
INF FAKULTÄT FÜR INFORMATIK

# SIMD Acceleration for Index Structures

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# Agenda

**Motivation**

**Excursion: $B^+$-Tree**

**SIMD Style Processing**

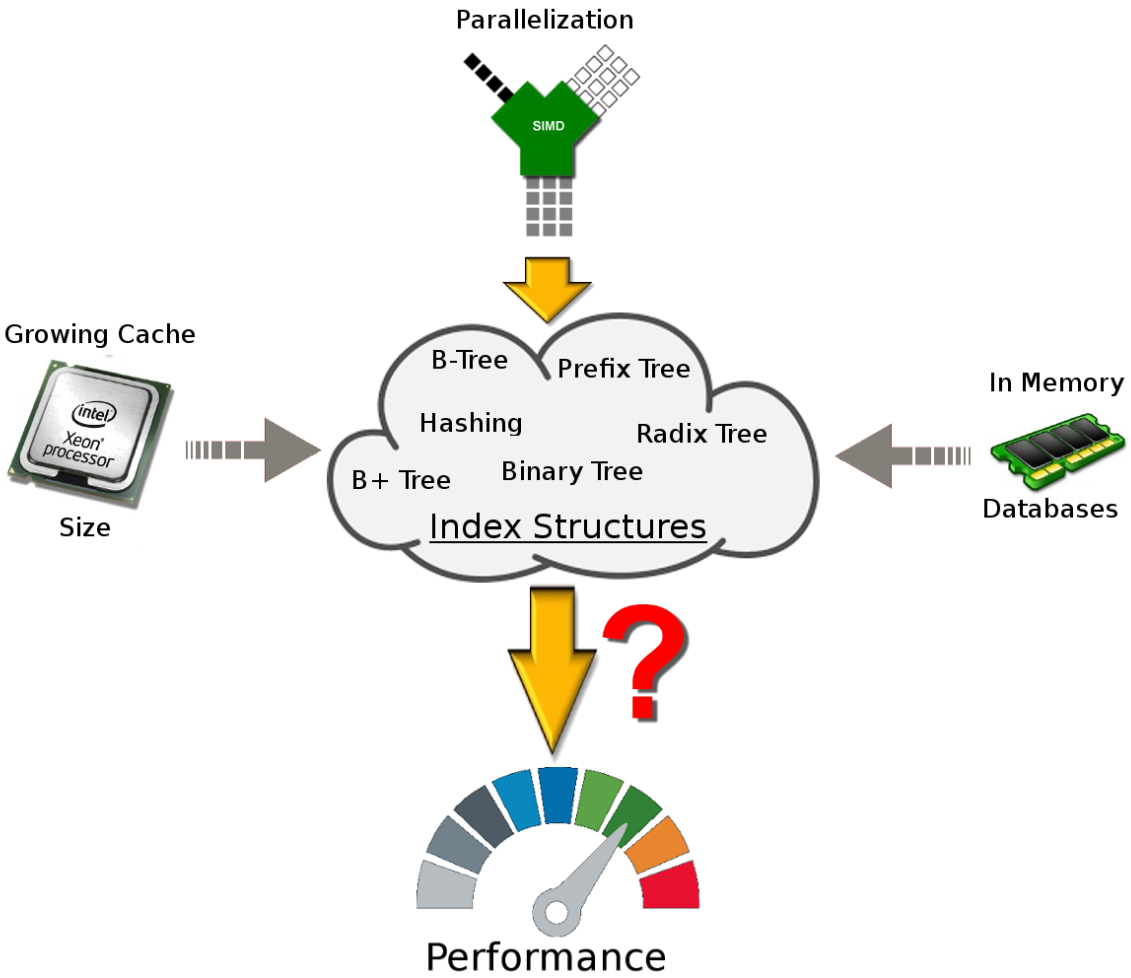
**Adapted Tree structures**

- Seg-Tree/Trie
- FAST

