Tailor-Made Native XML Storage Structures

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Conference on
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Varna, Bulgaria

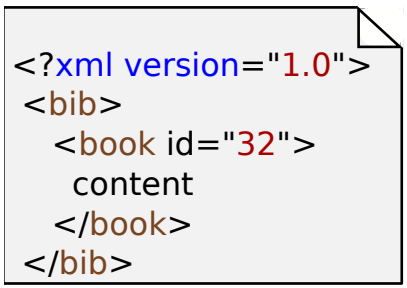
DASMOD
Dependable Adaptive Systems and Mathematical Modeling

Outline

1. Essentials for XML Databases
2. Content Compression in XML Databases
3. Collecting Document Parameters
4. Tailor-Made Storage Structures
5. Experimental Results

XML Databases

Current Situation



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   <book id="32">
    content
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shredding

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3	id	32	2
n	...	–	...
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NT

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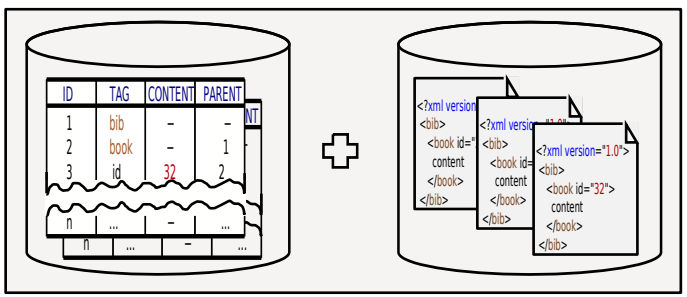

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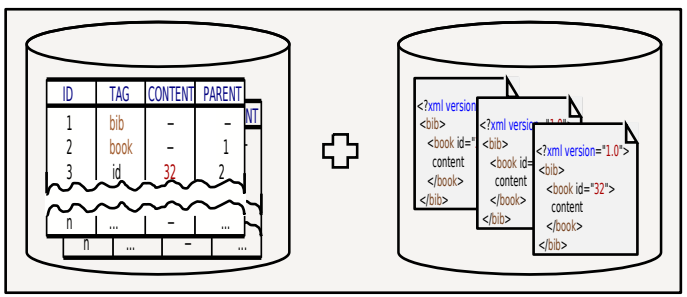

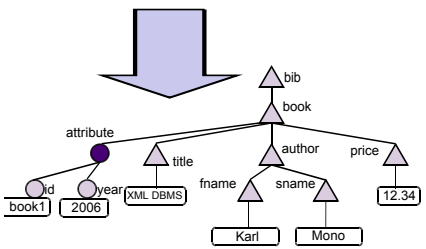

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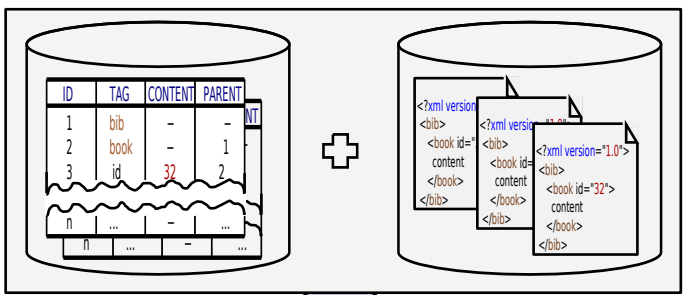
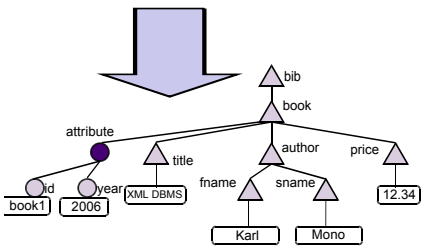
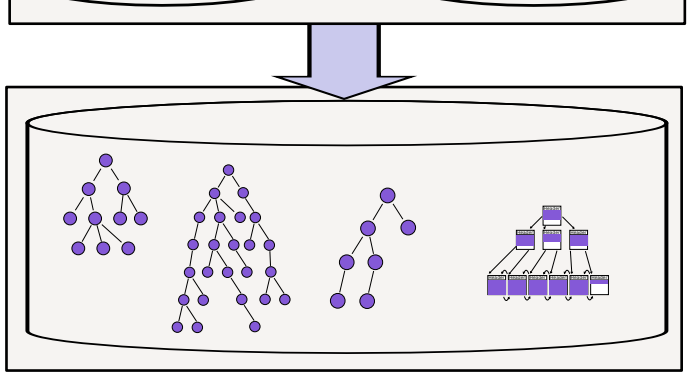


native





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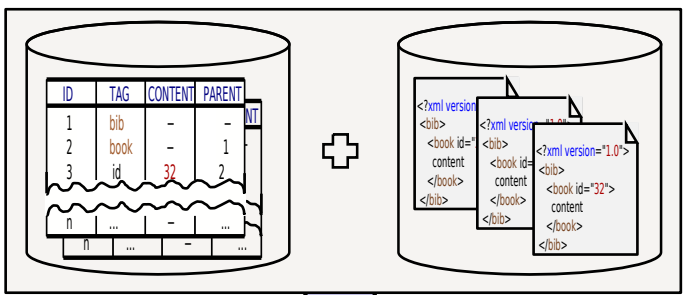

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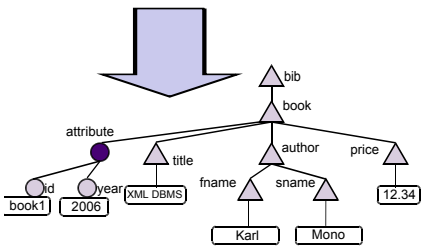

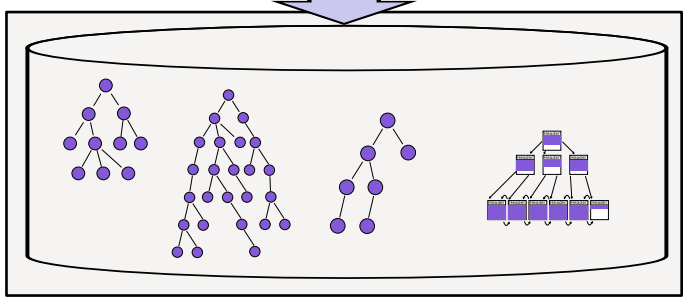

PROBLEMS CHALLENGES & OPEN ISSUES ??

Round Trip property & Variety of XML documents
(performance, indexing, access −operators / structures, ...)

