Designing an Index for ZooDB

Jonas Nick & Bogdan Vancea

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Outline

ZooDB
The JDO Database

- an open source object database written in Java
- JDO standard compliant
- 4 times faster than competitor db4o
- `zoodb.org`

Database Index

Key-Value data structure

1. **fast** retrieval
2. **ordered** iteration
3. stored in a **file**

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Attribute Index
Value → Object-ID

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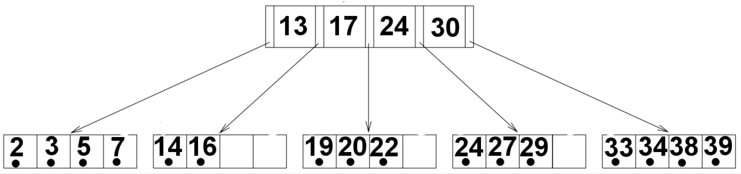
Attribute Index	ObjectID Index	Free Space Index
Value $\rightarrow$ Object-ID	OID $\rightarrow$ Diskpos	Page-ID $\rightarrow$ TxID

B+ Tree

Images adapted from Database Management Systems by Ramakrishnan and Gehrke.

B+ Tree



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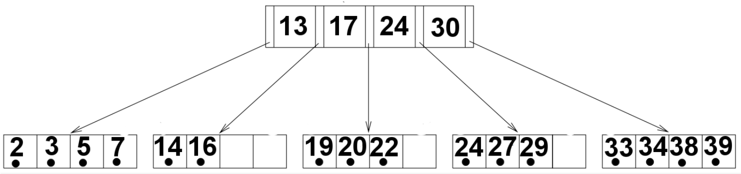

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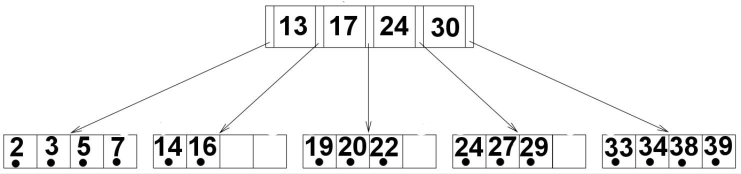

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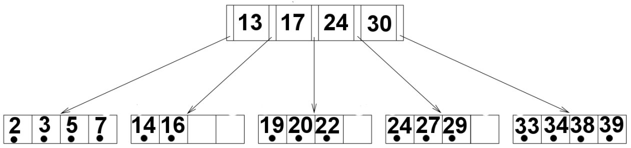

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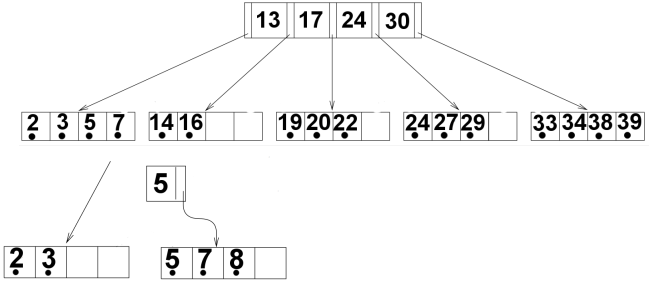

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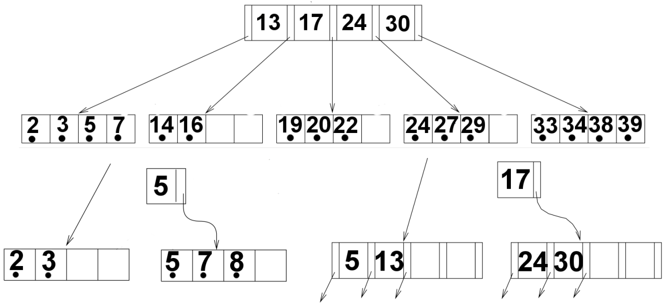

