# Special instructions: Predicated instructions, SIMD


[SW04] P. Sanders and S. Winkel. *Super Scalar Sample Sort*.
12th Annual European Symposium on Algorithms (ESA), LNCS 3221, 784-796, 2004.

[SGL09] Benjamin Schlegel, Rainer Gemulla, Wolfgang Lehner. *k-ary search on modern processors*.
5th International Workshop on Data Management on New Hardware (DaMoN), 52-60, 2009.

[K+10] C. Kim, J. Chhugani, N. Satish, E. Sedlar, A.D. Nguyen, T. Kaldewey, V.W. Lee, S.A. Brandt, and P. Dubey.
*FAST: fast architecture sensitive tree search on modern CPUs and GPUs*.
2010 ACM SIGMOD International Conference on Management of data, 339-350, 2010.

# Conditional instruction: cmovge

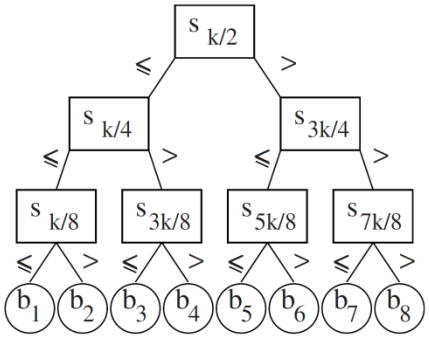
```
for (int i=0; i<100; i++)
  if (X[i]>50) large+=7;
```

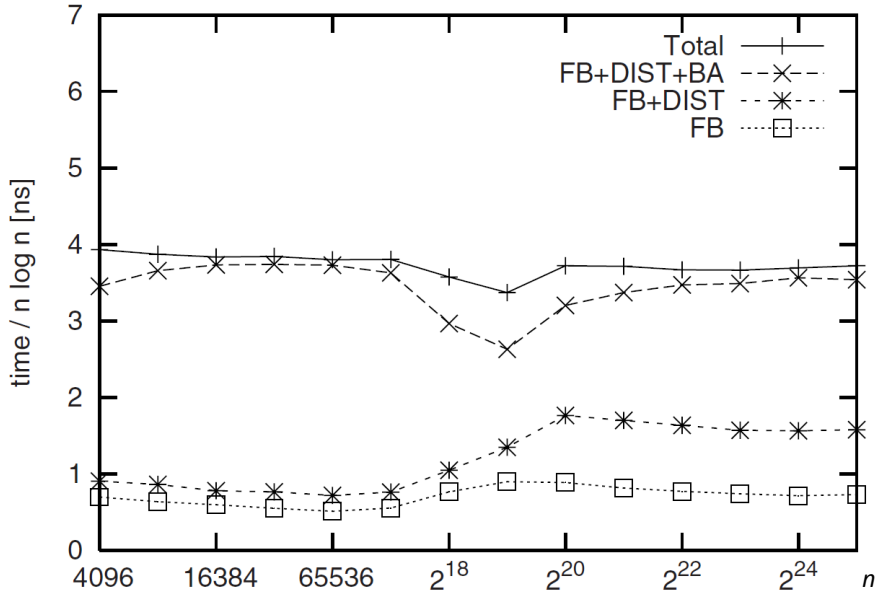
```
L6:
        cmpl    $51, (%edi,%eax,4)
        leal    7(%edx), %ecx
        cmovge  %ecx, %edx
        addl    $1, %eax
        cmpl    $100, %eax
        jne     L6
```

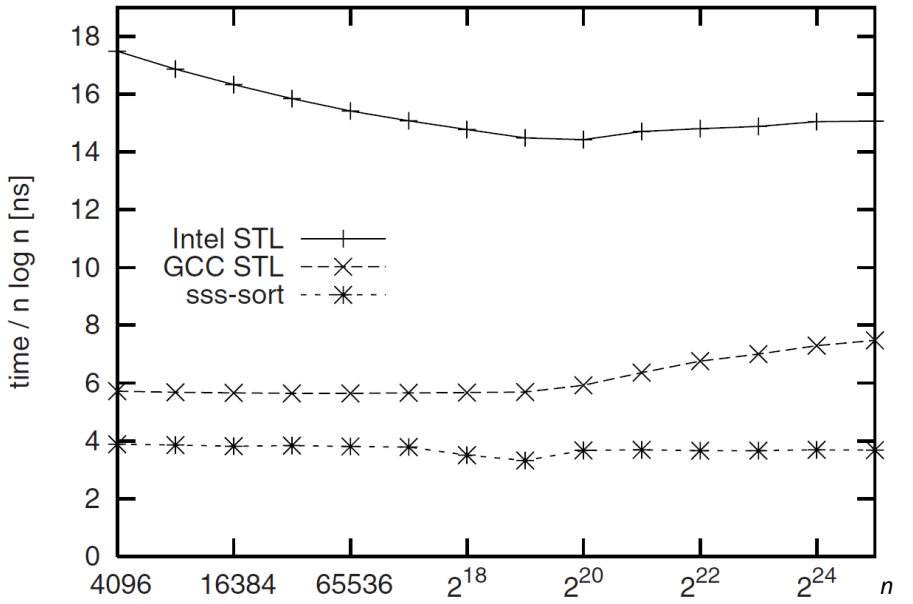
# Super Scalar Sample Sort

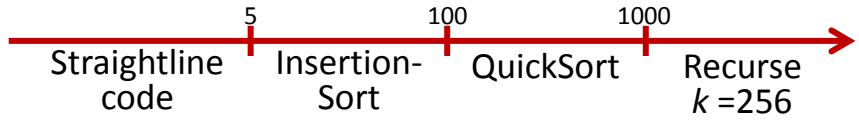
$t := \langle s_{k/2}, s_{k/4}, s_{3k/4}, s_{k/8}, s_{3k/8}, s_{5k/8}, s_{7k/8}, \ldots \rangle$
**for** $i := 1$ **to** $n$ **do** // locate each element
  $j := 1$ // current tree node := root
  **repeat** $\log k$ *times* // will be unrolled
    $j := 2j + (a_i > t_j)$ // left or right?
  $j := j - k + 1$ // bucket index
  $|b_j|{+}{+}$ // count bucket size
  $o(i) := j$ // remember oracle

