Document Size Distribution

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Database Group Talk - Feb. 12th 2014

(LSDS-IR 2014 workshop paper with Frank Wm. Tompa)

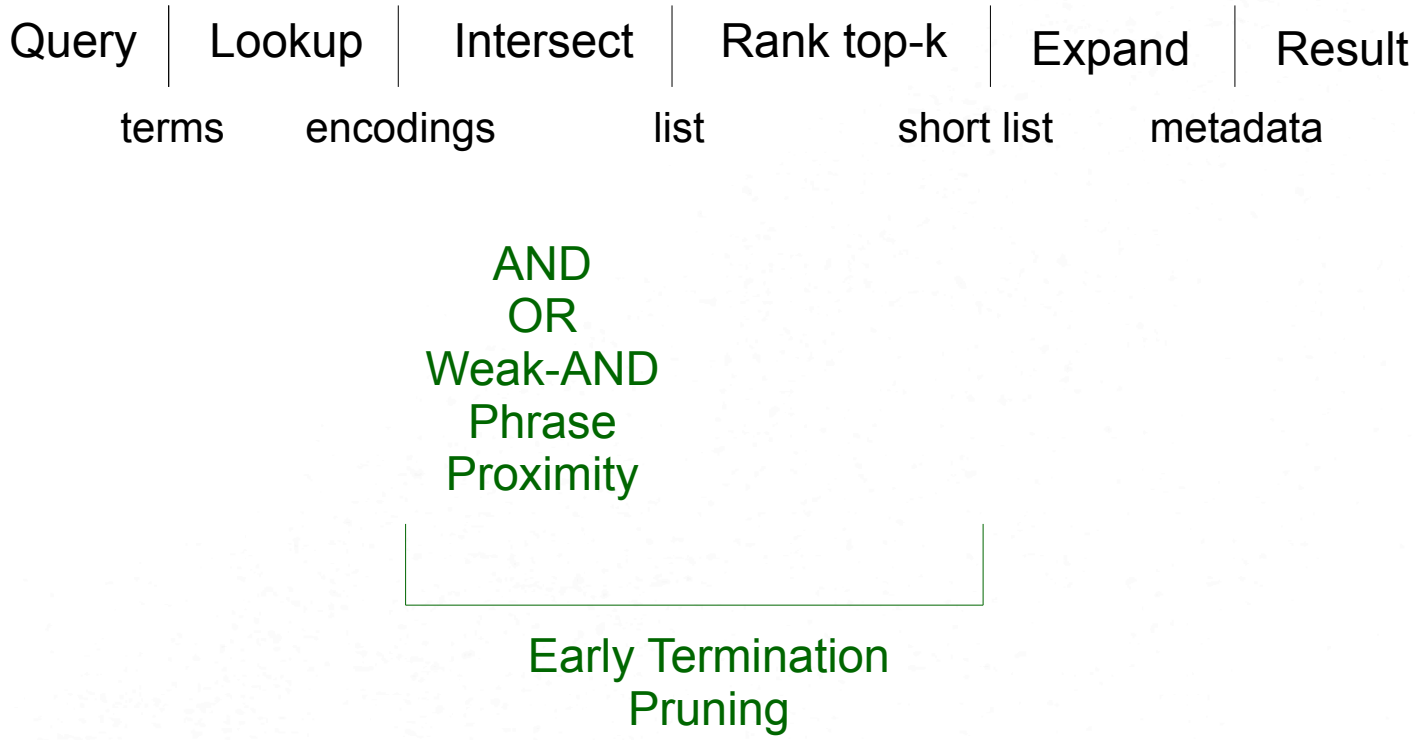
Outline

- Introduction to search engines.
- Distribution by document size.
- List intersection.
- Experiments:
  - Space improvement.
  - Runtime improvements.
- Applications in practice.

Indexing

- Input: (document, metadata)$^+$
- Name: (docID, documents, metadata)$^+$
- Convert: (docID, text, metadata)$^+$
- Tokenize: (docID, tokens and offsets)$^+$
- Invert: map of token to docID$^+$
  - i.e. list of documents containing that token (postings list).
  - Add frequency for ranking.
  - Add offsets for phrase, proximity and ranking.

