Document Size Distribution

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Outline

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

Search Engine Query Processing

Query | Lookup | Intersect | Rank top-k | Expand | Result

terms encodings list short list metadata

AND
OR
Weak-AND
Phrase
Proximity

Early Termination
Pruning

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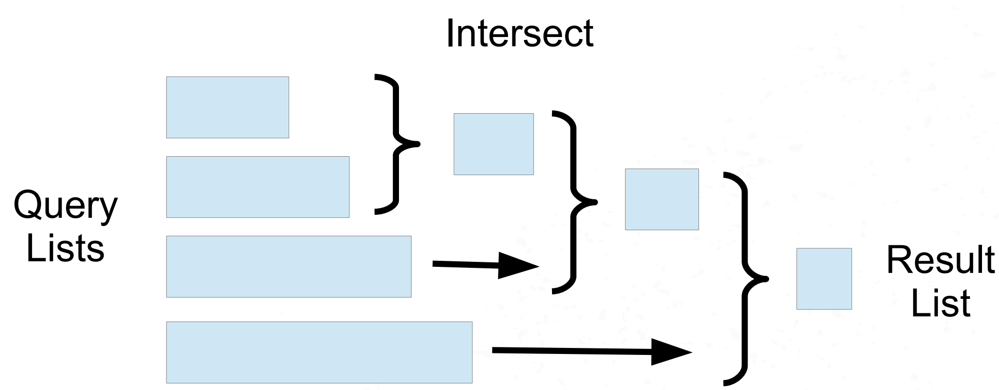
List Intersection



- Pairwise list intersection
  - Here we use conjunctive-AND with lists ordered by document ID.

Document Ordering

- Renumbering the documents affects space-time efficiency.

  - <u>Best is URL ordering</u> (similar to clustering).

  - Document size ordering (terms-in-document or td) is worse than URL ordering.
    - So, <u>people typically ignore td ordering</u>.

  - Random ordering is used as a base of comparison.

Early Termination

- When list intersection will produce lots of results:
  - Store each list in impact order (usually frequency), rather than by document ID.
  - Process only fronts of lists (early termination).
  - Use accumulators to combine lists.

- Impact ordering can outperform URL ordering.