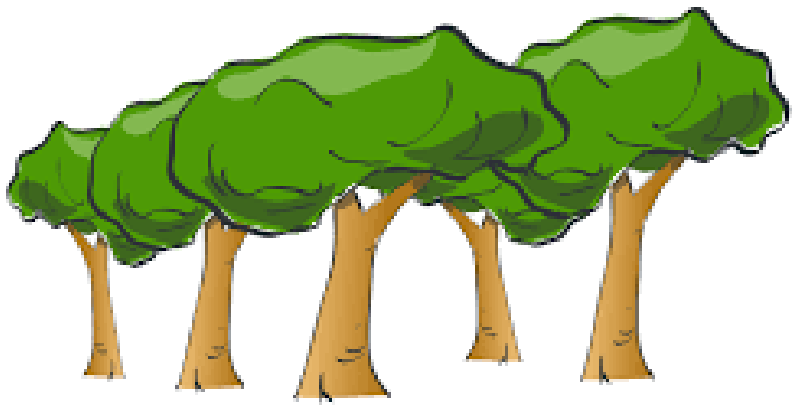
**Evaluation**

**Conclusion**

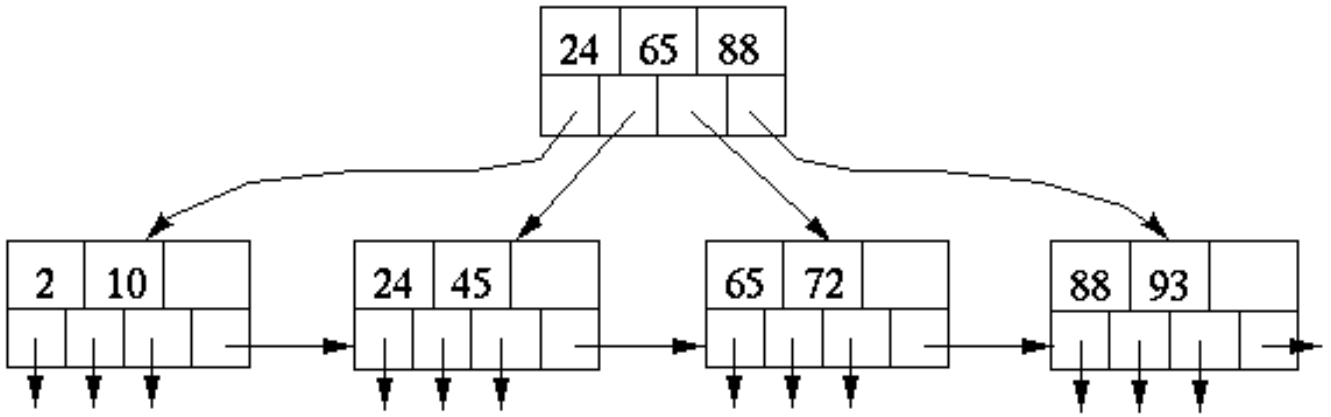
# Motivation


Parallelization
SIMD
Growing Cache
intel
Xeon processor
Size
B-Tree
Prefix Tree
Hashing
Radix Tree
B+ Tree
Binary Tree
Index Structures
In Memory
Databases
?
Performance