Search Engine Query Processing



Search Engine Query Processing

AND
OR
Weak-AND
Phrase
Proximity

Early Termination
Pruning

Document Distribution

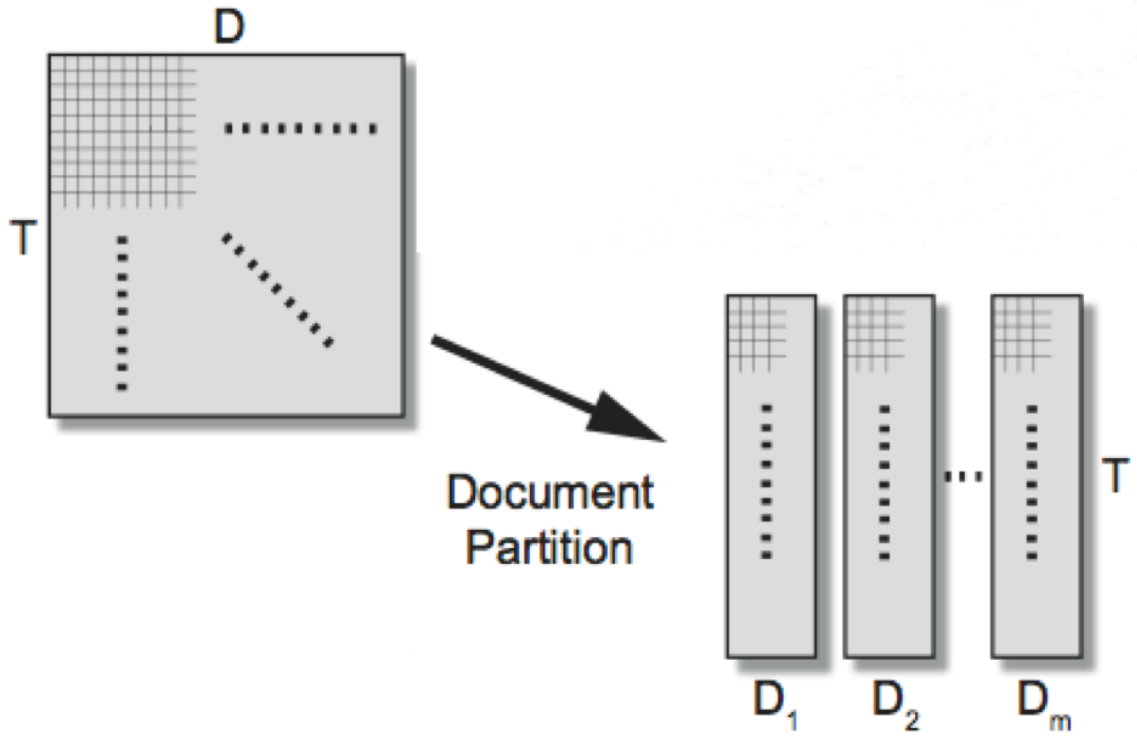


Figure from Baeza-Yates et al. ICDE 2007

- How do you distribute documents to partitions?

Document Distribution

- Random distribution is normally used:
  - Balanced distribution of query work and index size.
  - We refer to this as rand-p
- Document size distribution improves performance:
  - Benefits to index size and query resource usage.
  - Balancing requires tuning of the partition cutoff points.
  - We measure size by # terms in document.
  - We refer to this as td-p

Within Partitions

- Can use any document ordering within the partitions.
  - We use random ordering for our tests to avoid bias, so we compare rand-p-rand vs. td-p-rand.
  - Using URL ordering produces similar types of improvement.