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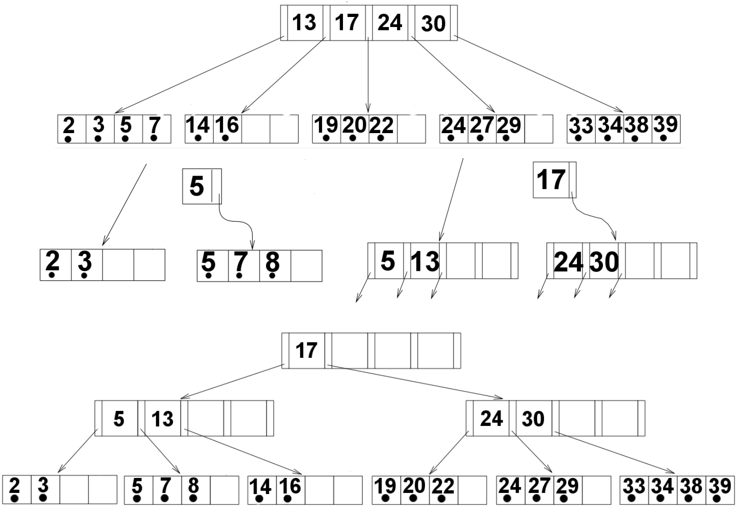

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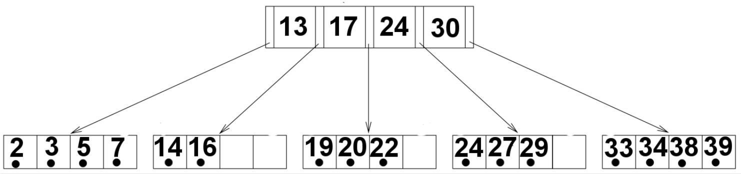

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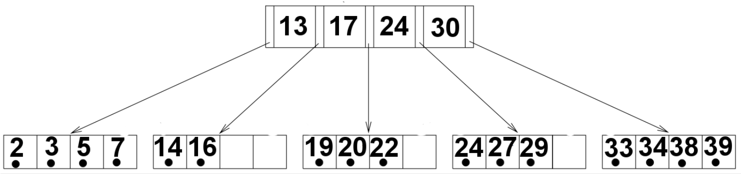

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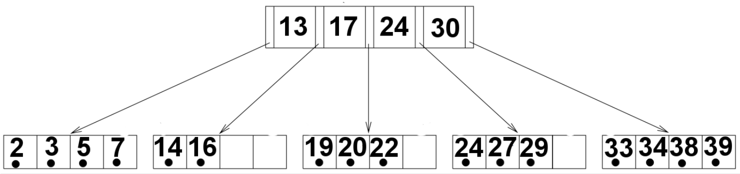

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- Insert, remove, search are logarithmic.

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- prefix sharing

Prefix Sharing

Exploit common prefix

$$\boxed{\begin{array}{c}00010000\\00010100\\00010110\end{array}}$$

Prefix Sharing

Exploit common prefix

00010|000
00010|100 ⟶
00010|110

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00010 | 000 00010 | 100 00010 | 110	→	00010 000 100 110

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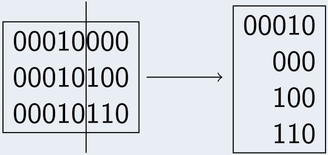

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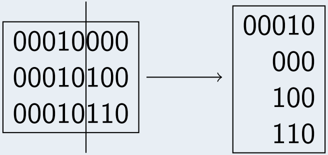

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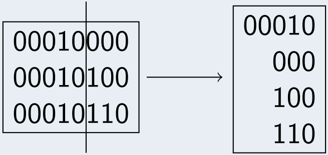

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00010	100		000
00010	110		100
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  - if can be split without underflow
  - if can be merged without overflow
  - the number redistributions

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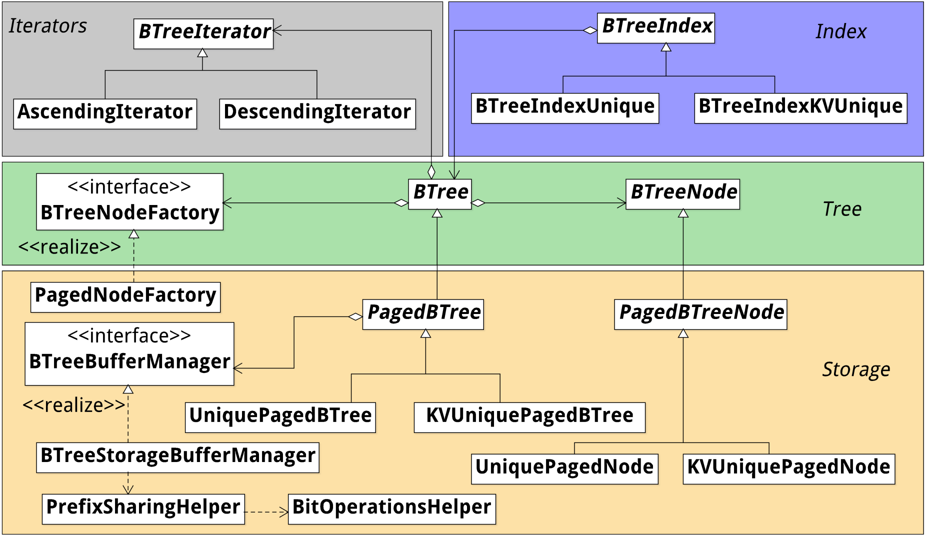
    1. not optimized for practical scenarios
    2. do not cover duplicates nor prefix sharing
- low-level implementation optimizations