# Excursion: $B^+$-Tree

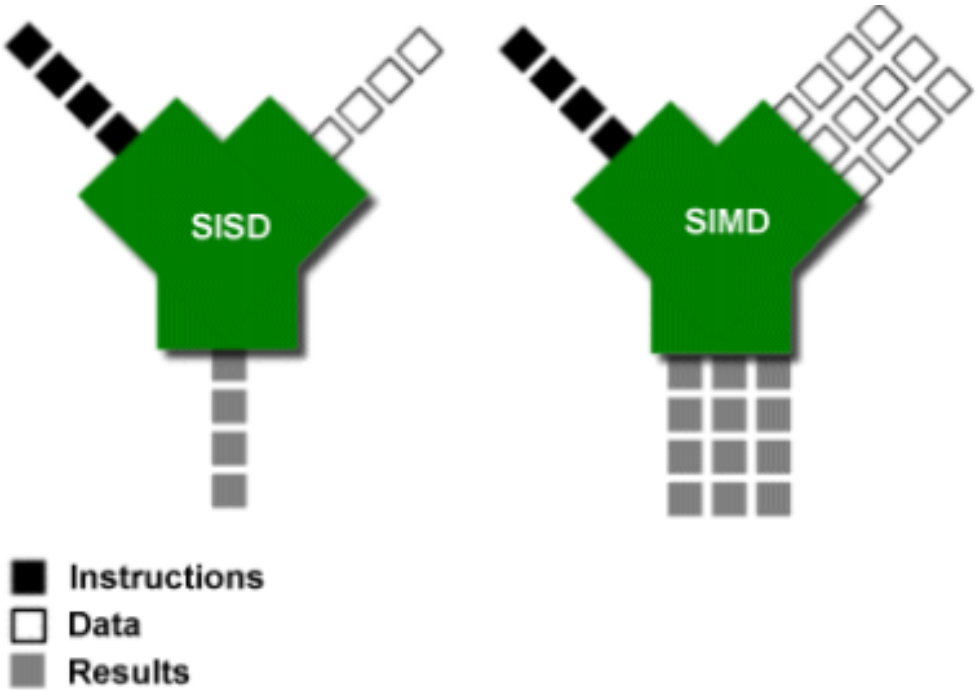


# B$^+$-Tree




- N-ary tree with large number of children per node
- Only leaf nodes contain values
- Leaf nodes often linked for range based scans

# Single Instruction Multiple Data

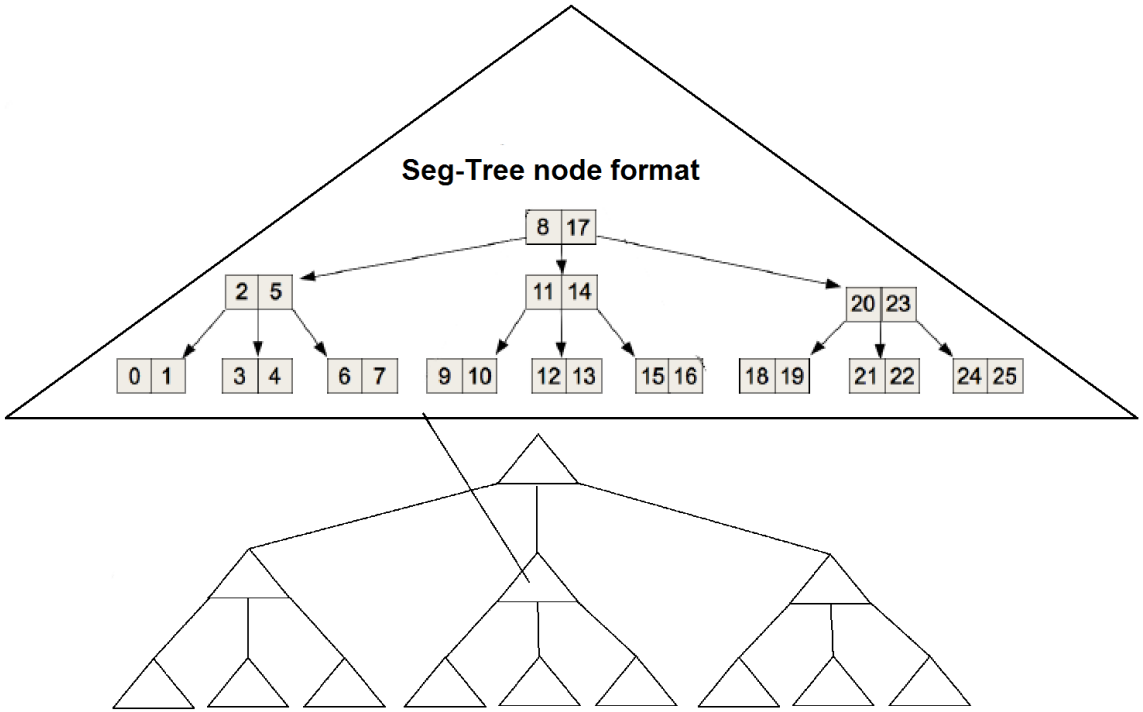



- **__m128i _mm_cmpgt_epi32 (__m128i a, __m128i b)**
  Compares 4 signed 32-bit integers in a and 4 signed 32-bit integers in b for greater-than.

