Indexing for Near-Sorted Data

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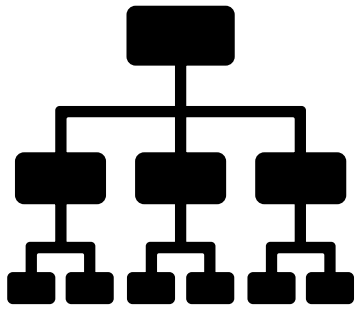
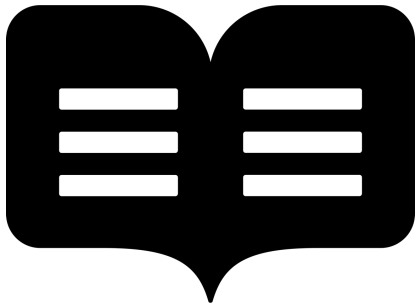
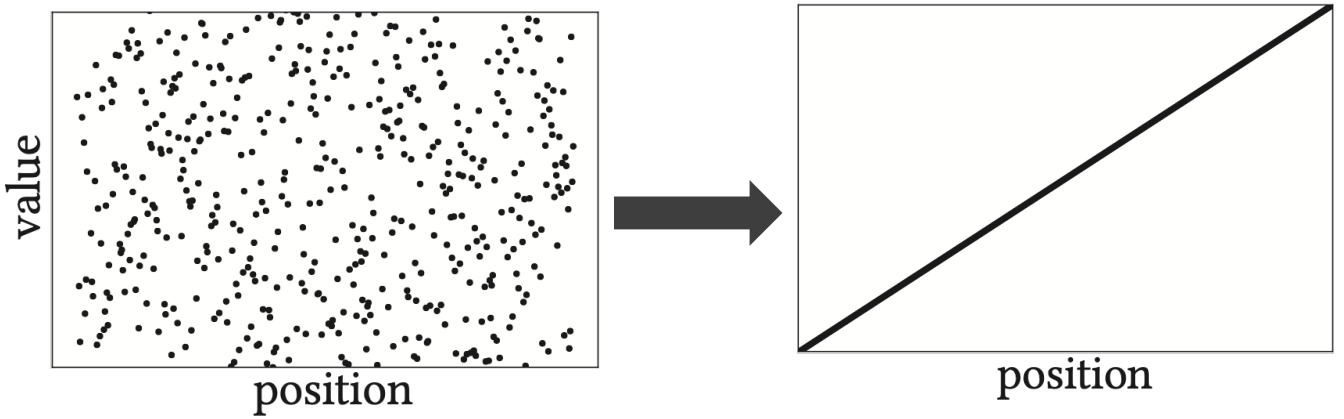
Indexes in Databases



organize data



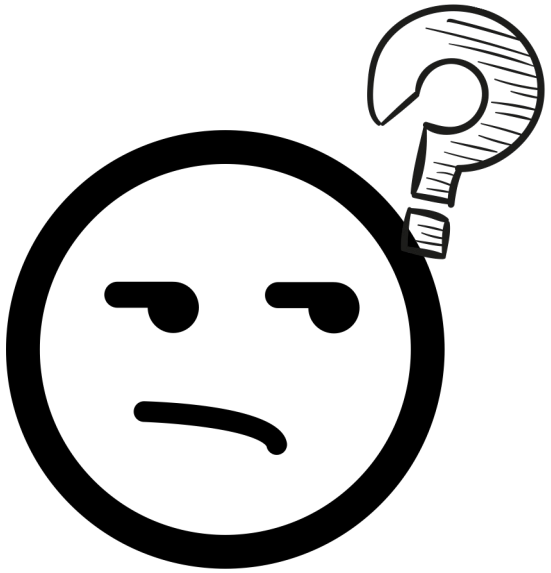
efficient queries



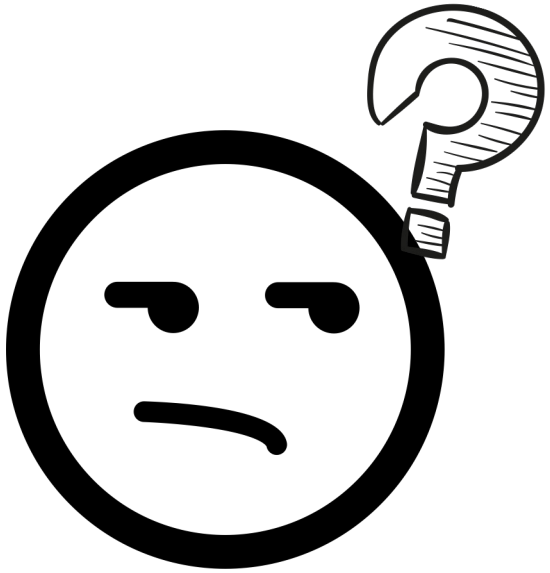
unstructured data

structured data

The process of inducing "*sortedness*" to an otherwise unsorted data collection



What if data already has some structure?



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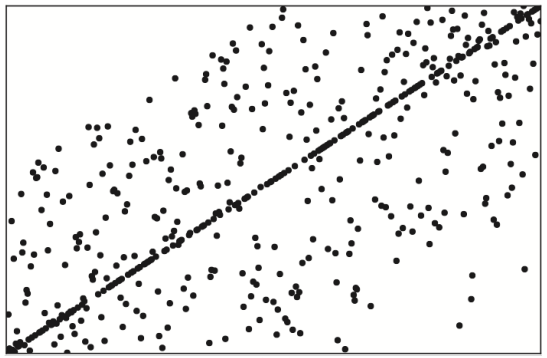
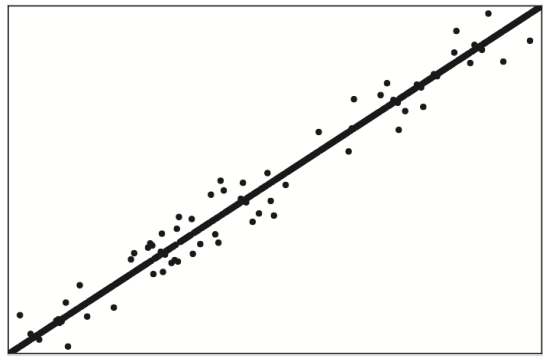
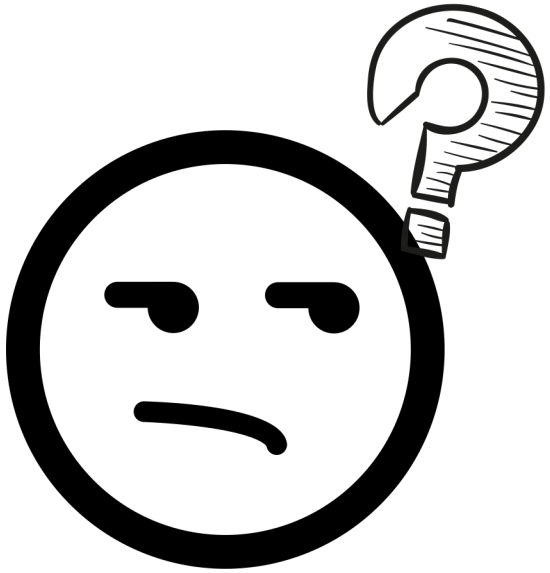