Storage Structures

XML document

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Storage Structures - Tree View

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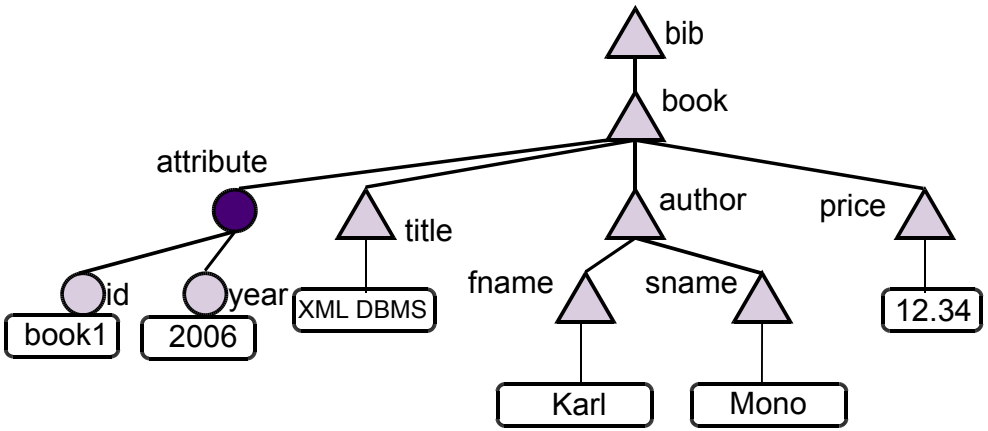

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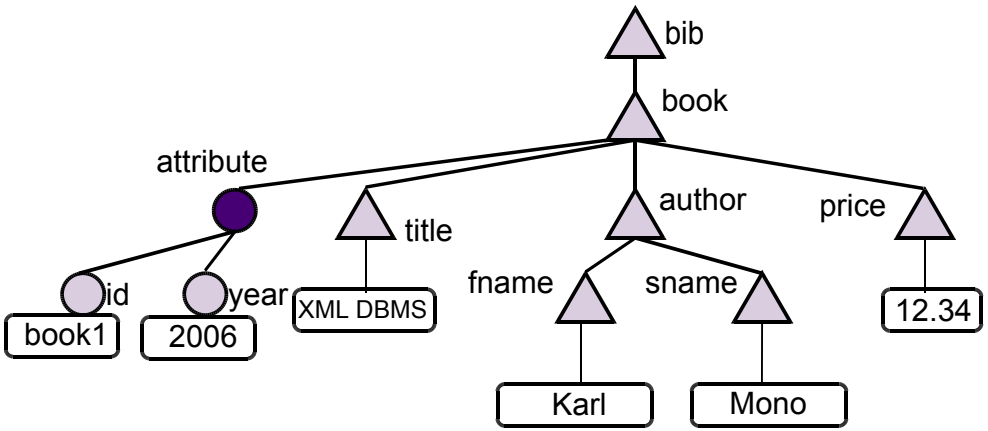


- Variable tree width/depth
- Separation into element nodes, text nodes and attribute nodes
- Determination of paths, inner nodes and leaves

Storage Structures - Node Labeling

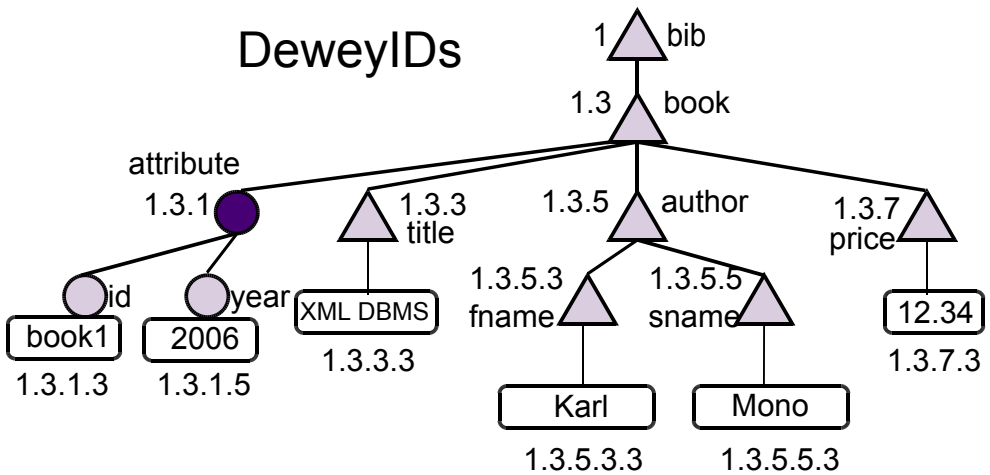
Properties

- Dynamic assignment
- Preserve order
- Stable on modifications
- Space consumption
- Query support

⇒ Prefix-based

  - Support for XPath axes, locks, and compression

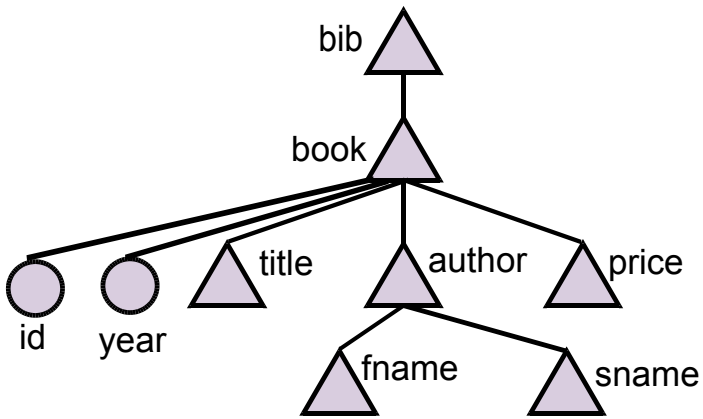
- e.g.: OrdPath, DeweyID, DLN



Path Synopsis - Improving Storage Consumption

Path Synopsis

- Concise representation of path classes
- Basis for the “elementless” storage



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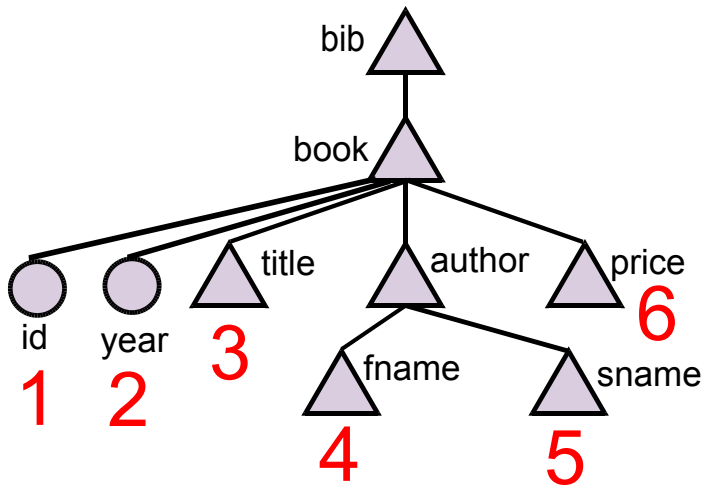
Path Class Reference - PCRs

- **1** /bib/book@id
- **2** /bib/book@year
- ...
- **6** /bib/book/price



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Requirements

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- Full document flexibility (indexes, query processing, modifications) $\longrightarrow$ disqualifies XMill, XGRIND, Xpress, ...