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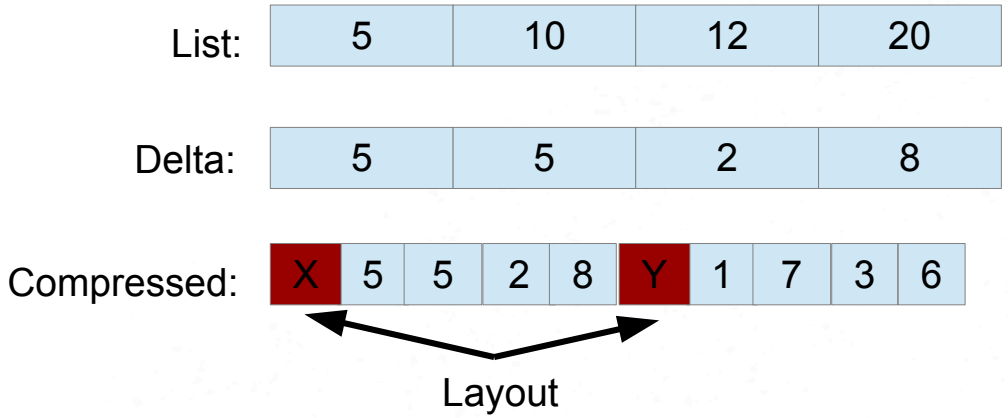
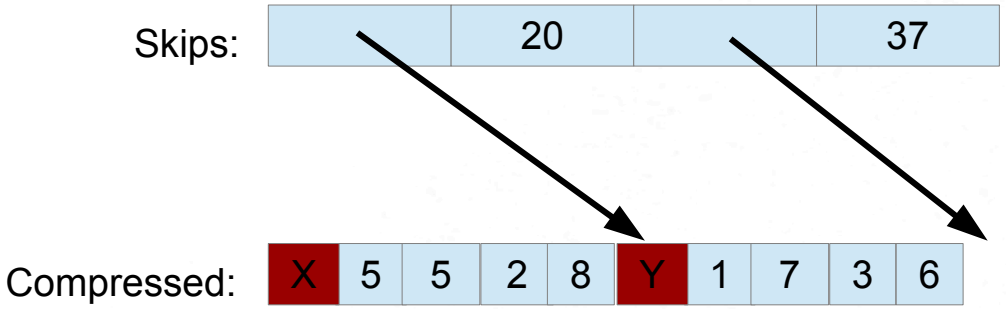
List Intersection



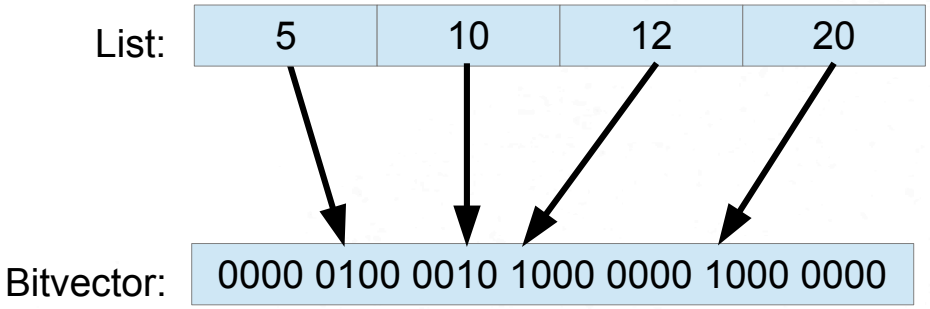
- Uncompressed lists: next(), fsearch(int,method).
- Compressed lists: next().
  - We use simple16 compression: layout+data = 4+28 bits

List Intersection



- Skips over compressed lists: next(), fsearch(int).