Near-sorted data



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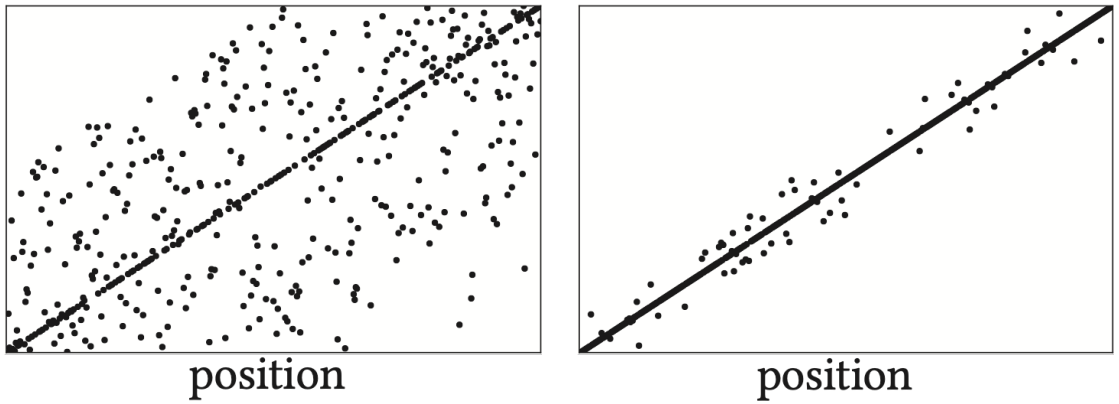
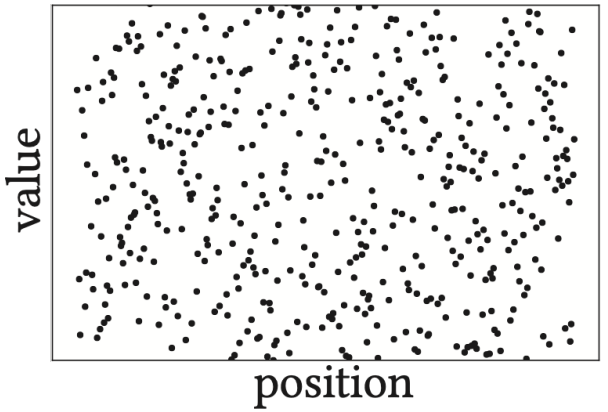


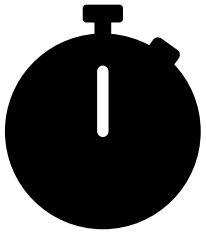
Near-sorted data

$\approx$



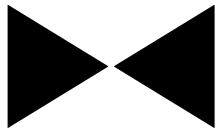
treated same as unstructured data!

Intermediate-Sortedness in Practice

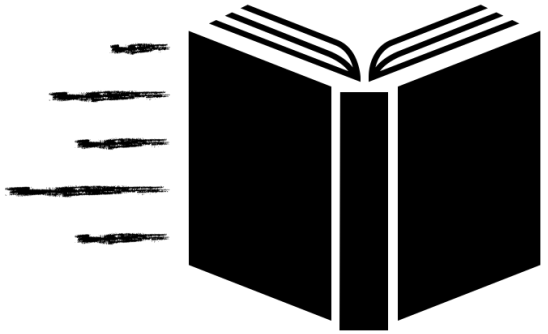


Time Series

Stock market



Join/query

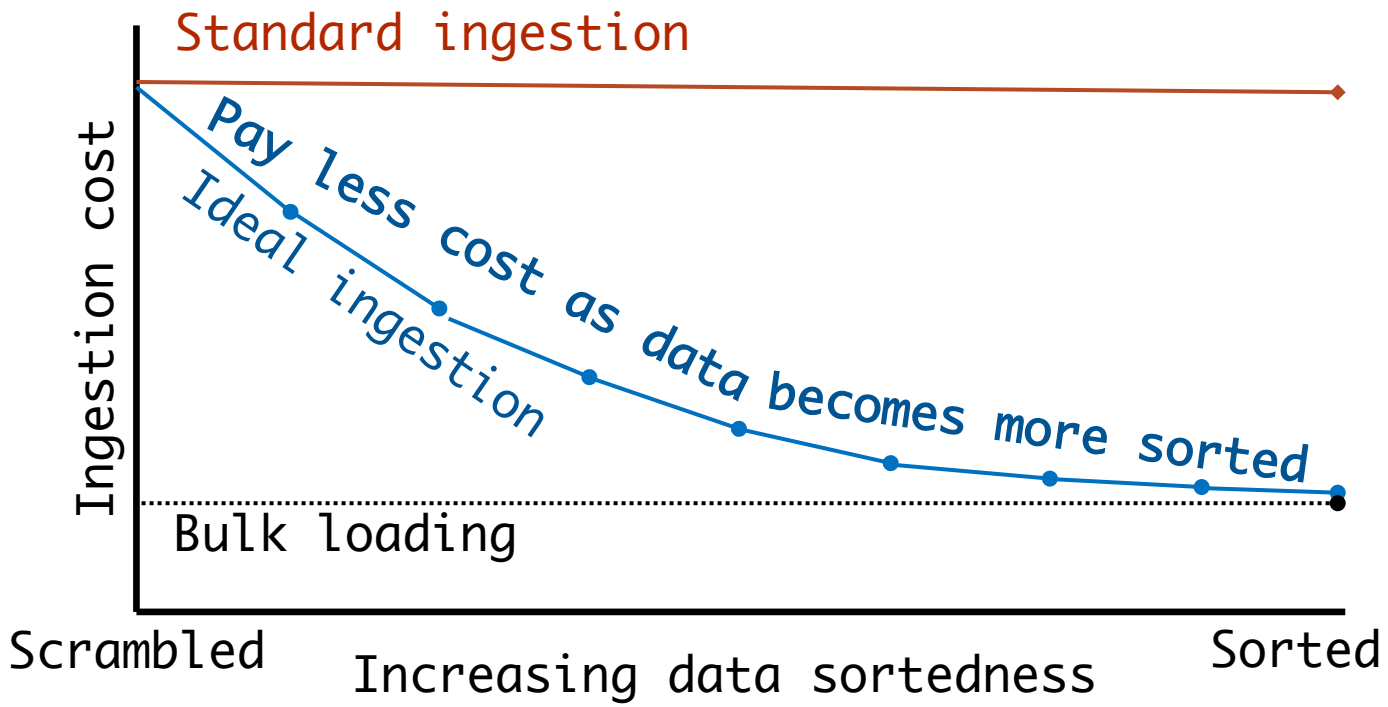


efficient reads

fast writes

classical indexes carry *redundant* effort!

Ideally...


Standard ingestion
Pay less cost as data becomes more sorted
Ideal ingestion
Bulk loading
Ingestion cost
Scrambled
Increasing data sortedness
Sorted