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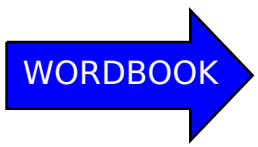

word	symbol
XML	0
documents	1
in	2
⋮	⋮

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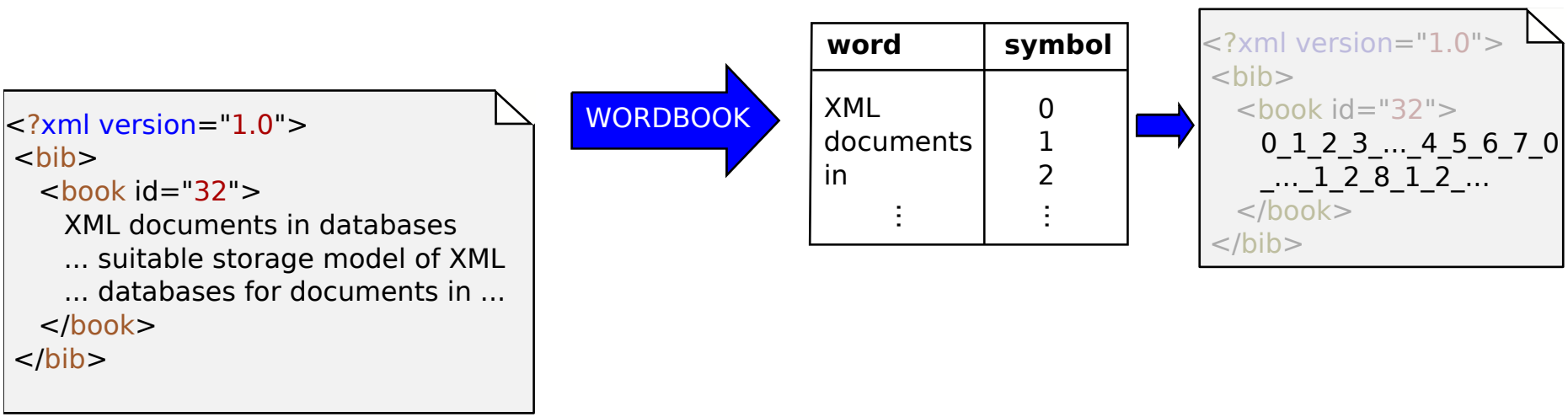

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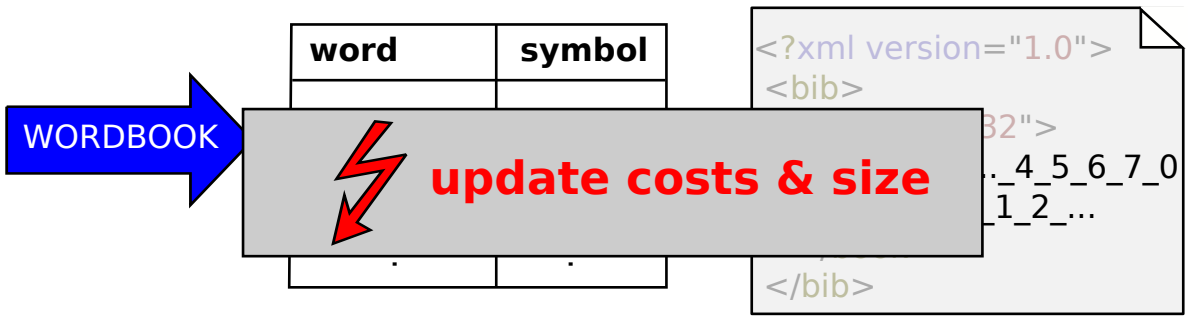

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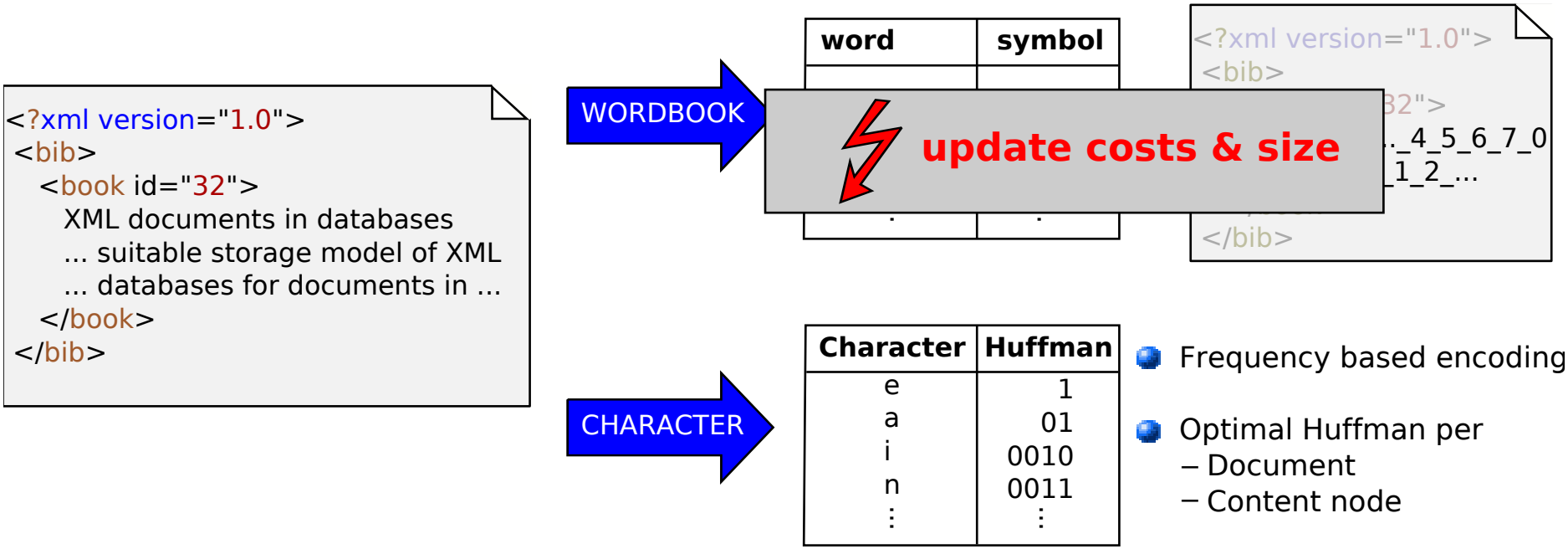