Search Engine Query Processing

Scale by Distribution

Query | Lookup | Intersect | Rank top-k | Expand | Result

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Document Distribution

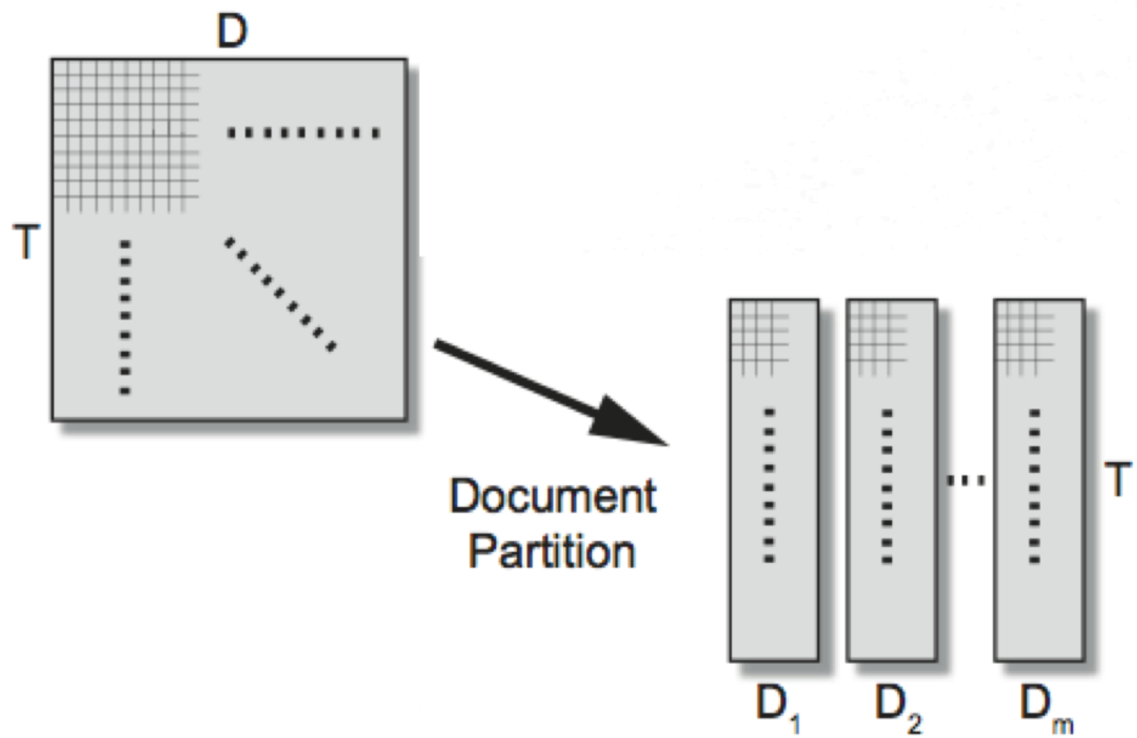


Figure from Baeza-Yates et al. ICDE 2007

- 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.
- Claim:
  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.