The Sortedness-Aware (SWARE) Paradigm

Sortedness-Aware (SWARE) Paradigm

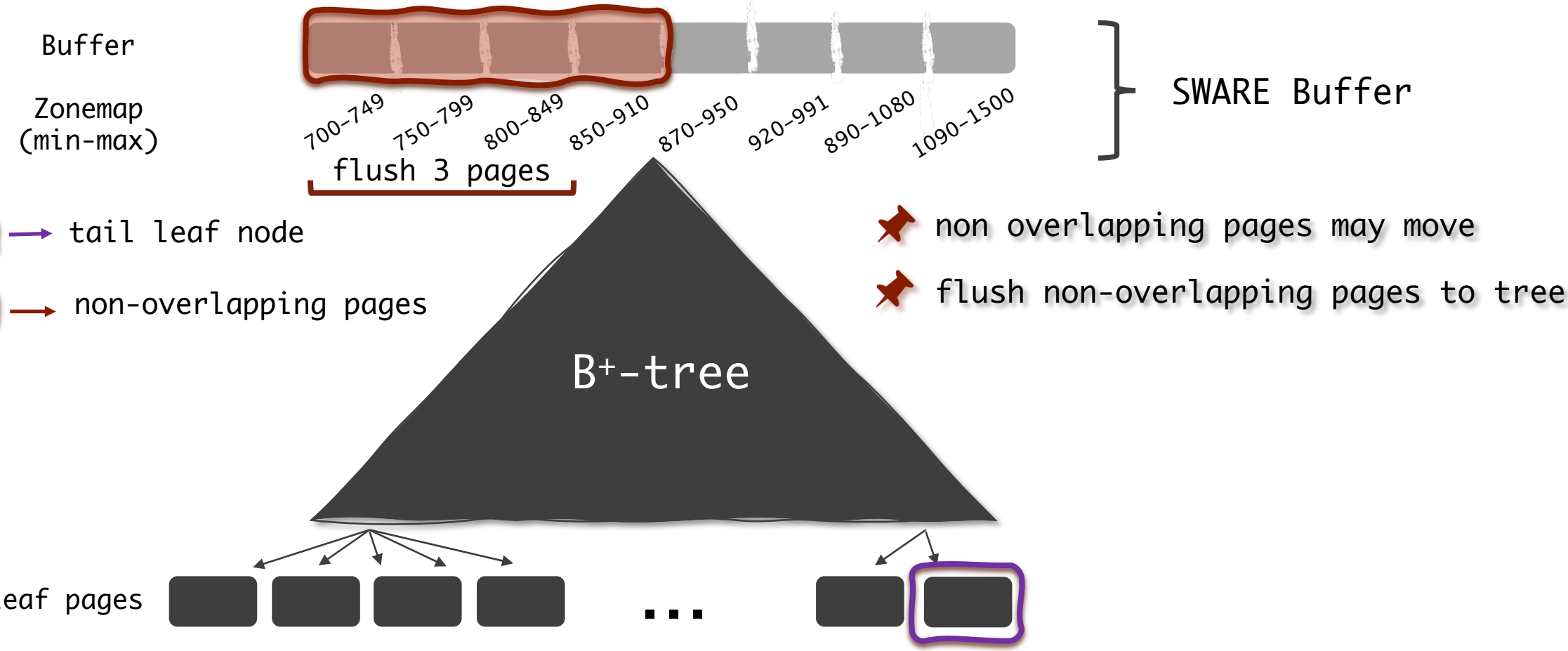
intelligent buffering

opportunistic bulk loading

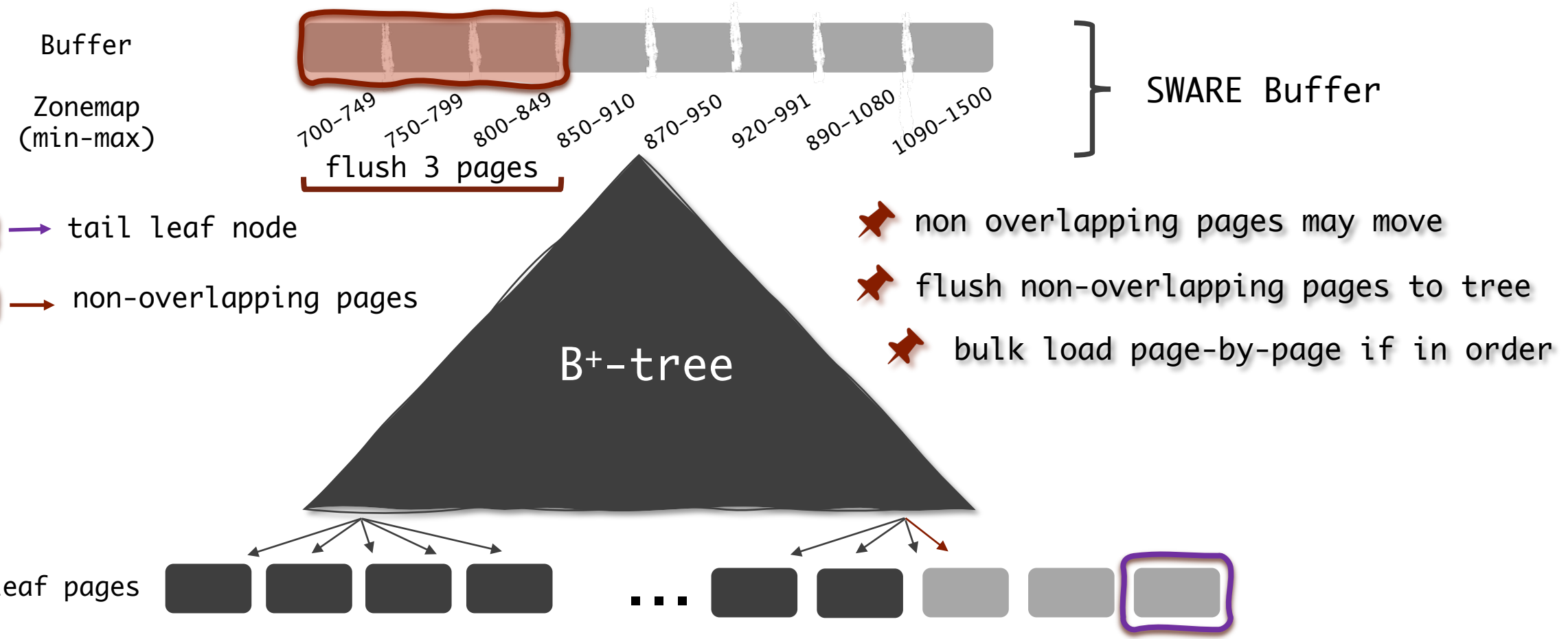
increased fill and split factor

SWARE framework can be applied to any tree-index!

SWARE Ingestions



SWARE Ingestions



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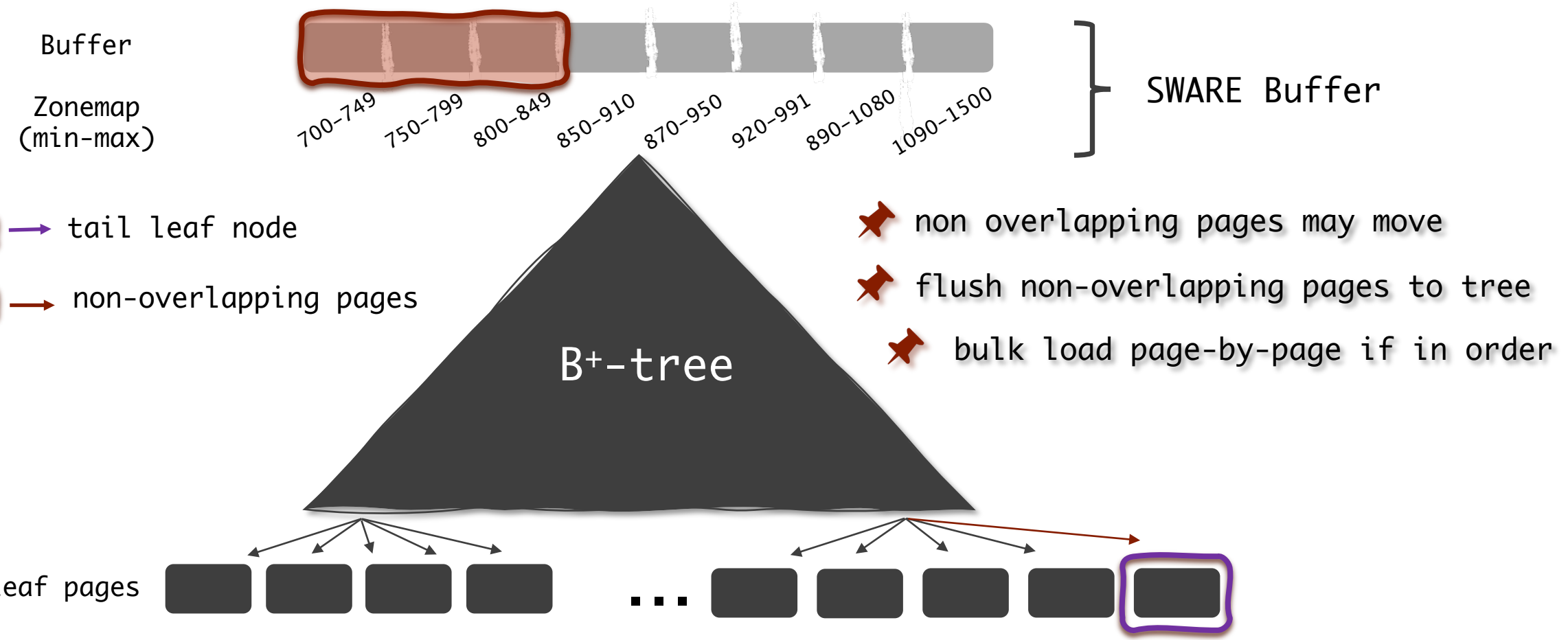