- Frequency based encoding
- Optimal Huffman per
  - Document
  - Content node

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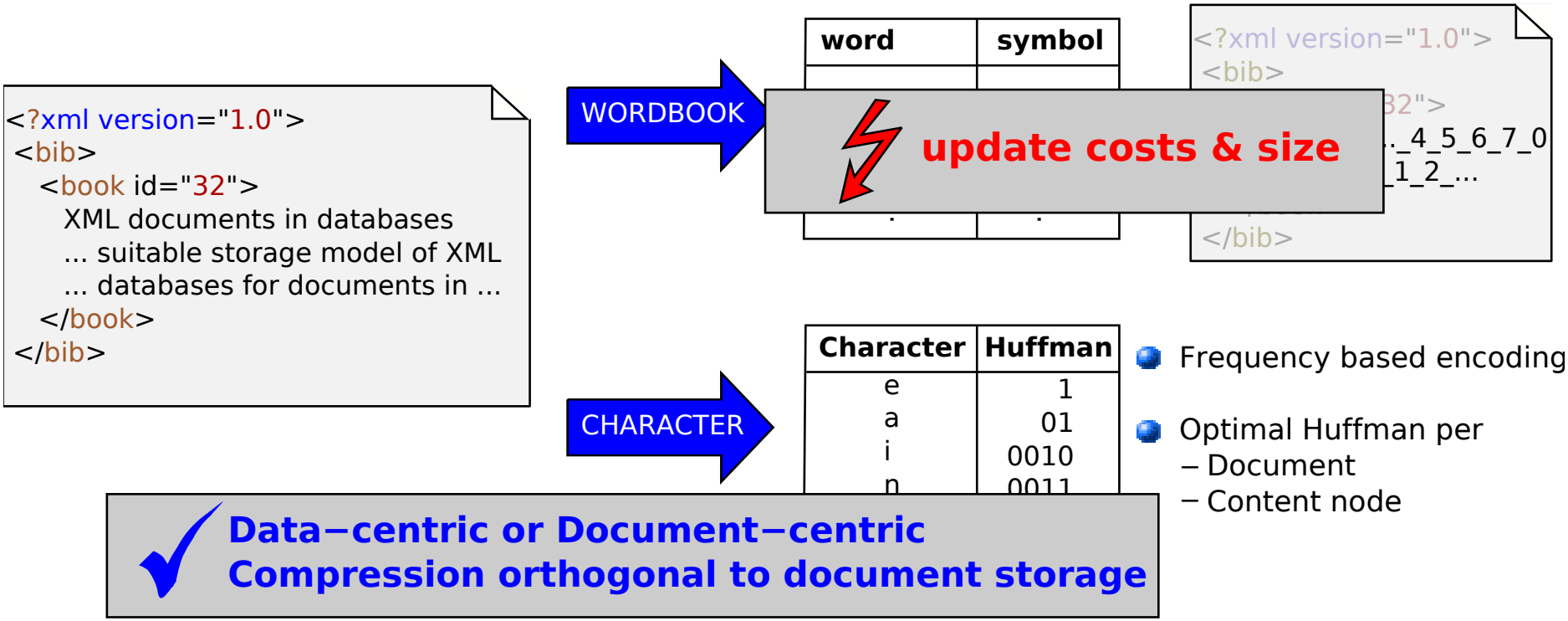

Example Documents & Variety

1. Size

Example Documents & Variety

1. Size
2. No of Attributes & Elements

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3. No of Text Nodes

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5. Max. Depth / Avg. Depth

Example Documents & Variety

1. Size — 32 MB - 1,820 MB
2. No of Attributes & Elements — 1 Mio - 82 Mio
3. No of Text Nodes — 1 Mio - 54 Mio
4. No of Path Classes — 17 - 220,894
5. Max. Depth / Avg. Depth — 4/3.3 - 37/8.4

- Example documents: lineitem uniprot dblp treebank

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- Widespread document parameters: factor 10^4 and more!
- Simple structured vs. complex documents
- Storage parameters need adjustment

(Pre)-Analysis?

Analysis and Sampling (Step 1)

Purpose

- Collect XML document specific characteristics (elements, text length/nodes, attributes, path classes, vocabulary, depth, fan-out, ...)
- Optimize physical database parameters (page layout, record format, Dewey encoding, storage structures, indexes, ...)

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Complete Pre-Analysis

– Scans the complete document
\+ Precise parametrization
\+ Predictable space consumption
– Long runtime

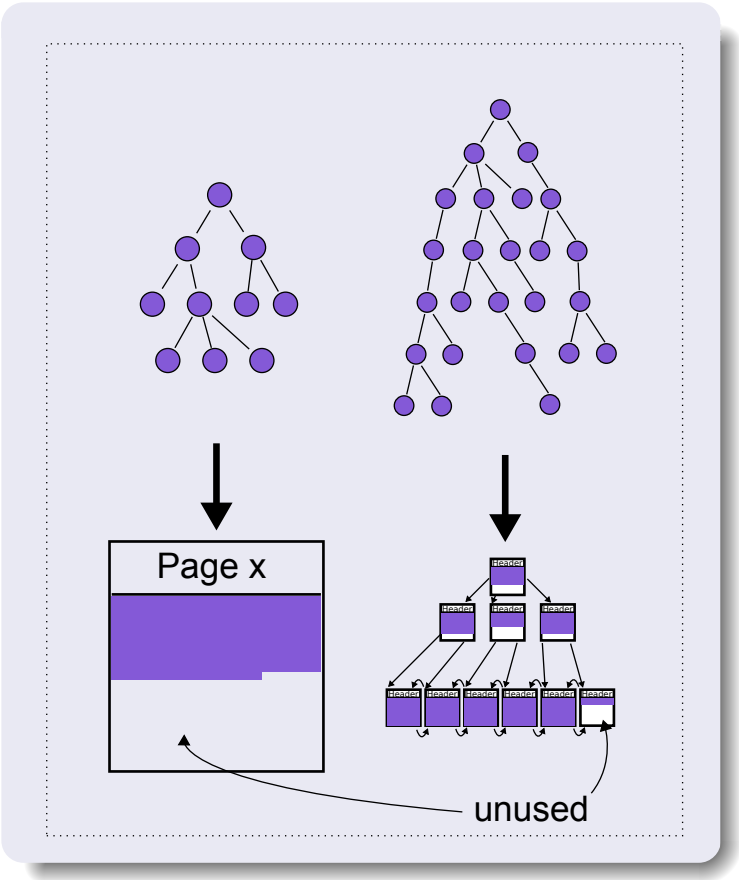
Sampling

– Scans the first x bytes
\+ Short runtime
\+ Stable parameters for $< 10\%$
\+ By buffering XML streams analyzable
– Limited to document head
– Imprecise parametrization
– Worst case treatment necessary

Configuration (Step 2)

Model 1 - Single Documents

- Dedicated storage per document
- Optional document index (big documents)
- Additional indexes/path synopsis separated



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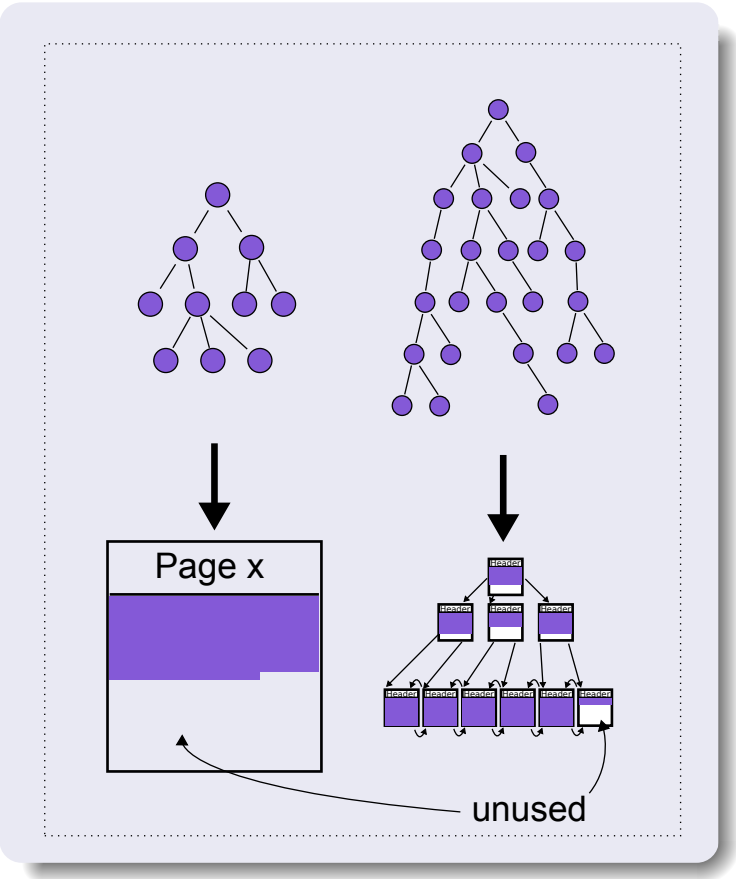
- Single (big) documents
- Sequential scan (SAX)
- Transactional processing (DeweyID)
- Structure independence



