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# Lab 8

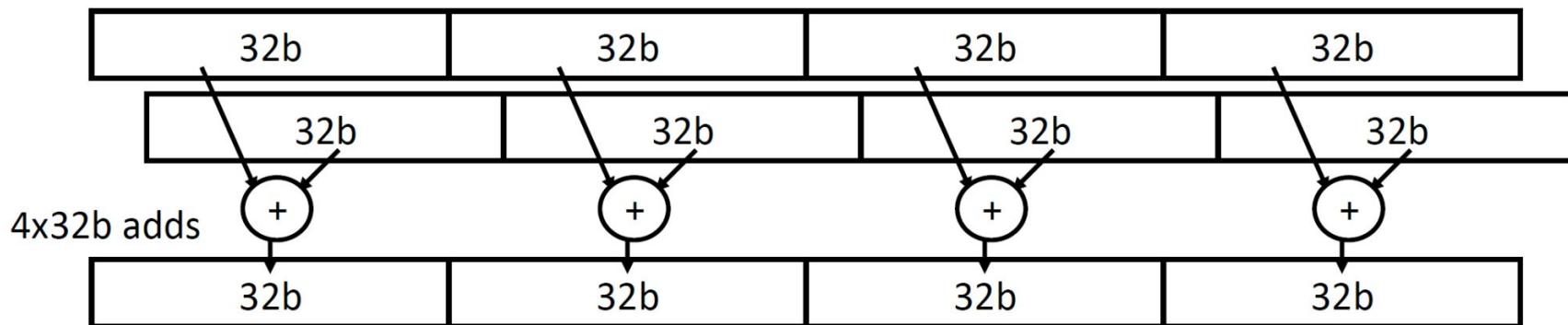
CS61C

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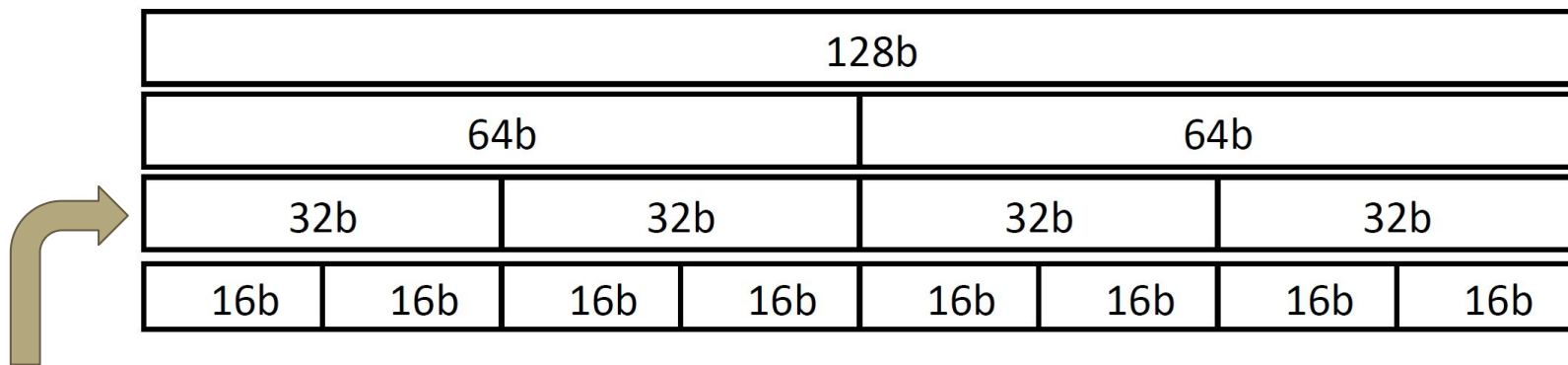
# What is SIMD?

- Single Instruction, Multiple Data
- Data are packed together then same operations can be done in parallel



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4 32-bit integers combined to form 128-bits

# SIMD Functions

- For this class, we'll use Intel's SIMD instructions

## Intel® Intrinsic Guide

Updated  
12/06/2021

Version  
3.6.1

### Instruction Set

- ☐ MMX
- ☒ SSE
- ☒ SSE2
- ☒ SSE3
- ☒ SSSE3
- ☒ SSE4.1
- ☒ SSE4.2
- ☒ AVX
- ☒ AVX2
- ☐ FMA
- ☐ AVX\_VNNI
- ☐ AVX-512
- ☐ KNC
- ☐ AMX
- ☐ SVML
- ☐ Other

The Intel® Intrinsic Guide contains reference information for Intel intrinsics, which provide access to Intel instructions such as Intel® Streaming SIMD Extensions (Intel® SSE), Intel® Advanced Vector Extensions (Intel® AVX), and Intel® Advanced Vector Extensions 2 (Intel® AVX2).

- For information about how Intel compilers handle intrinsics, view the [Intel® C++ Compiler Classic Developer Guide and Reference](#).
- For questions about Intel intrinsics, visit the [Intel® C++ Compiler board](#).