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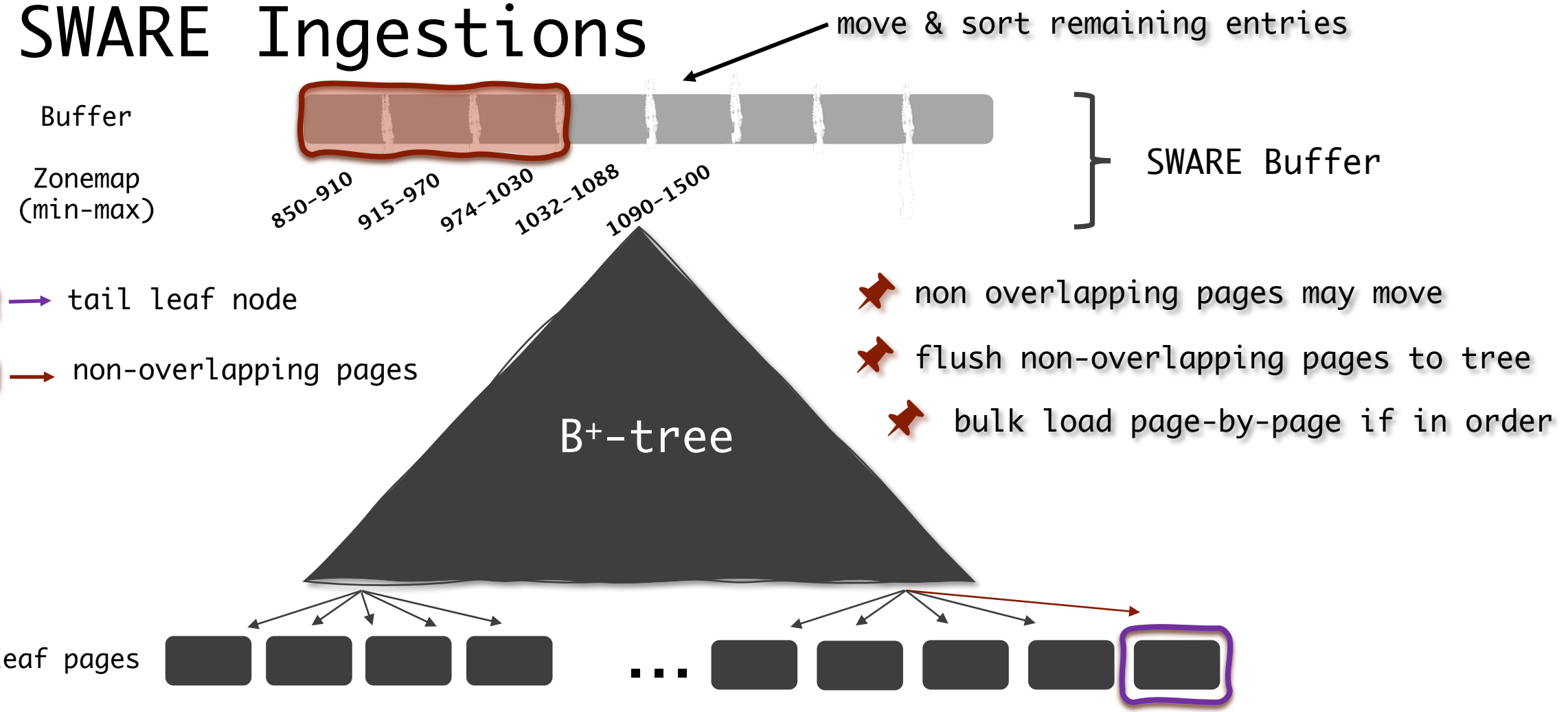

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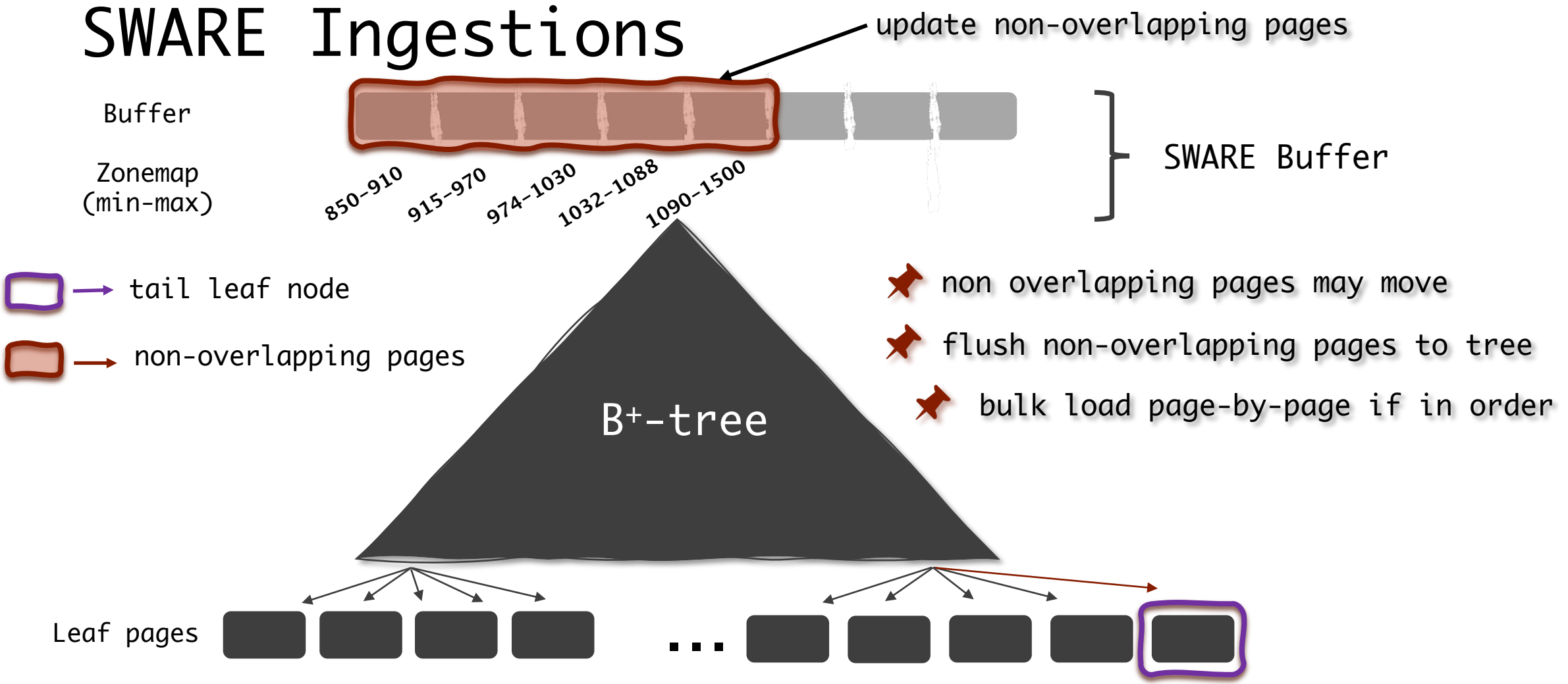

