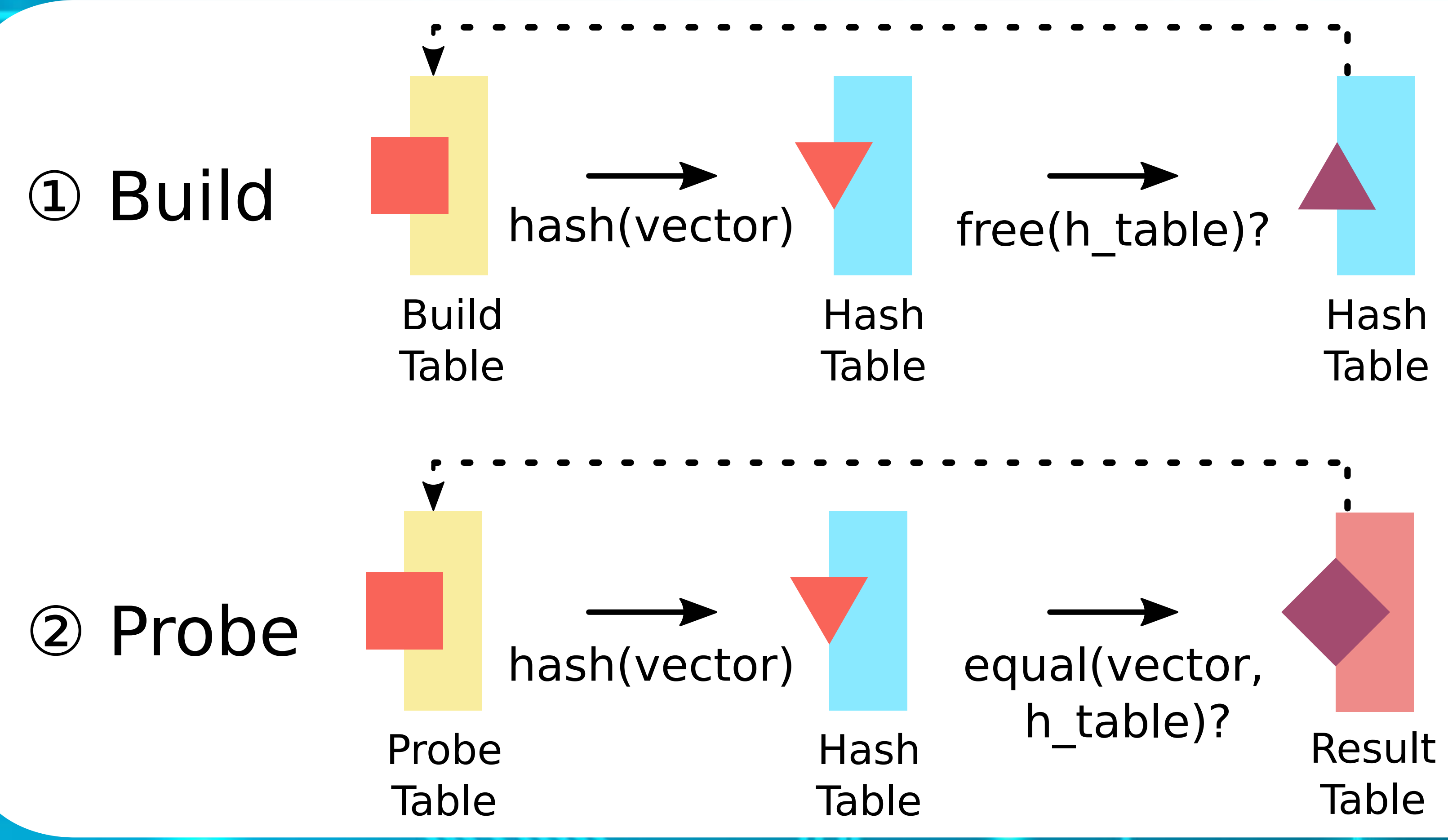
Vectorized Data Movement Primitives

Selective Load – Copies data from contiguous memory into selectable SIMD lanes. (Probe / Build Table)

Selective Store – Copies data from selectable SIMD lanes to contiguous memory. (Result Table)