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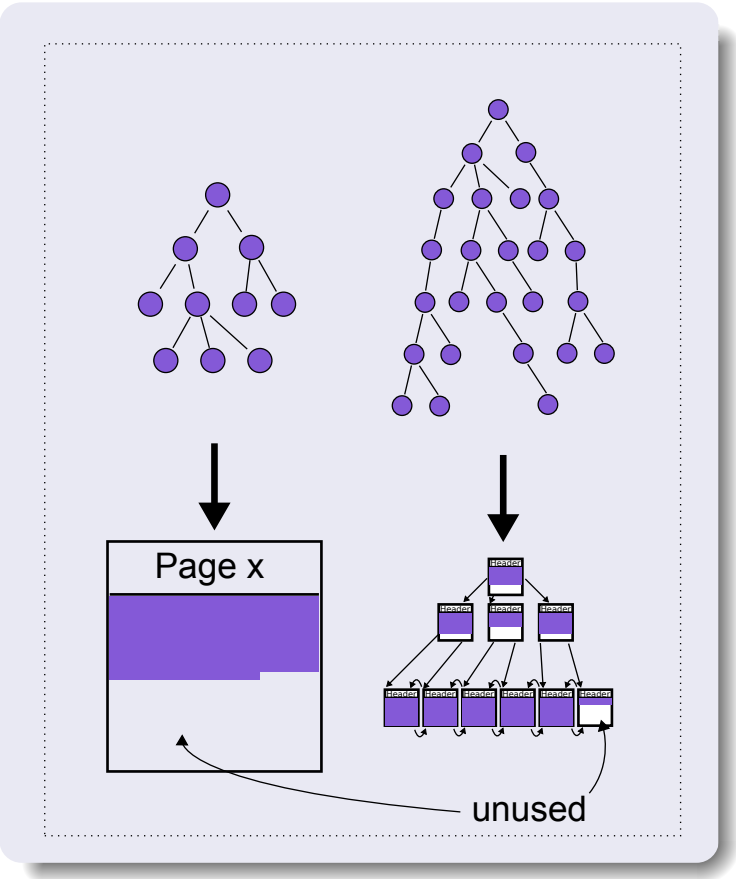
- Unused space
  document size $<$ page size



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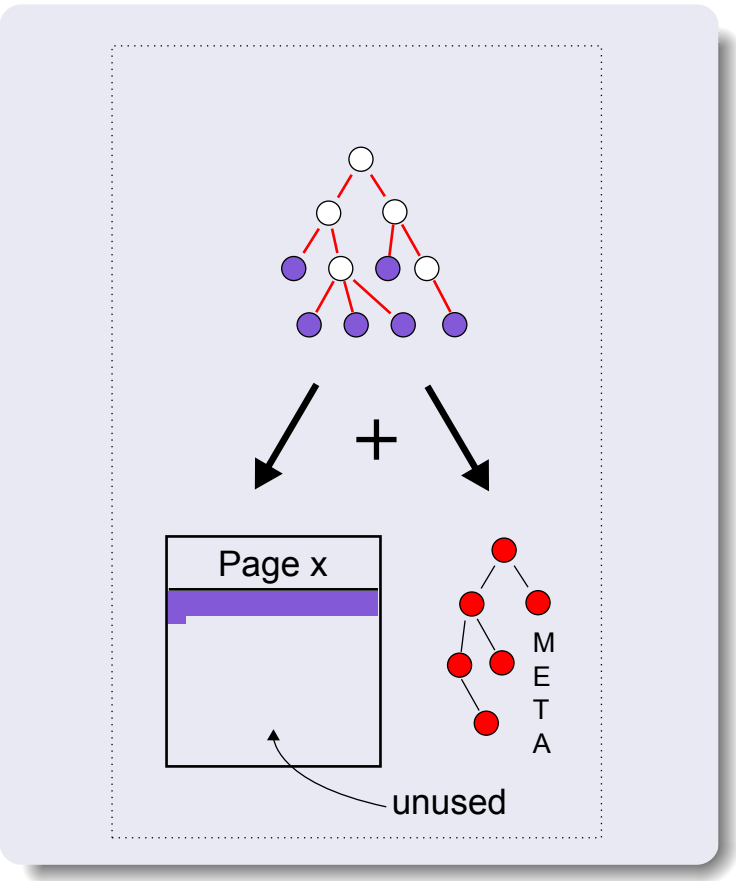
- Inner structure rebuilt on-demand



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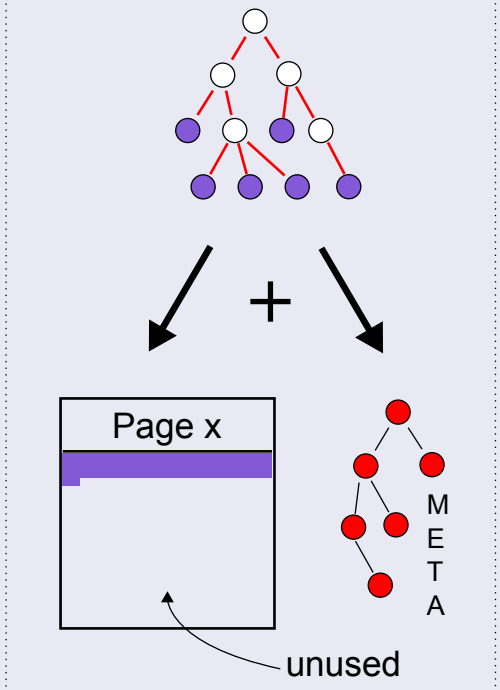

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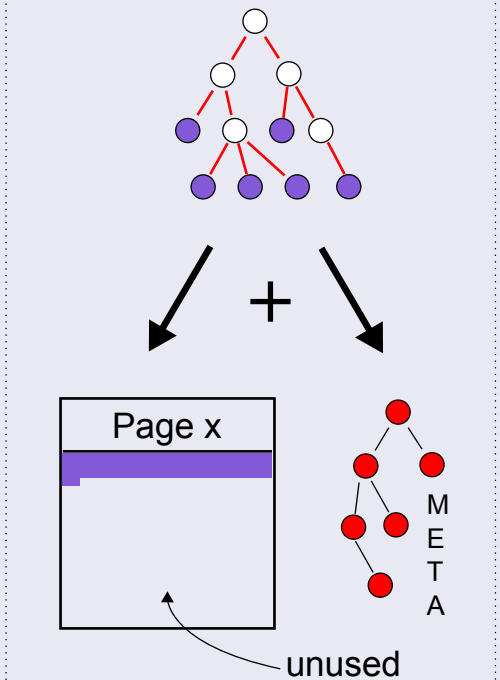
- Limited to path synopsis usage (number of path classes)