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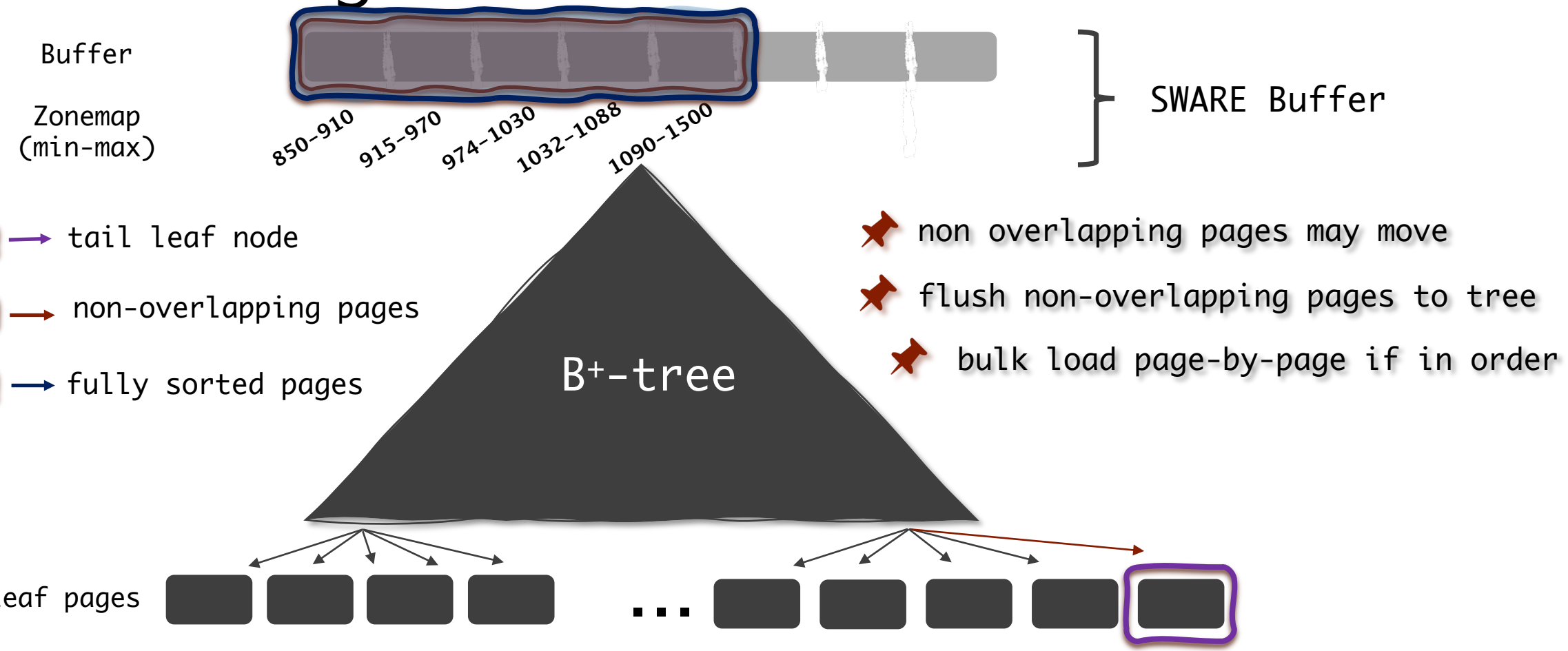
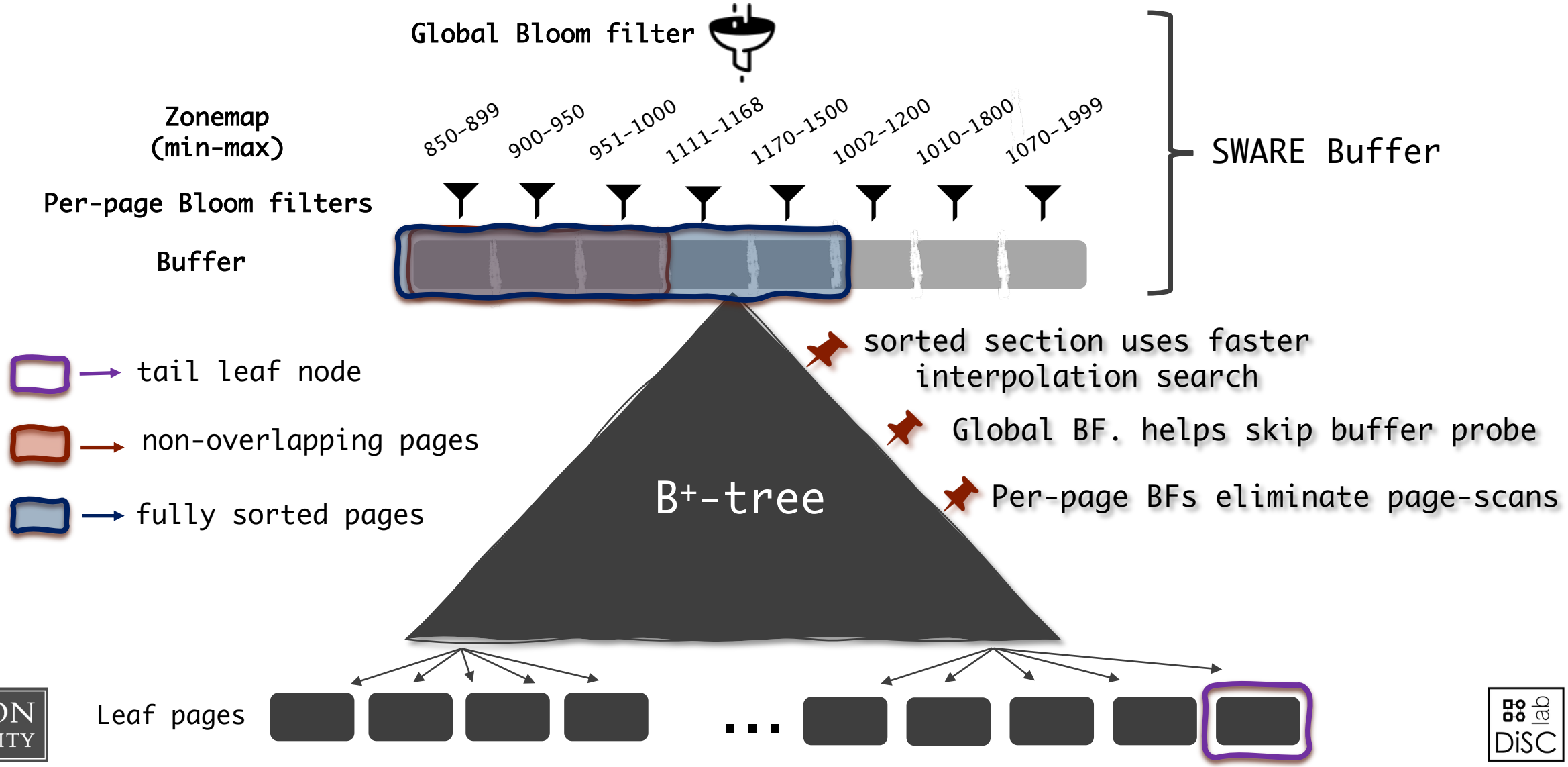


How do lookups work?