List Intersection

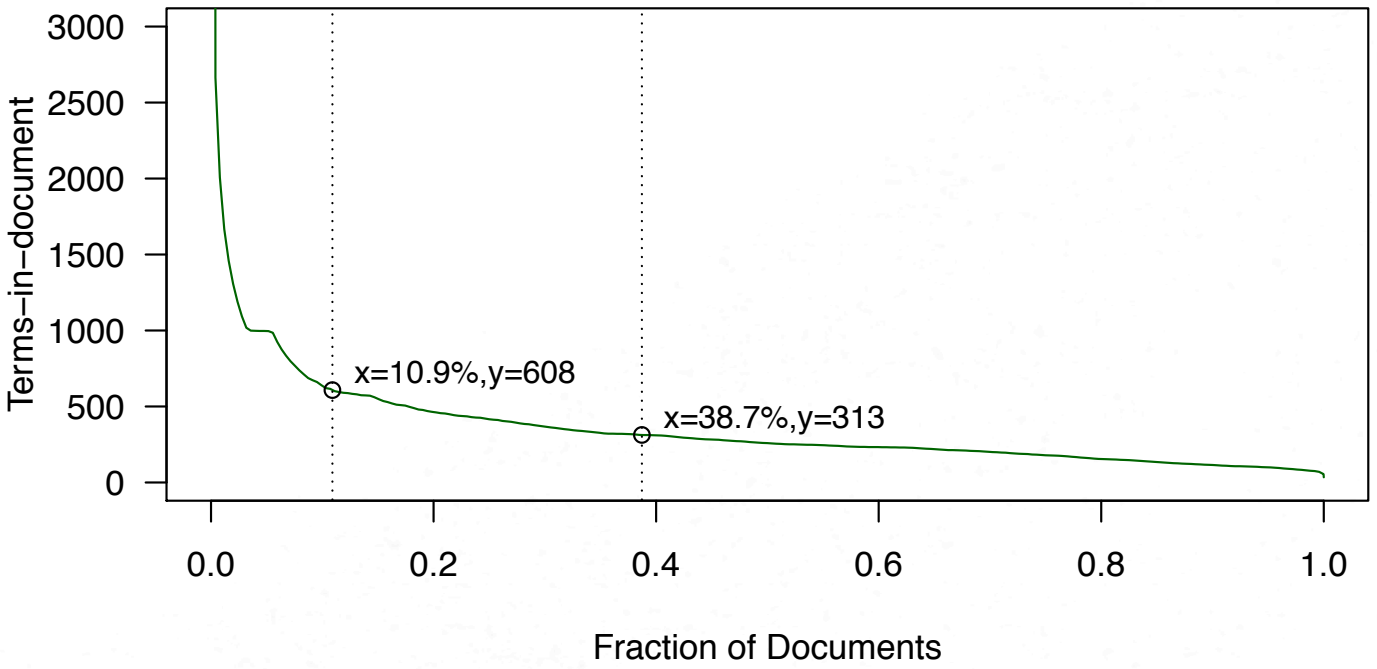


- Bitvector: contains(int), bitwiseAND(bitvector), convertToList().
- Hybrid: Use bitvectors if freq. > F and compressed lists for others [Culpepper and Moffat 2010].

Experiments

- Conjunctive-AND list intersection.
- Three partitions with equal number of postings.
- Sum index space and query runtime over partitions.
- Setup:
  - Using GOV2 dataset (426GB) and 5000 corpus queries (4.1 terms per query).
  - AMD Phenom II X6 1090T 3.6Ghz Processor running Ubuntu Linux 2.6.32-43-server.

Document Size



- Terms-in-document count for GOV2 dataset, split by number of postings into three partitions.