Gather – Copies data from discontiguous memory into SIMD lanes. (Hash Table)

Scatter – Copies data from SIMD lanes into discontiguous memory. (Hash Table)



① Build

Build Table → hash(vector) → Hash Table → free(h_table)? → Hash Table

② Probe

Probe Table → hash(vector) → Hash Table → equal(vector, h_table)? → Result Table

Gather OpenCL

```
// tables: Bucket *table, uint 8 mask
// Output: uint8 vector
vector.s0 = table[mask.s0].key;
vector.s1 = table[mask.s1].key;
//   ... up to vector.s7 = table[mask.s7].key
```

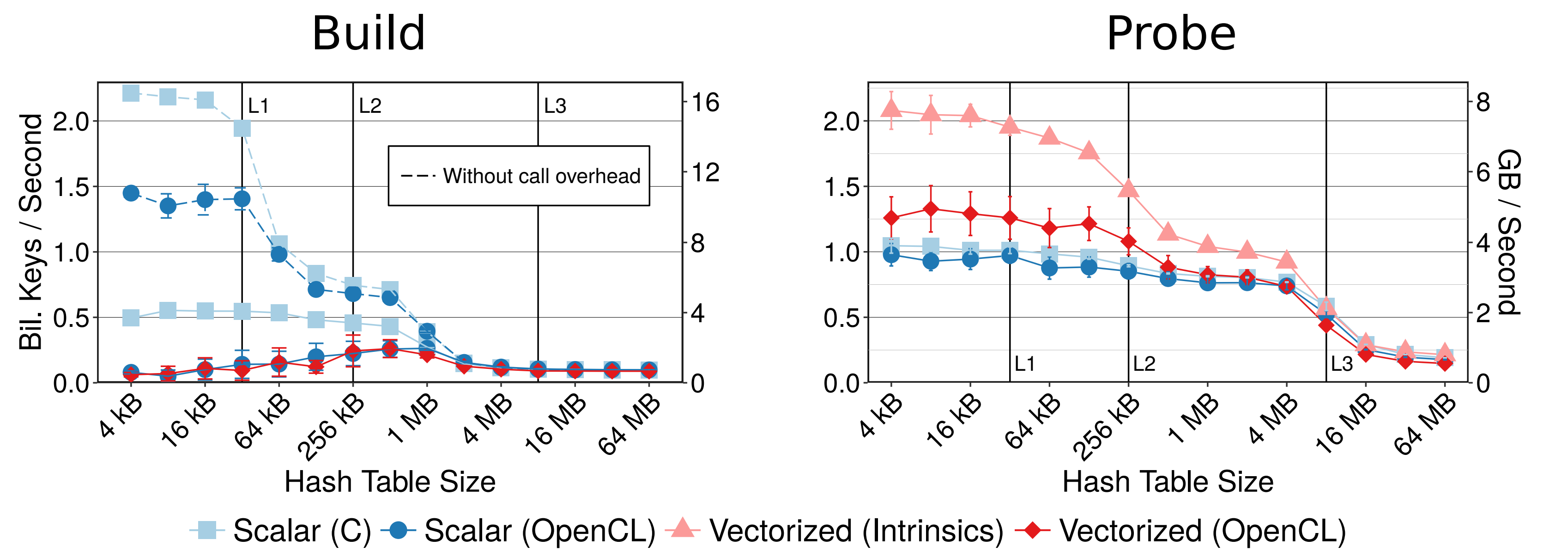
vs.

Gather Intel Intrinsics

```
// Inputs: uint64_t* table, __128i index
// Output: __m256i res
__m128i index_R = _mm_shuffle_epi32(index, _MM_SHUFFLE(1, 0, 3, 2));
__m128i i12 = _mm_cvtepi32_epi64(index);
__m128i i34 = _mm_cvtepi32_epi64(index_R);
size_t i1 = _mm_cvtsi128_si64(i12);
size_t i3 = _mm_cvtsi128_si64(i34);
__m128i d1 = _mm_loadl_epi64((__m128i *)&table[i1]);
__m128i d3 = _mm_loadl_epi64((__m128i *)&table[i3]);
i12 = _mm_srli_si128(i12, 8);
i34 = _mm_srli_si128(i34, 8);
size_t i2 = _mm_cvtsi128_si64(i12);
size_t i4 = _mm_cvtsi128_si64(i34);
__m128i d2 = _mm_loadl_epi64((__m128i *)&table[i2]);
__m128i d4 = _mm_loadl_epi64((__m128i *)&table[i4]);
__m256i d12 = _mm256_castsi128_si256(_mm_unpacklo_epi64(d1, d2));
__m256i d34 = _mm256_castsi128_si256(_mm_unpacklo_epi64(d3, d4));
__m256i res = _mm256_permute2x128_si256(d12, d34, _MM_SHUFFLE(0, 2, 0, 0));
```