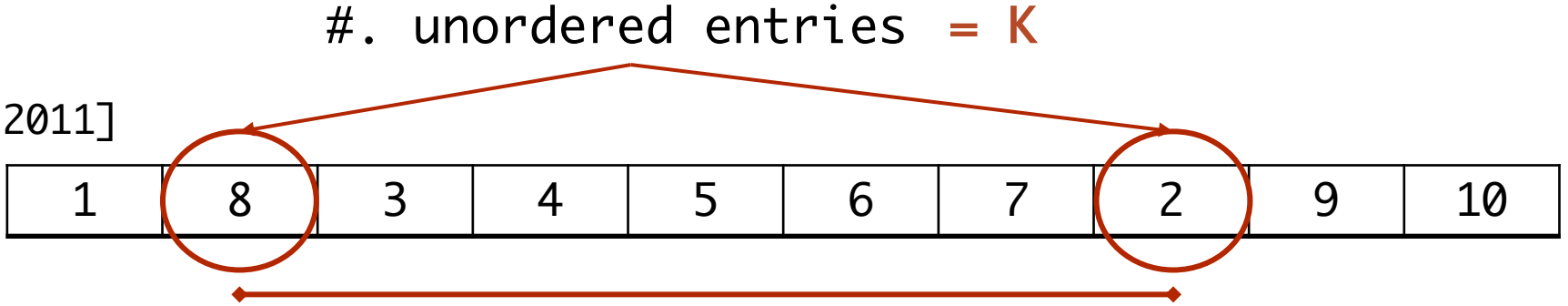
Overall Structure for Queries



How do we evaluate SWARE?

Benchmark on Data Sortedness (TPCTC 2022)

[BenMoshe, ICDT 2011]



Insert Only

Mixed Workloads
(interleaved reads and writes)

Experimental Setup

Metrics:
1. Overall performance (speedup)
2. Raw performance (latency)

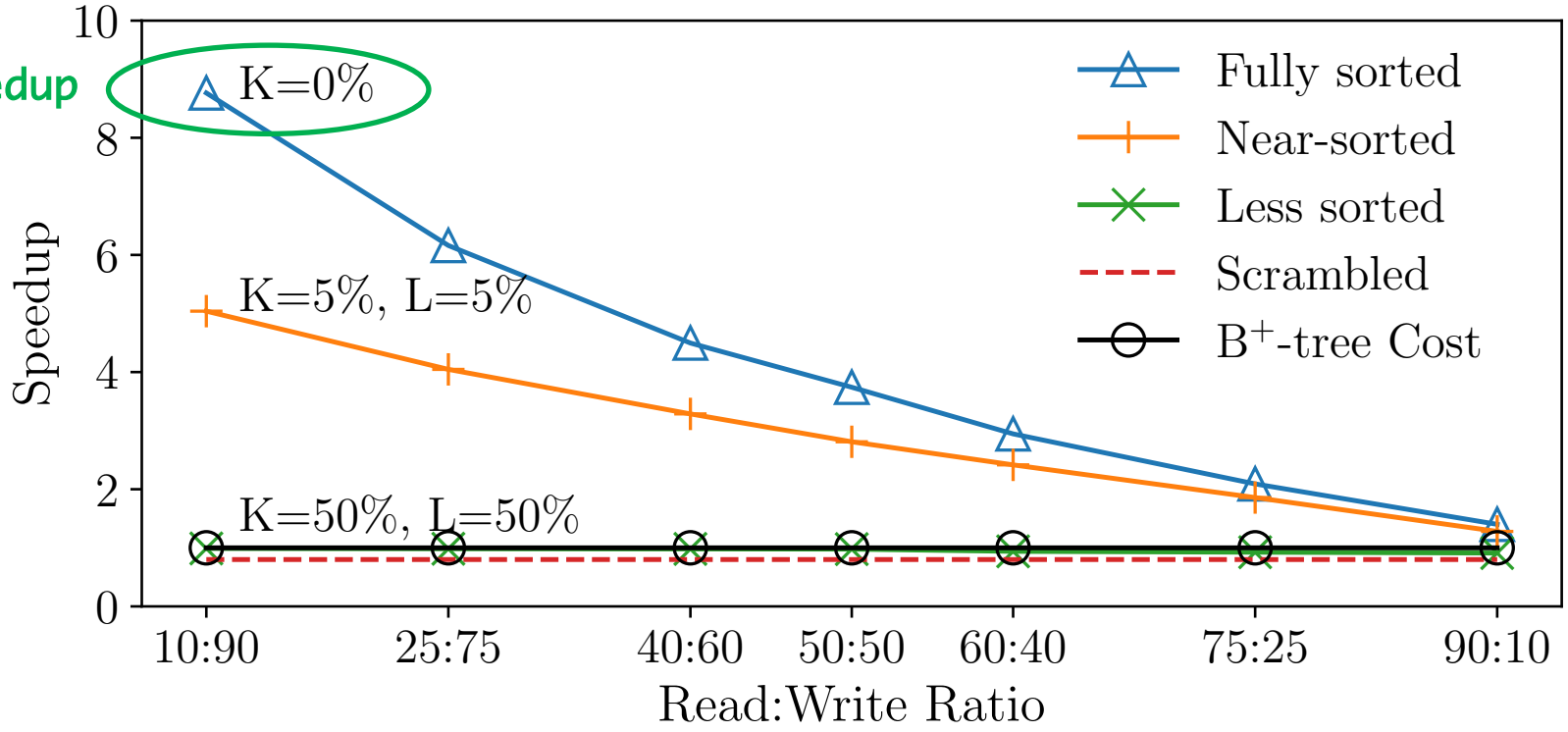
Workload Generator: **BoDS**
1. 500M Integer keys (~ 4GB)
2. Random existing lookups

System Setup:
1. Intel Xeon Gold 5230
2. 2.1GHZ processor w. 20 cores
3. 384GB RAM, 28MB L3 cache

Default Index Setup:
1. Buffer = 40MB; flush <= 50%
2. BFs = 10 BPK; Murmur Hash
3. Split at 80%