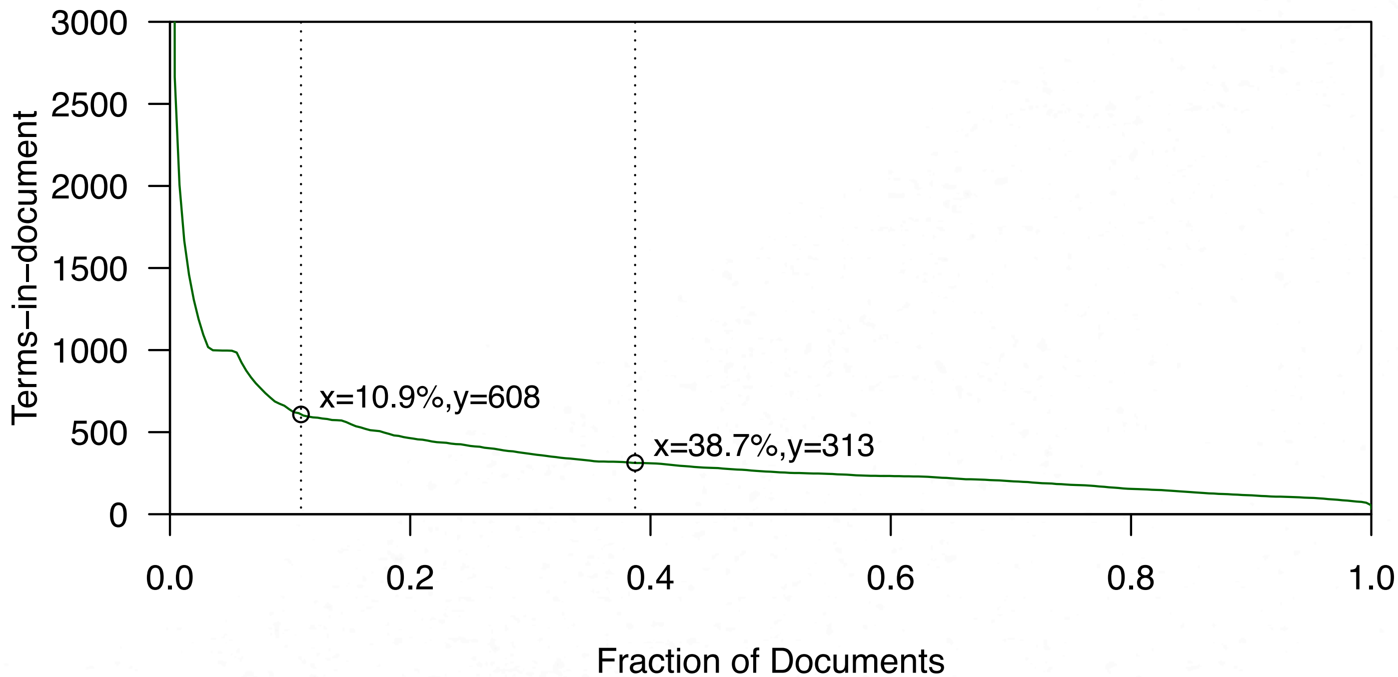
Within Partitions

- Can use any 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 (i.e., td-p-url is better than url-p-url).
  - Future work: compare td-p-impact and rand-p-impact.

Experiments

- Conjunctive-AND list intersection in memory.
- 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).

Document Size



- Terms-in-document count for GOV2 dataset, split by number of postings into three partitions, produces skew.
  - Area under the curve is equal for each partition.

Density in Partitions

- Skew in list density (for queries):

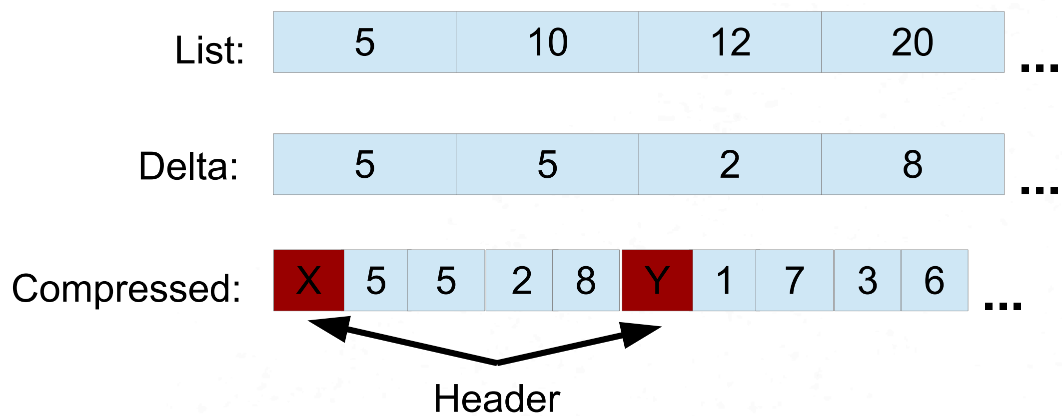
	D_{Large}	D_{medium}	D_{Small}
Smallest list density	2.39%	0.98%	0.23%

- Skew in result density is even larger:

	D_{Large}	D_{medium}	D_{small}
Result list density	0.50%	0.11%	0.02%

- So, exploit this skewed density.

Compressed List Encoding



- We use simple16 compression: header+data = 4+28 bits

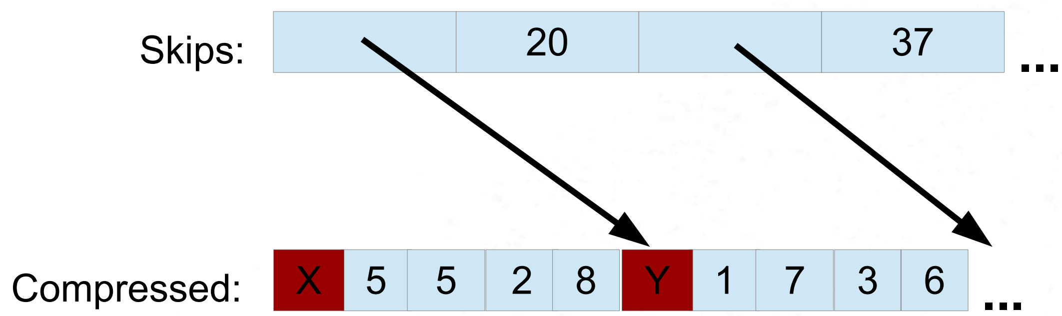
Results for Compressed Lists

- 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%.