Index Implementation



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- Write
  - only write dirty nodes
  - prefix encoding
- insert/delete more constly, exactly how much?

Microbenchmarks

- full in-memory, index only tests

Duration

Operation	No Prefix sharing	Prefix sharing
Search	1	0.9 - 1.1
Insert	1	1.6 - 2.8
Delete	1	1.45 - 2.9

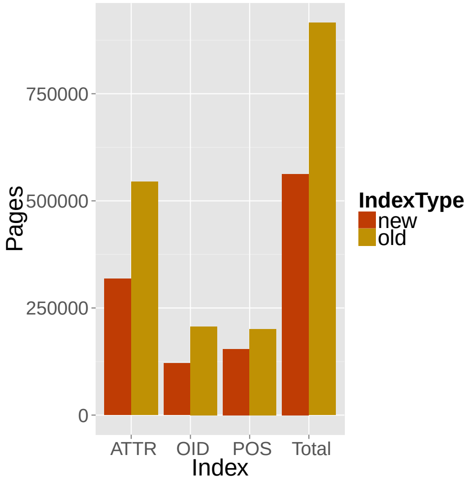
Size of B+ tree

Operation	No Prefix sharing	Prefix sharing
Insert	1	0.5 - 1.1
Delete	1	0.5 - 0.75

StackOverflow Data Import

- real-world workload
- StackOverflow data
  - 1.3 million users
  - 10.3 million posts
  - 13 million comments
  - 25 million votes
- 3 key unique attribute indexes
- 9 key-value unique indexes

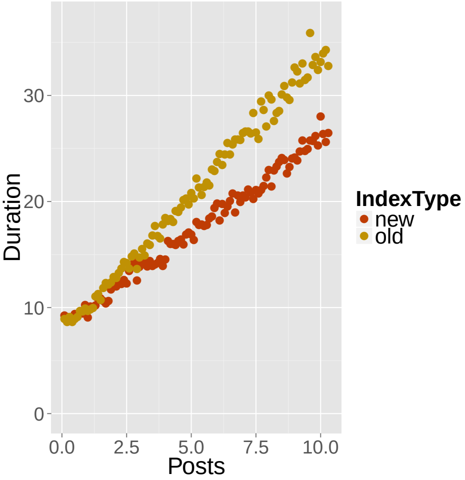
StackOverflow Import - Index Sizes



- page size: 4KB
- database size: 31 GB

Index	Space saving (%)
Atrribute	41.6
OID	41.5
POS	23.1
Total	38.5

StackOverflow Import - Commit times



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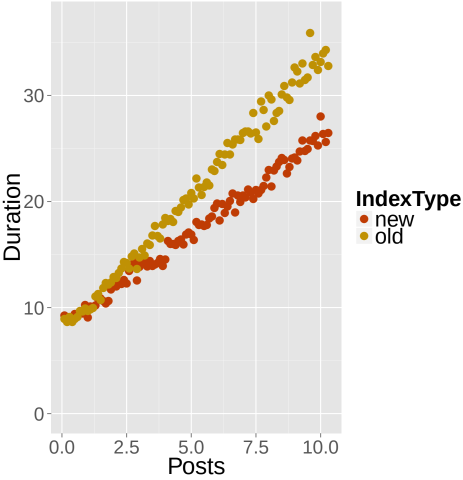

- import with new index 25% faster
- why?
- more entries in a node
  → fewer dirty nodes
- data locality

Summary

- prefix sharing: trade-off between speed and space
- works well in practice
- microbenchmarks
- implementation complexity.

Q&A

- Thank you for your attention!
- Questions ?