Overall Performance

≅ 9x speedup



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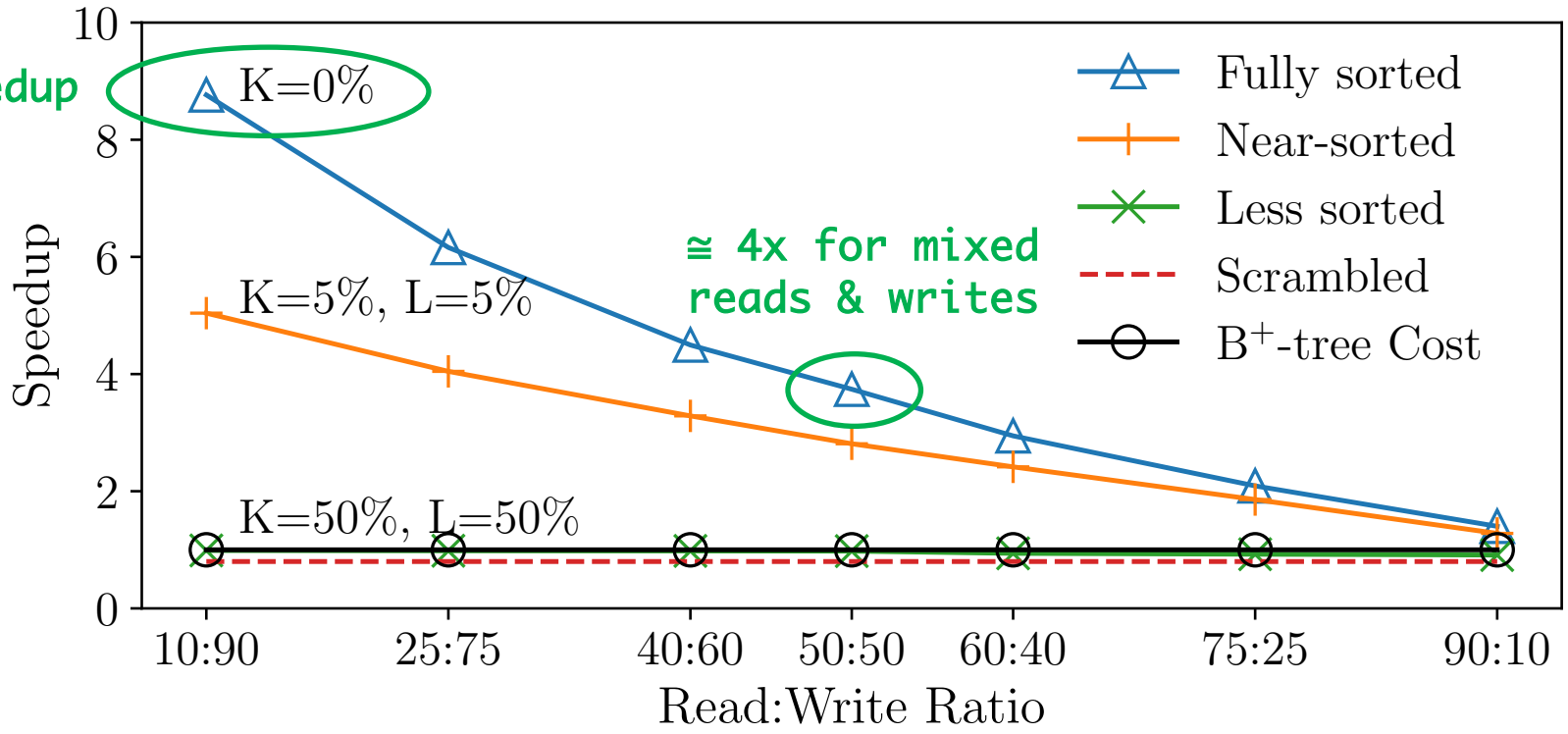
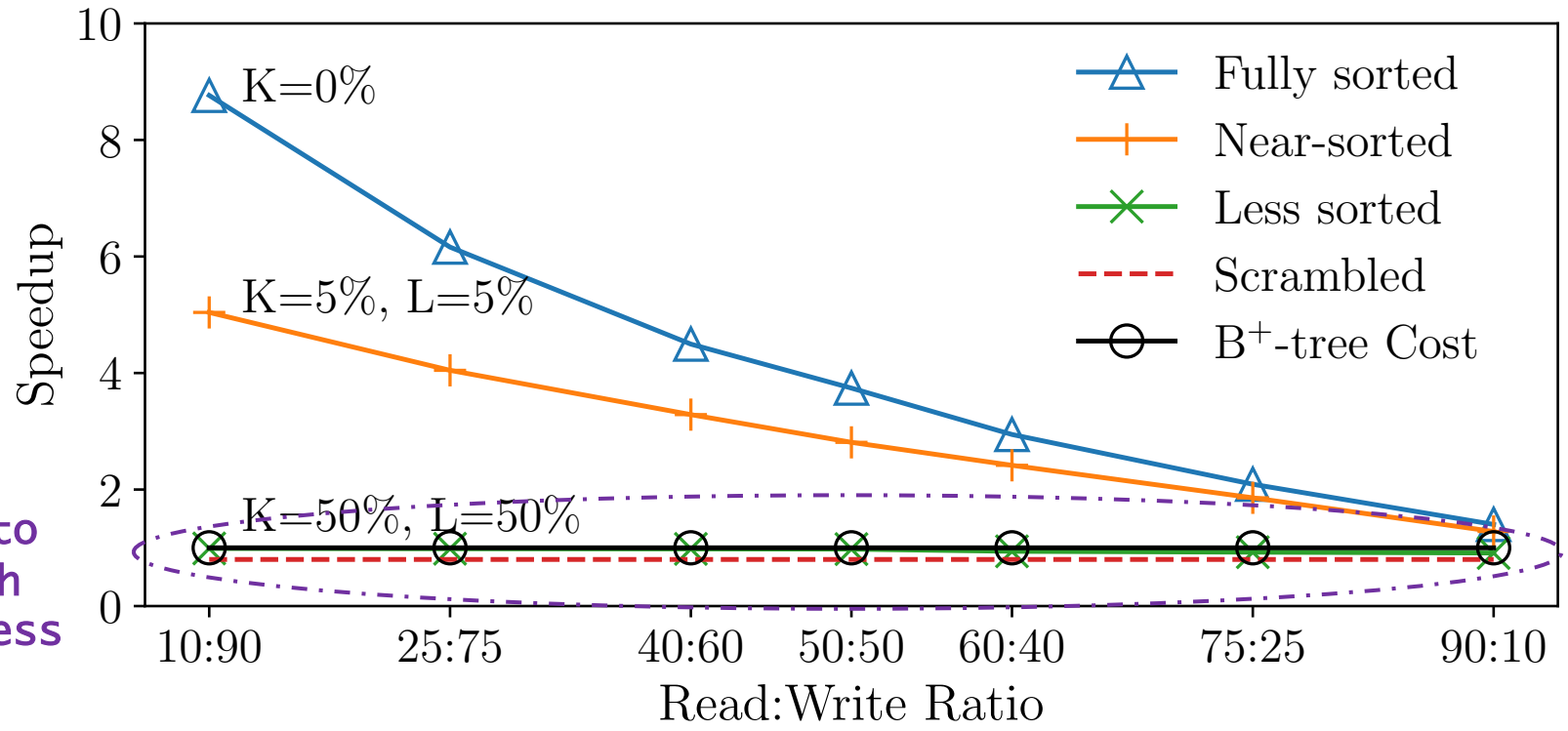
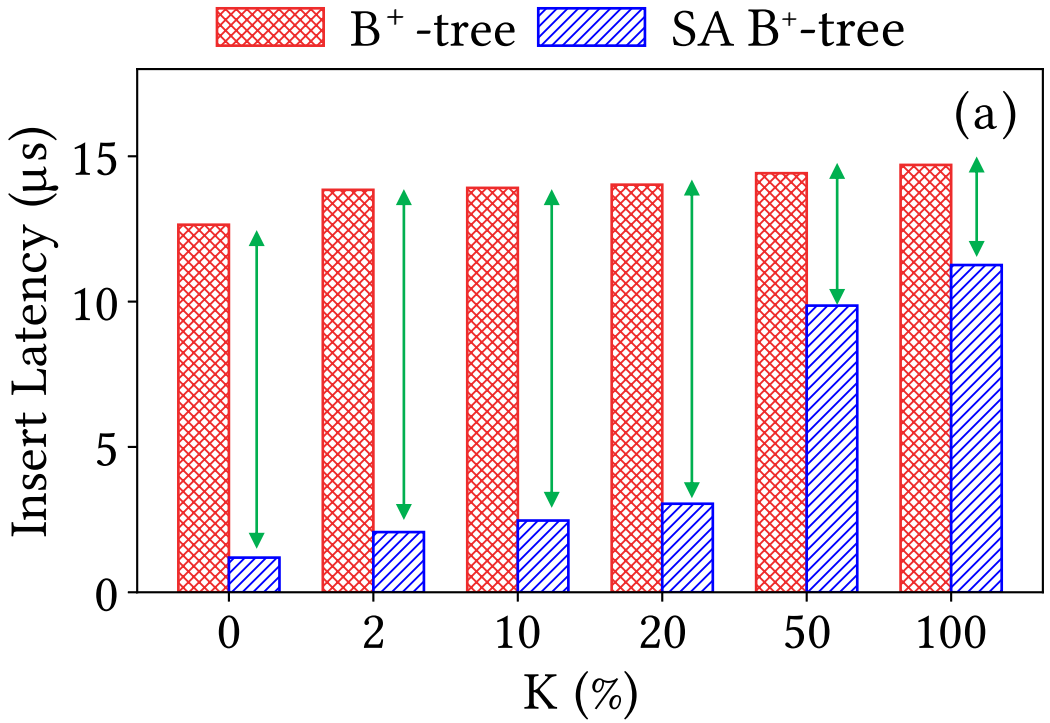