  - Runtime essentially the same.

Adding Skips to Encoding

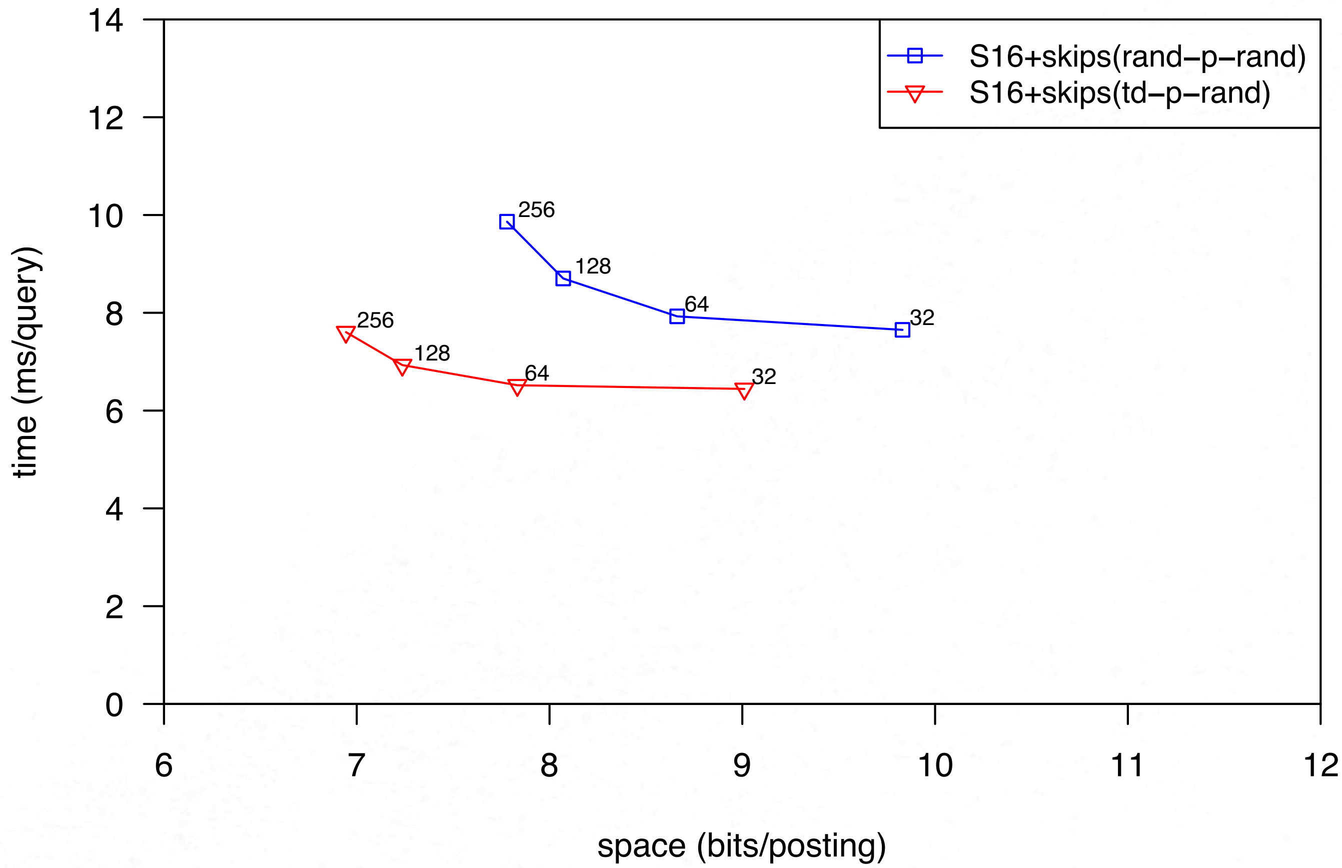


- Tuning: number of postings skipped.