After Partitioning

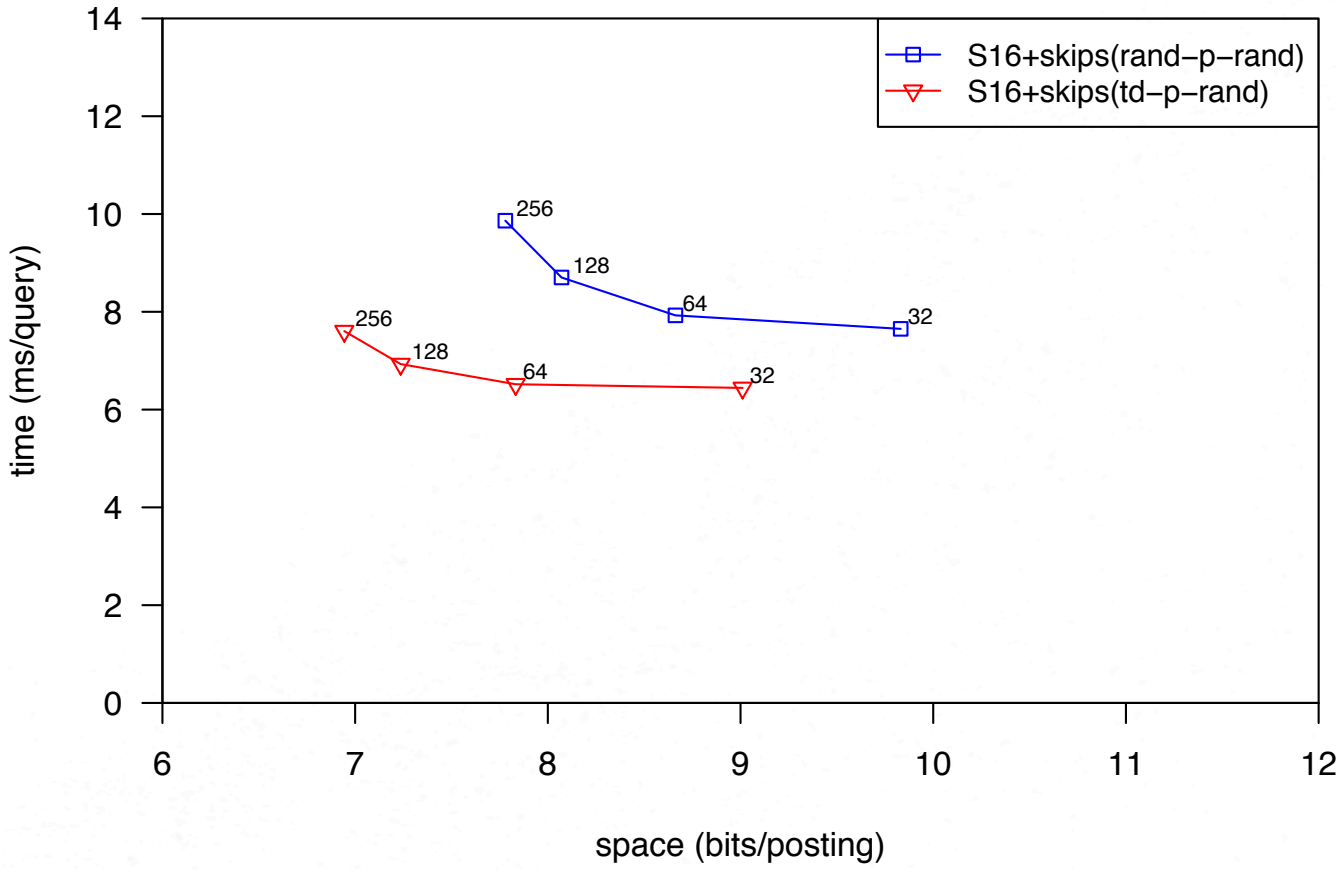
- Encoding as compressed lists of deltas (simple16):
  - rand-p-rand: 7.54 bits/posting.
  - td-p-rand: 6.70 bits/posting.

  - Space improvement of 11.1%.