\_mm\_search

<code>_mm128i_abs_epi16 (__m128i a)</code>	<code>pabsw</code>
<code>_mm256i_abs_epi16 (__m256i a)</code>	<code>vpabsw</code>
<code>_mm128i_abs_epi32 (__m128i a)</code>	<code>pabsd</code>
<code>_mm256i_abs_epi32 (__m256i a)</code>	<code>vpabsd</code>
<code>_mm128i_abs_epi8 (__m128i a)</code>	<code>pabsb</code>
<code>_mm256i_abs_epi8 (__m256i a)</code>	<code>vpabsb</code>
<code>_mm64_abs_pi16 (__m64 a)</code>	<code>pabsw</code>

List of all possible functions that you can use for SIMD operations

<https://www.intel.com/content/www/us/en/docs/intrinsics-guide/index.html>

# Some SIMD Functions

- `__m128i _mm_setzero_si128()`
  - returns a 128-bit zero vector
- `__m128i _mm_loadu_si128(__m128i *p)`
  - returns 128-bit vector stored at pointer p
- `__m128i _mm_add_epi32(__m128i a, __m128i b)`
  - returns vector ( $a_0 + b_0, a_1 + b_1, a_2 + b_2, a_3 + b_3$ )
- `void _mm_storeu_si128(__m128i *p, __m128i a)`
  - stores 128-bit vector a into pointer p

# Review `sum()` and `sum_unrolled()`

# SIMD Functions recap

- `__m128i _mm_setzero_si128()`
  - returns a 128-bit zero vector
- `__m128i _mm_loadu_si128(__m128i *p)`
  - returns 128-bit vector stored at pointer p
- `__m128i _mm_add_epi32(__m128i a, __m128i b)`
  - returns vector  $(a_0 + b_0, a_1 + b_1, a_2 + b_2, a_3 + b_3)$
- `void _mm_storeu_si128(__m128i *p, __m128i a)`
  - stores 128-bit vector a into pointer p

# Sample SIMD code

```
1  #include <x86intrin.h>
2
3  int arr[8] = {3, 1, 4, 1, 5, 9, 2, 6};
4  // Initialize sum vector to {0, 0, 0, 0}
5  __m128i sum_vec = _mm_setzero_si128();
6
7  // Load array elements 0-3 into a temporary vector register
8  __m128i tmp = _mm_loadu_si128((__m128i *) arr);
9  // Add to existing sum vector
10 sum_vec = _mm_add_epi32(sum_vec, tmp);
11 // sum_vec = {3, 1, 4, 1}
12
13 // Load array elements 4-7 into a temporary vector register
14 tmp = _mm_loadu_si128((__m128i *) (arr + 4));
15 // Add to existing sum vector
16 sum_vec = _mm_add_epi32(sum_vec, tmp);
17 // sum_vec = {3 + 5, 1 + 9, 4 + 2, 1 + 6}
18
19 // Create temporary array to hold values from sum_vec
20 // Store the vector into an array to access the individual values
21 int tmp_arr[4];
22 _mm_storeu_si128((__m128i *) tmp_arr, sum_vec);
23 // Collect values from sum_vec in a single integer
24 int sum = tmp_arr[0] + tmp_arr[1] + tmp_arr[2] + tmp_arr[3];
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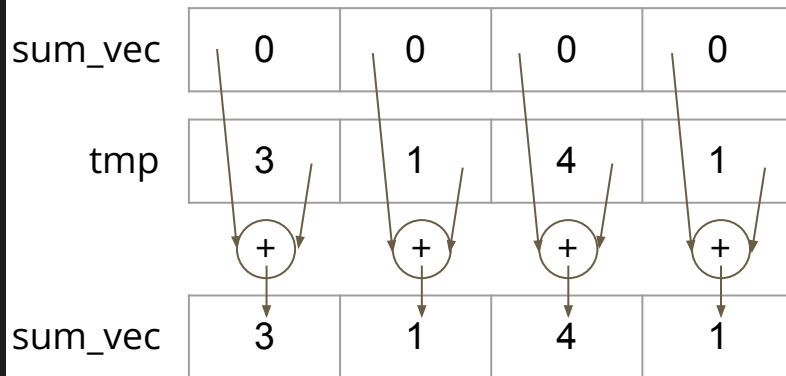
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← C library to use the SIMD functions

← Initial array that will be “SIMDized”

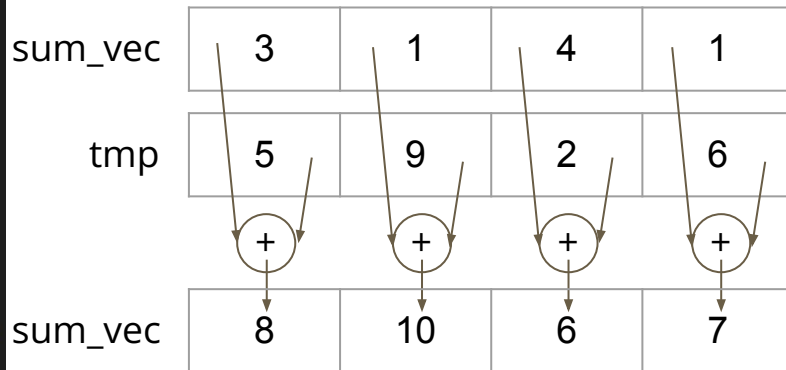
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```

sum\_vec

8	10	6	7
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sum

8	+	10	+	6	+	7
---	---	----	---	---	---	---

# SIMD Functions

- `__m128i _mm_and_si128(__m128i a, __m128i b)`
  - returns vector (a & b), where & represents the bitwise AND operator
- `__m128i _mm_cmpgt_epi32(__m128i a, __m128i b)`
  - returns the vector ( $a_n > b_n ? 0xffffffff : 0x0$  for  $n$  from 0 to 3). AKA a 32-bit all-1s mask if  $a_n > b_n$  and a 32-bit all-0s mask otherwise

a	0x3	0x4	0x5	0x6
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b	0x0	0x5	0x6	0x3
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<code>_mm_cmpgt_epi32()</code>	0xFFFFFFFF	0x0	0x0	0xFFFFFFFF
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# Ex3 and Ex4 time