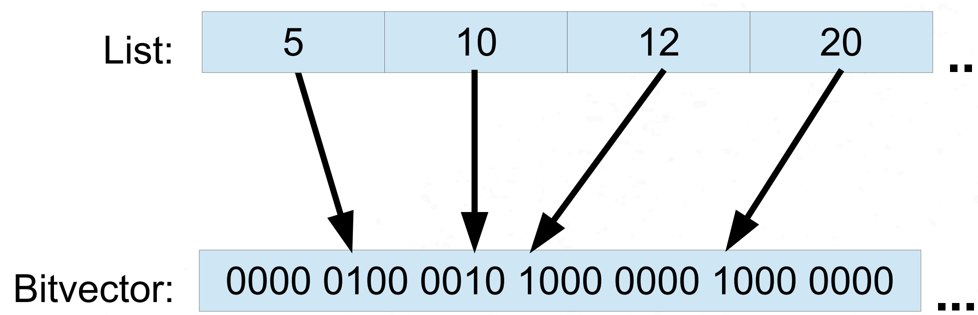
Benefits with Skips

- Skew from terms-in-document distribution:
  - In small-document partitions:
    - Reduces density of intermediate results.
    - Therefore, <u>skips</u> more effective.
  - In large-document partitions:
    - Increases density of postings.
    - Therefore, <u>cache line clustering</u> (locality of access).
    - Amortized costs to decode a block.