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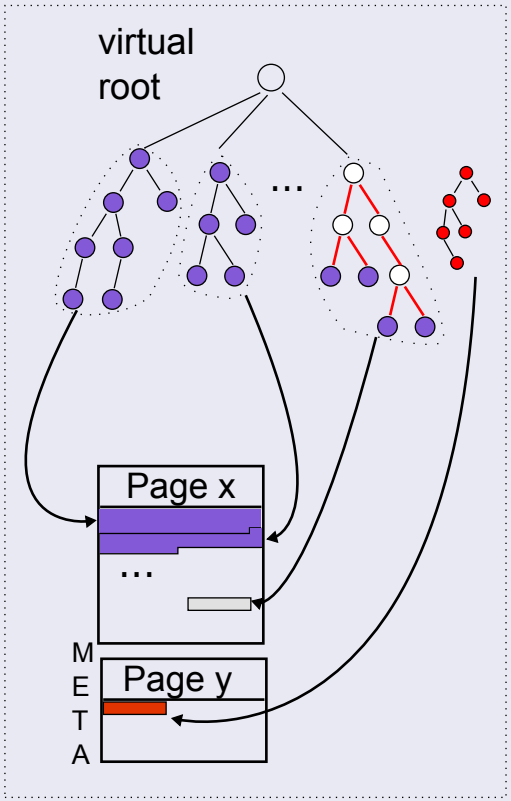
Model 3 - Collections

- (small) Documents (of one domain) combined
- Virtual root node
- Combination of single and elementless documents possible
- Optional indexes for all documents



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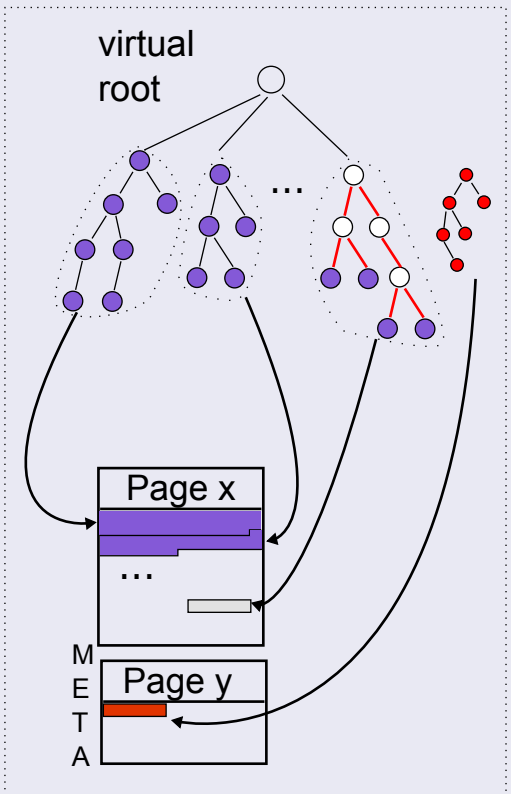

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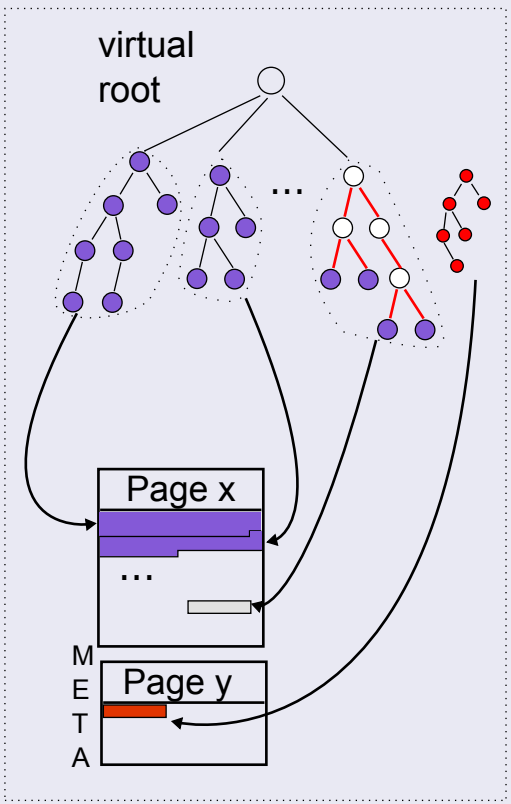
- Metadata management required
- Higher abstraction level (mostly compensated by prefix compression)



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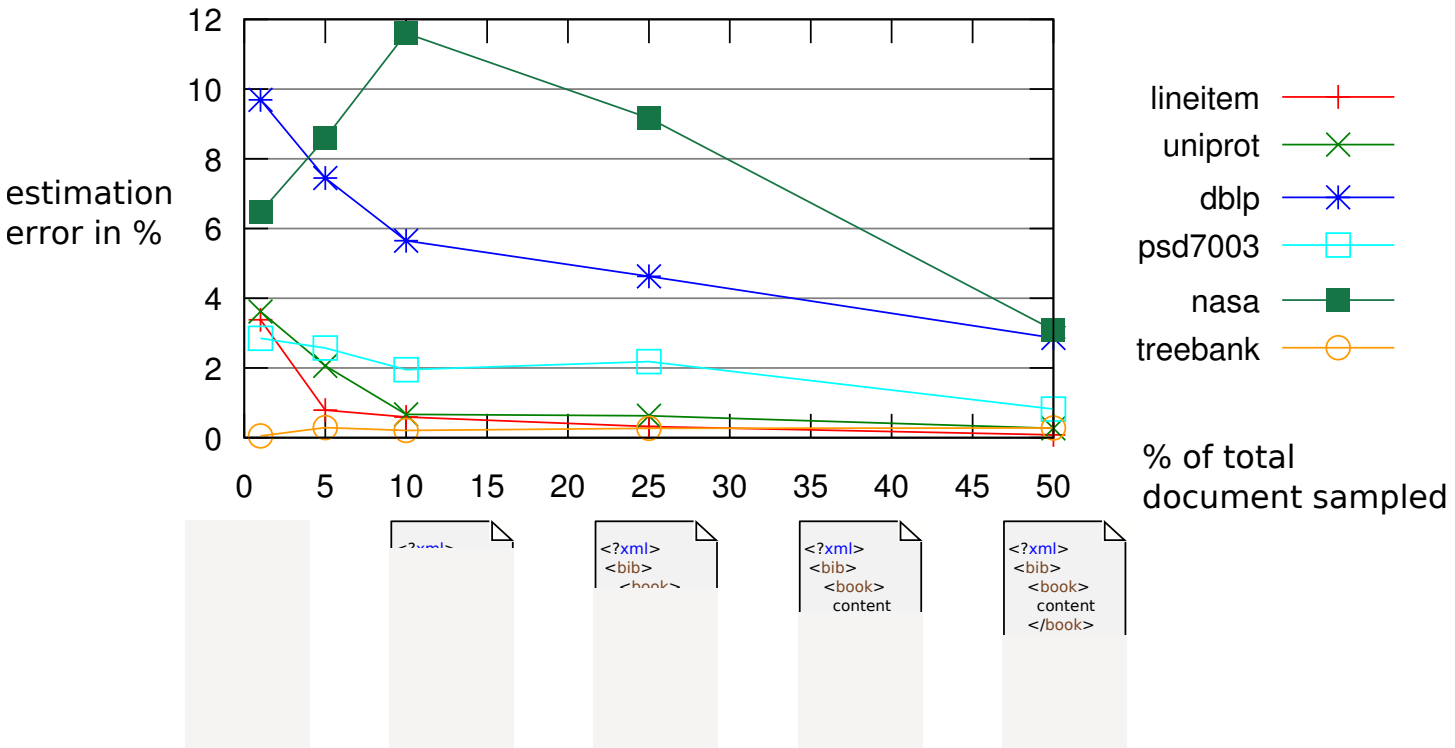