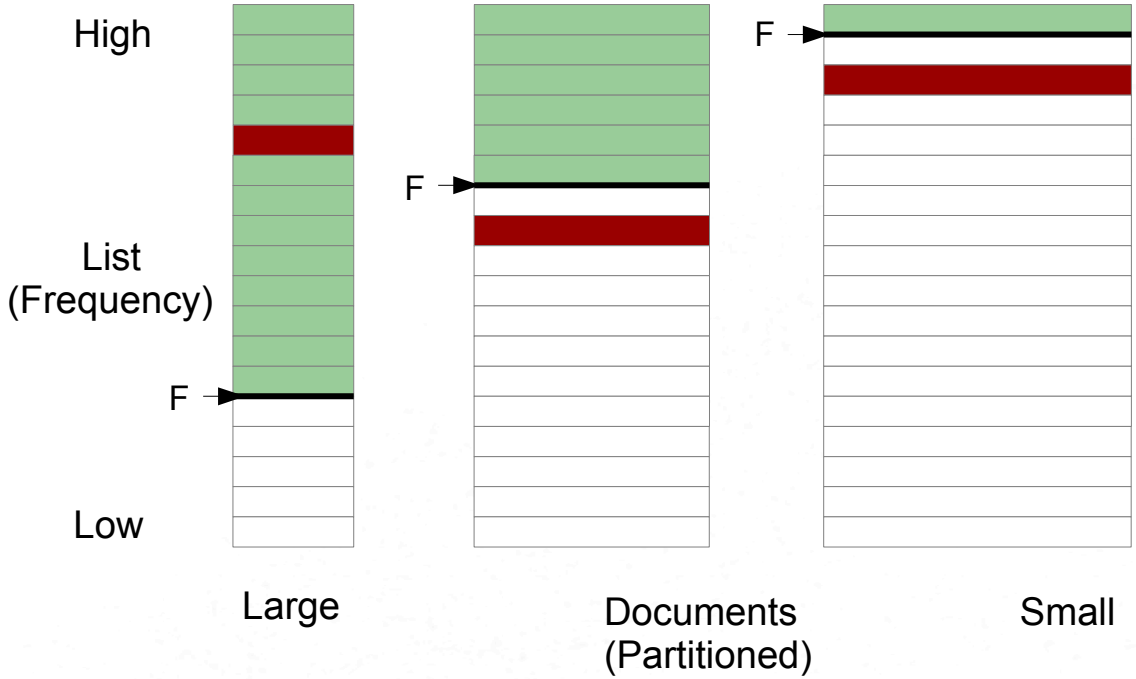
Benefits with Skips

- Skew from terms-in-document distribution:
  - In large-document partitions:
    - Increases density of postings.
    - Therefore, cache line clustering (locality of access).
  - In small-document partitions:
    - Reduces density of intermediate results.
    - Therefore, skips more effective.