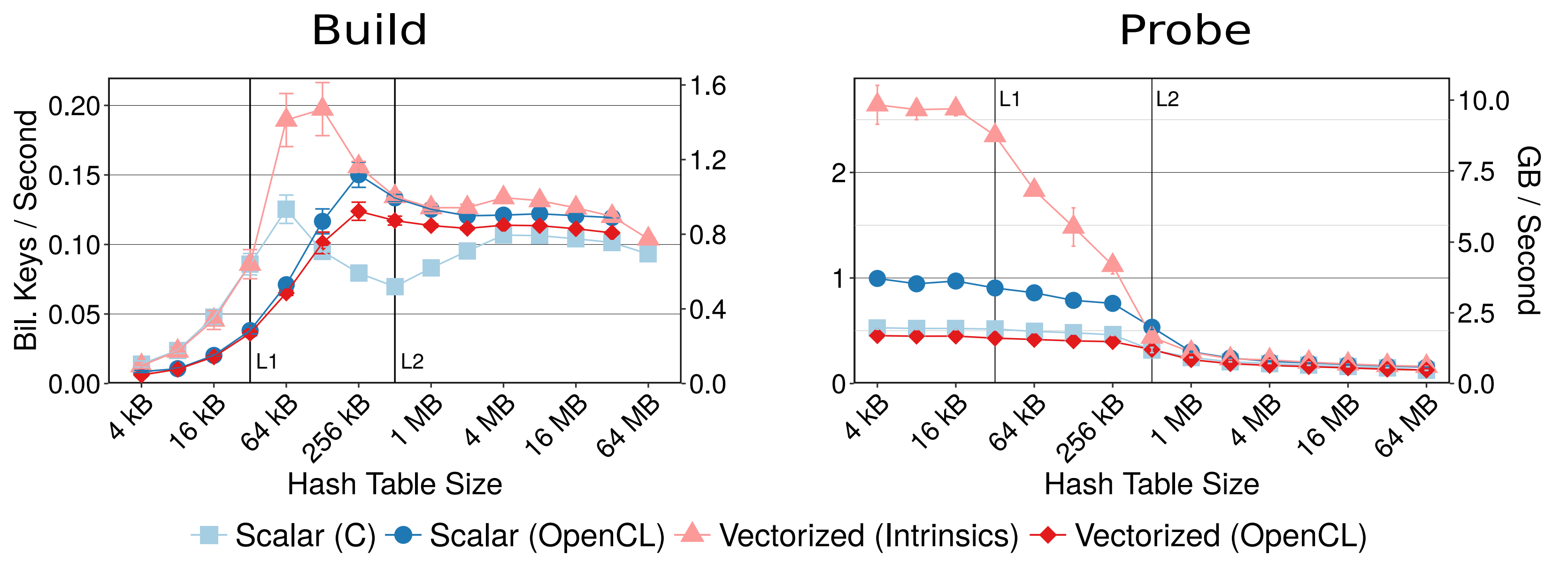
Portable and Maintainable Code

Performance on Xeon CPU



Build is overhead dominated, OpenCL-based probe outperforms scalar implementation.

Performance on Xeon Phi



Intrinsic-based implementation outperforms OpenCL-based on Xeon Phi.

Take Home

OpenCL reduces code complexity and ensures portability of vectorized primitives.

OpenCL-based vectorized hashing outperforms scalar hashing on Xeon CPU.

Processor specific intrinsics are still faster, especially on Xeon Phi.

Open Source Repository

github.com/TU-Berlin-DIMA/OpenCL-SIMD-hashing

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