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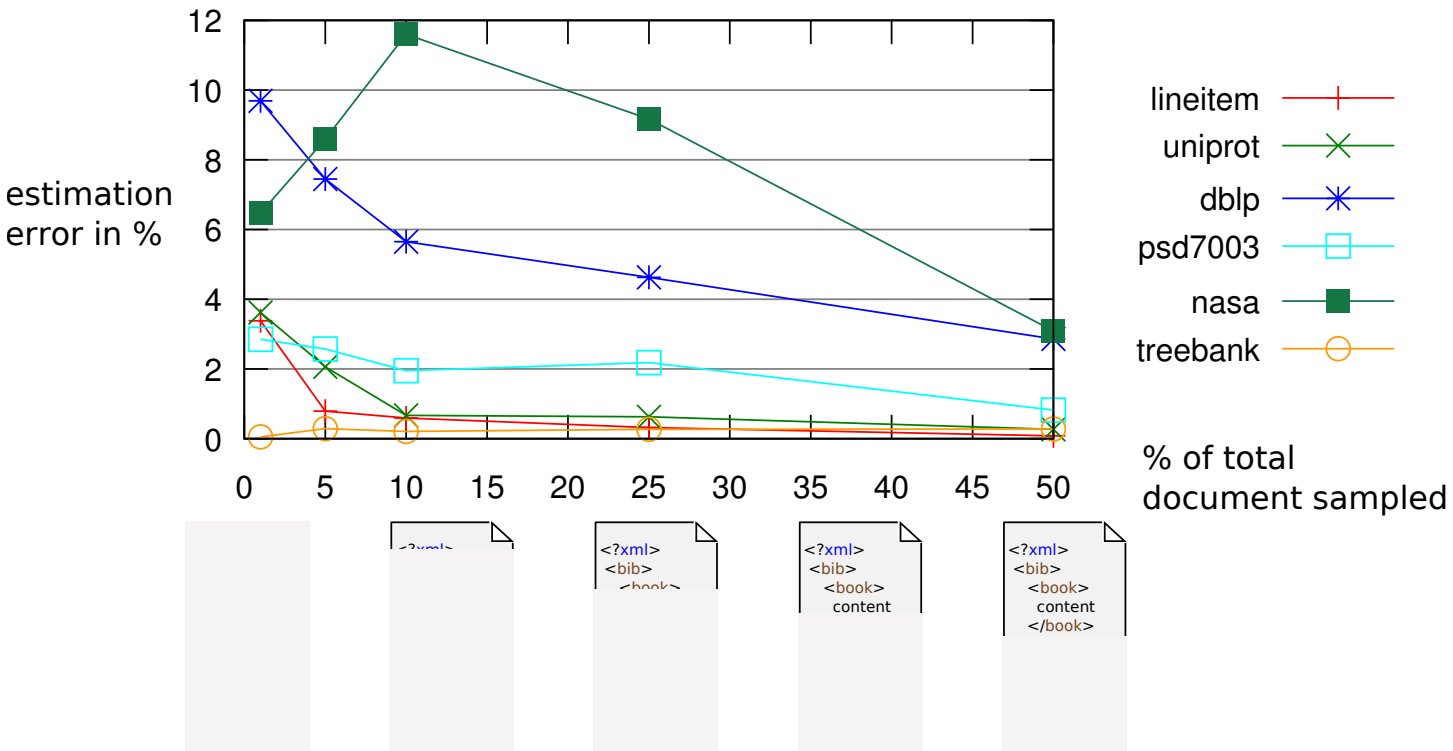
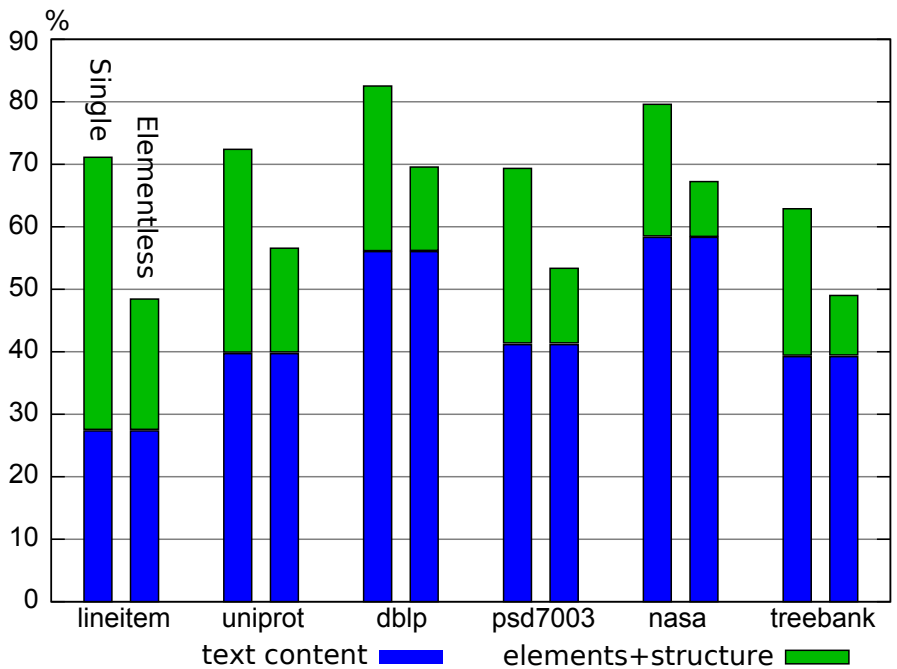


- Low sampling error on $< 10\%$ of data
- Extrapolation lead to fairly good and fast approximations

Storage Space Consumption Analysis

Single and Elementless Storage

- On average Elementless saves up to 50% of structural information
- DeweyIDs are prefix compressed and element names substituted by IDs
- 100% refers to "naive" storage (full names, IDs)