# Adapted Tree structures

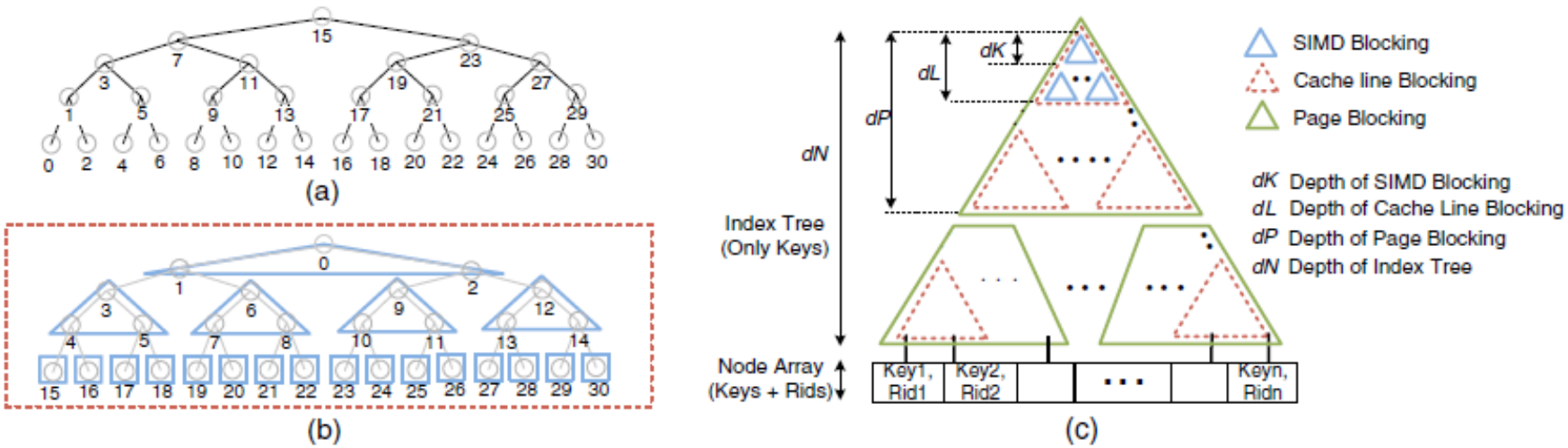
- Seg-Tree/Trie
- FAST: Fast Architecture Sensitive Tree

# Seg-Tree/Trie




- Each node is a k-ary search tree
- Each node is linearised to use k-ary search
- $k = \frac{|SIMD|}{|Key|}$, k keys are compared in parallel

# Fast Architecture Sensitive Tree




- Based on binary tree
- Hierarchical blocking: SIMD, cache line and page blocks
- Efficient cache line and page usage

# Evaluation

Important criteria for performance increase:

- Horizontal vectorization
- Minimized key size
- Adapted node sizes and types
- Decreased branch misses
- Full use of cache line using blocking and alignment
- Usage of compression
- Adapt search algorithm for linearised nodes

# Evaluation

Implementation of the considered performance criteria and their impact:

| Criterium | Seg-Tree/Trie | FAST | ART | VAST | Impact |
|---|---|---|---|---|---|
| Horizontal vectorization | x | x | x | x | high |
| Minimized key size | o | - | x | x | high |
| Adapted node sizes and types | - | x | - | x | low |
| Decreased branch misses | - | x | - | x | medium |
| Full use of cache line using blocking and alignment | - | x | - | x | medium |
| Usage of Compression | o | - | x | x | medium |
| Adapt search algorithm for linearised nodes | x | - | - | - | low |

Legend: x: implements the issue, o: partially implements the issue, -: not implements the issue

# Conclusion

How to adapt index structures to modern database systems:

- Compare as many keys as possible in parallel with SIMD
  - Direct performance increase up to a multiple
- Efficient usage of cache line
- Decrease branch misses
- Use compression or adapted search algorithms

# Sources

- http://infolab.stanford.edu/~nsample/cs245/handouts/hw2sol/sol2.html
- https://en.wikipedia.org/wiki/Radix_tree
- https://www.clker.com/clipart-bosque.html

# Thank you for your attention!