Results for Skips

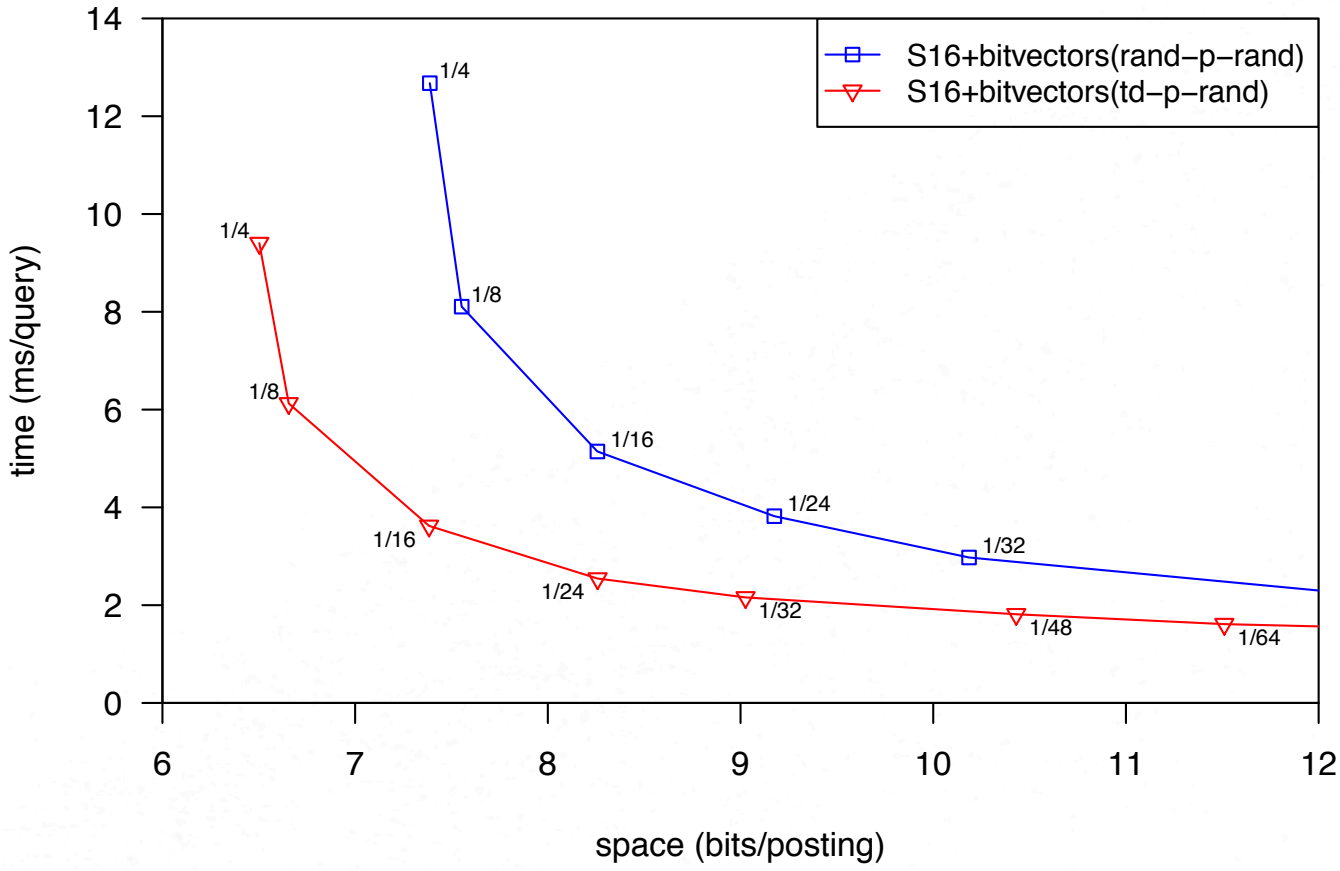


Benefits with Bitvectors



- Bitvectors chosen independently in each partition (red).
- More bitvectors in partitions with larger documents (green).

Results for Bitvectors



Ranking

- Direct improvements:
  - Delta compression and skips are often used in ranking systems.
- Expected improvements:
  - Locality of access from increased density of lists.
  - Sparse intermediate results.
  - Structures/processing that adapts to each partition.

Potential Improvements

- Within a partition:
  - Tune algorithms in each partition to fit the data in partition.
- Across partitions:
  - Run on subset of partitions to decide on subsequent processing. For example, decide on AND vs. Weak-AND processing for other partitions.

Distribution in Practice

- Use a hierarchy of distribution/ordering mechanisms in practice, for example:
  - Tier documents by global relevance (e.g., PageRank).
  - URL domain distribution (e.g., .gov) within a tier.
  - Document Size Distribution within a domain.
  - Order by URL within partition.

Conclusions

- We have shown that document size distribution improves:
  - Compression of postings lists.
  - Locality of access inside structures.
  - Performance of skips and bitvectors.

- Document size distribution is broadly applicable.

Questions/Comments

Related Ideas - Outline

- Databases:
  - Order by row size.
  - Order by usage.
- Using terms-in-document partitions:
  - Solving model constants.
- Other:
  - Replication vs. Partitioning.
  - Error identification.

Database Row Size

- Ordering by document size improves search systems.
- Reordering in databases is restricted to clustering by attributes.
- Use ordering by row size in database systems?
  - Number of non-null values.
  - Number of characters in row values.

Density vs. Usage

- Ordering by document size improves search systems.
- Document size correlates with likelihood of being in result list (at least for conjunctive-AND queries).
- For database queries, ordering rows by their usage in queries may produce similar improvements.
  - Improves locality of access and filtering of indexes.
  - Ordering by recency of update.
  - Ordering by recency of access.

Solving Model Constants

- Each document size distributed partition has different data distributions.
- Use partitions to solve system of linear equations and get performance model constants.
  - Random distribution gives singular system.
  - Normally need to isolate parameters to solve for constants.
    - Isolate by changing dataset or query workload.
    - Could be related to query mix.

Replication vs. Partitioning

- To improve throughput, should a search system add replicas or do more document partitioning?
- Assume: linear scaling of partitioning.
- For example:
  - 1x4GB partition = 1000 qps
  - 2x4GB replicas = 2000 qps
  - 2x2GB partitions = 2000 qps, but now have 2GB of memory per partition to improve throughput.

Error Identification

- Processing errors are more common with more data, and some application cannot tolerate errors (legal).
- While processing:
  - Verify data read from lists (error correcting codes).
  - Verify data decoded (encode last value in uncompressed form and compare).
- Post processing:
  - Verify intersection (result size boundary checks; signature checks).
  - Verify ranking (boundary checks).

Thank you.

Questions?

/* Comments */