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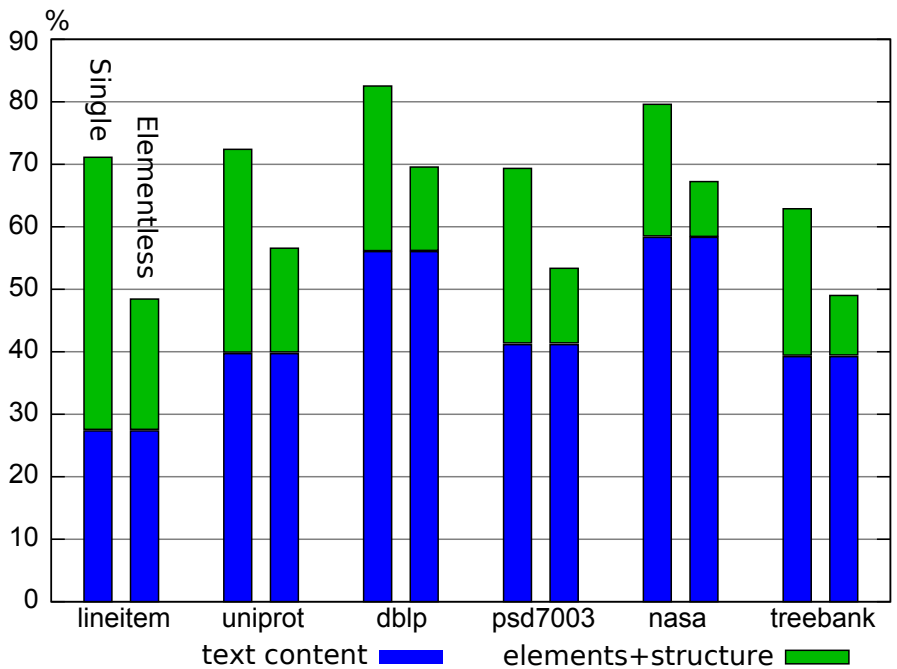
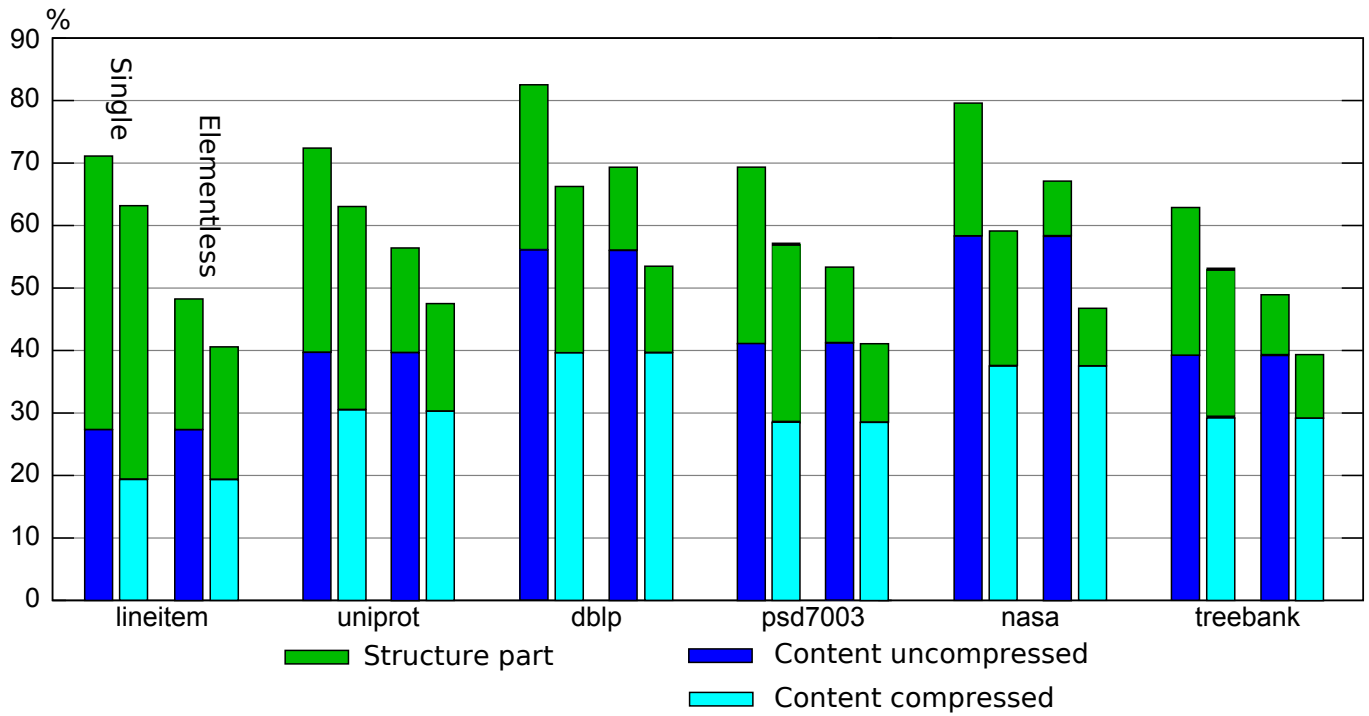


Collection Storage

Experiments on 527 randomly selected documents (wikipedia.com) reduced unused storage space up to **94.5%** by using collections! (compared to Single Document Storage)

Storage Space Consumption Analysis - Compression

Character-Based Compression for Single and Elementless



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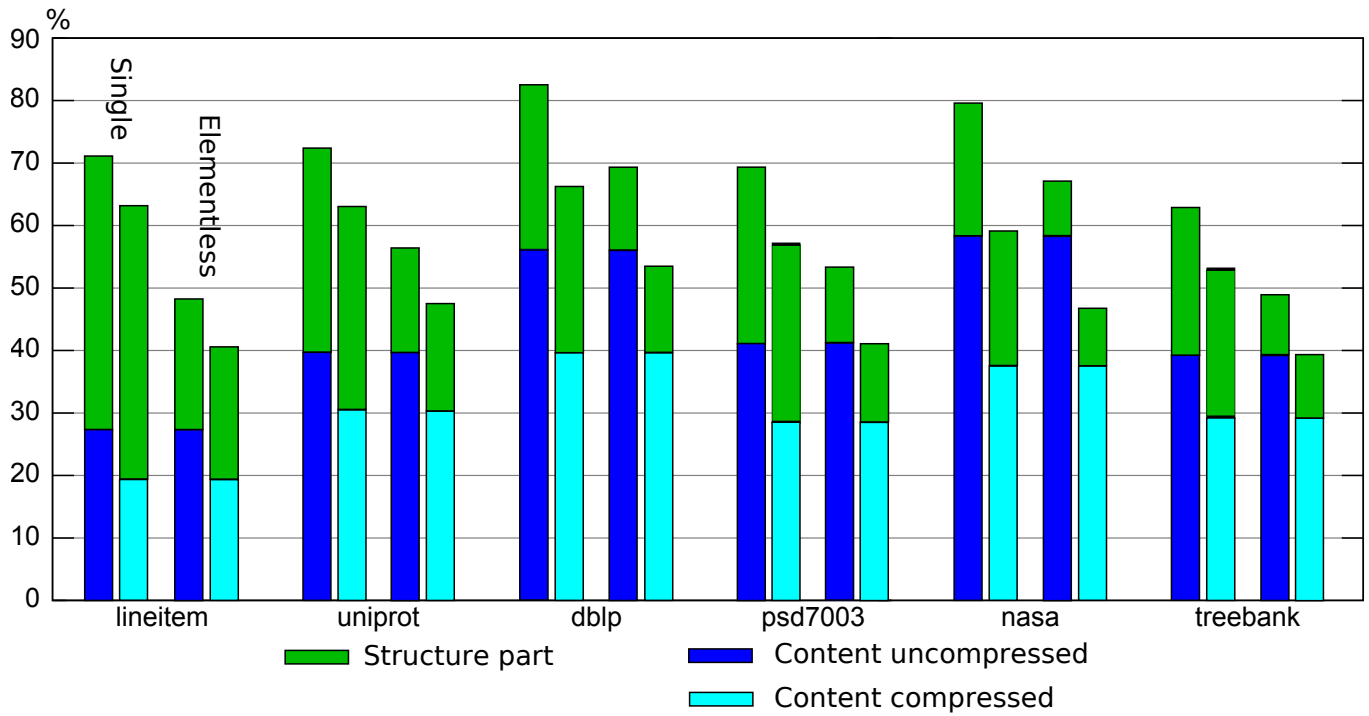

- Even storage and reconstruction timings could be reduced by $20 - 30\%$
- Adjusting storage parameters improves overall performance!

Thanks for your attention!

Questions?