Overall Performance



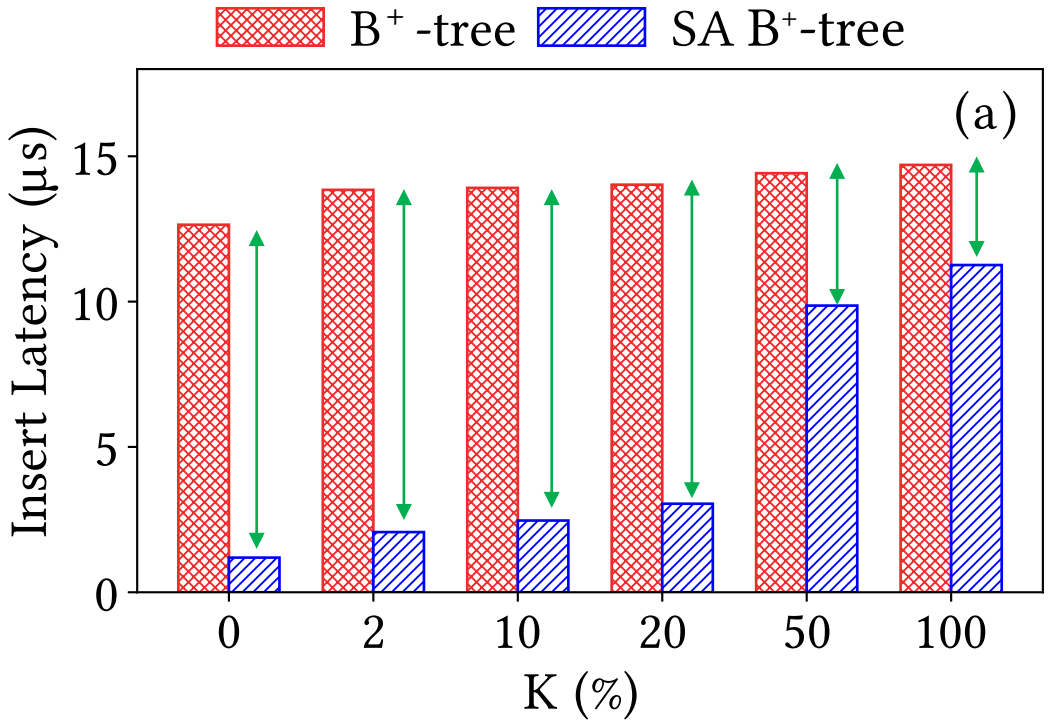
comparable to B+-tree with less sortedness

Raw Ingestion Performance



ingestion latency reduced between 27-90%

Raw Ingestion Performance



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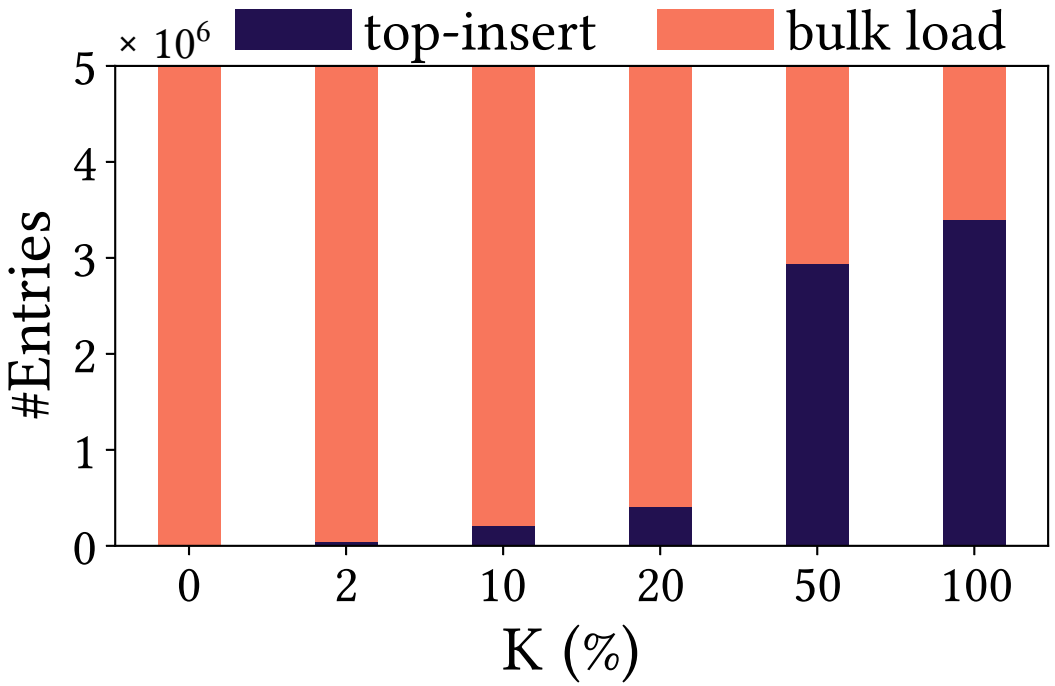

bulk loading is maximized
with high data sortedness

Space Efficiency

Sortedness Degree	#. Nodes (#. Internal, #. Leaf)	
	B+ tree	SA B+ tree
Fully Sorted	2.004M (8K, 1.996M)	0.52x
Near-Sorted	1.847M (7K, 1.840M)	0.6x
Less-Sorted	1.878M (4.3K, 1.873M)	1.01x

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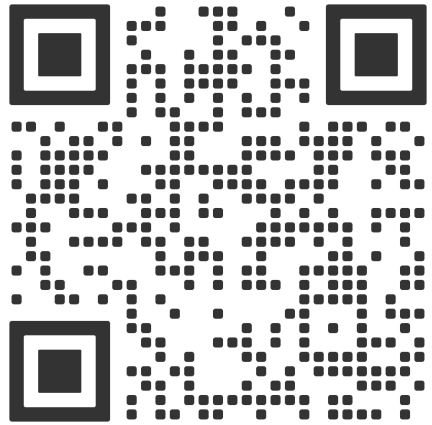
increased fill/split factor
helps reduce memory footprint

Summary

Identify “sortedness” as a resource

Smart buffering + bulk index appends
= faster ingestion

Works well with write-heavy or mixed
read-write workloads



Thank You!

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