**for** $i := 1$ **to** $n$ **do** $a'_{B[o(i)]++} := a_i$



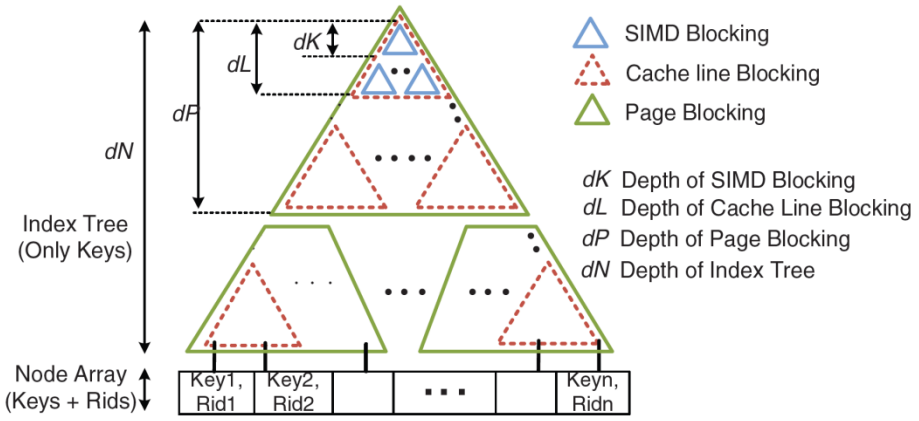



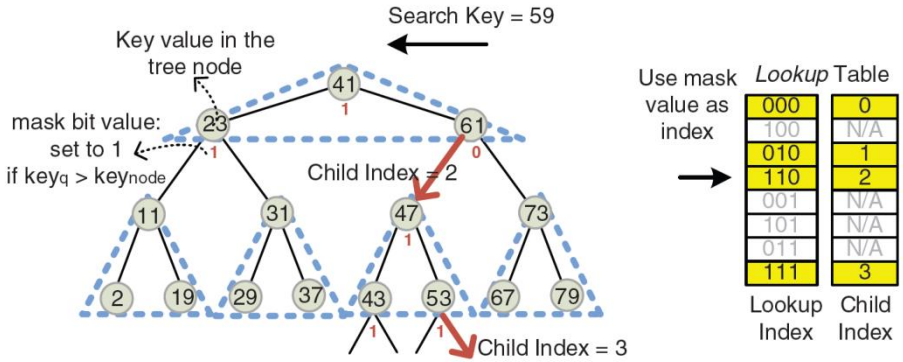




[SW04] P. Sanders and S. Winkel. *Super Scalar Sample Sort*. European Symposium on Algorithms 2004.

# Multiway Comparisons

## SIMD (Single instruction, multiple data)







```
/*
TΔ: starting address of a tree
page_address: starting address offset of a particular page blocking sub-tree
page_offset: starting address offset of a particular cache line blocking sub-tree
cache_offset: starting address offset of a particular SIMD blocking sub-tree
*/

__m128i xmm_key_q = _mm_load1_ps(key_q);
/* xmm_key_q : vector register Vkeyq, Splat a search key (keyq) in Vkeyq */

for (i=0; i<number_of_accessed_pages_within_tree; i++) {
    page_offset = 0;
    page_address = Compute_page_address(child_offset);
    for (j=0; j<number_of_accessed_cachelines_within_page; j++) {
        /* Handle the first SIMD blocking sub-tree (=2 levels of the tree)*/

        __m128i  xmm_tree = _mm_loadu_ps(TΔ + page_address + page_offset);
        /* xmm_tree: vector register Vtree. Load four tree nodes in Vtree*/

        __m128i xmm_mask = _mm_cmpgt_epi32(xmm_key_q, xmm_tree));
        /* xmm_mask: mask register Vmask. Set the mask register Vmask*/

        index = _mm_movemask_ps(_mm_castsi128_ps(xmm_mask));
        /* Convert mask register into index*/

        child_index = LookUp[index];

        /* Likewise, handle the second SIMD blocking sub-tree (=2 levels of the tree)*/
        xmm_tree = _mm_loadu_ps(TΔ + page_address + page_offset + Nk*child_index);
        xmm_mask = _mm_cmpgt_epi32(xmm_key_q, xmm_tree));
        index = _mm_movemask_ps(_mm_castsi128_ps(xmm_mask));
        cache_offset = child_index*4 + Lookup[index];
        page_offset =  page_offset*16 + cache_offset;
    }
    child_offset = child_offset*(2^dp) + page_offset;
}

/* child_offset is the offset into the input (Key, Rid) tuple (T) */
While (T[child_offset].key <= keq_q2)
        child_offset++
```

[K+10] *FAST: fast architecture sensitive tree search on modern CPUs and GPUs*. SIGMOD 2010.