Results for Skips

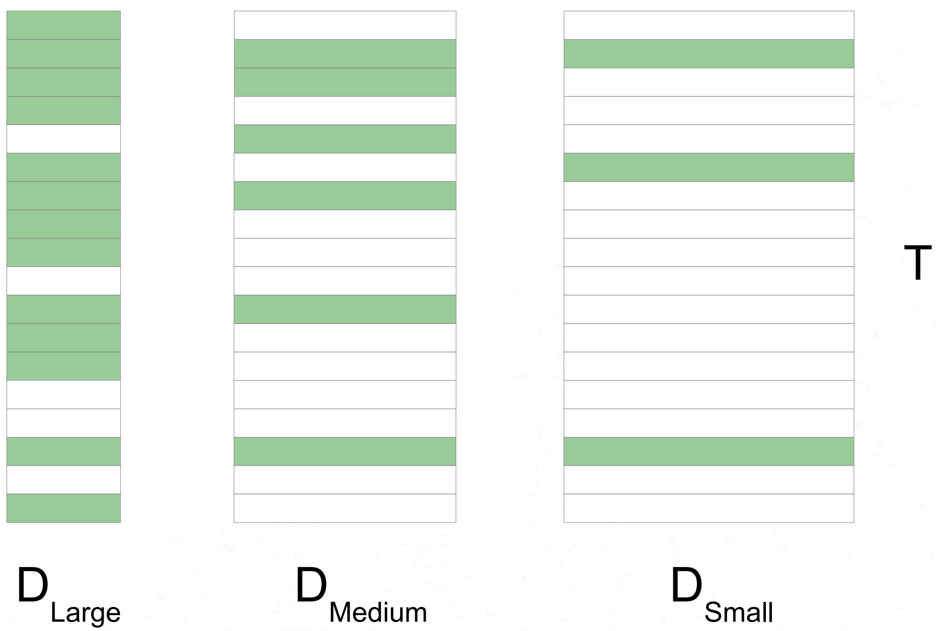


Bitvector Encoding



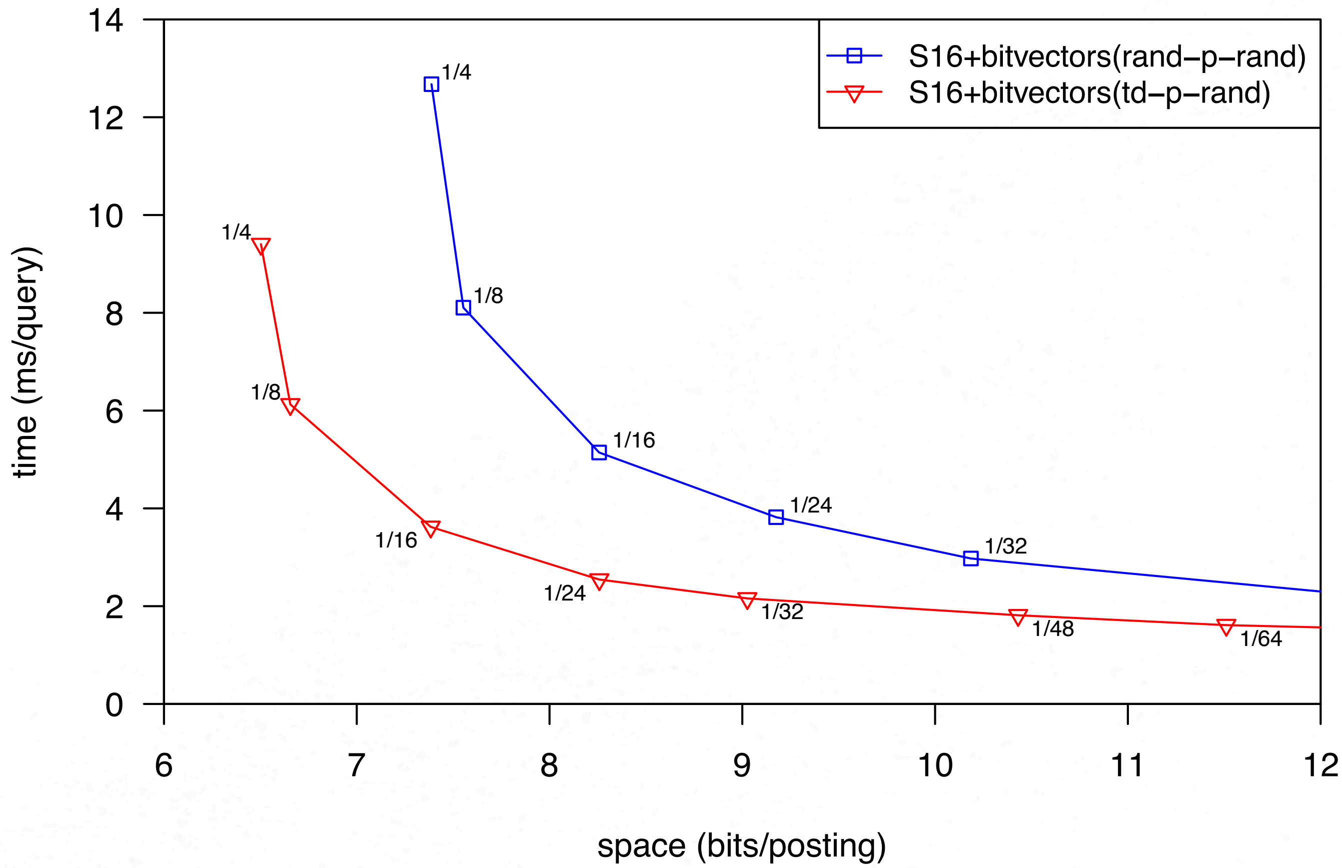
- Tuning: use bitvectors if freq. > F and compressed lists for others [Culpepper and Moffat 2010].

Benefits with Bitvectors



- Bitvectors used more effectively:
  - Density threshold F applied to each term independently in each partition.
  - Therefore, more bitvectors (green) in large-document partitions.

Results for Bitvectors



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 or impact within partition.

Conclusions

- We have shown that document size distribution <u>improves space and time</u>:
  - Compression of postings lists.
  - Locality of access inside structures.
  - Performance of skips and bitvectors.
- Document size distribution <u>is broadly applicable</u>.
- Future work:
  - Compare td-p-impact and rand-p-impact.

Thank you.

Questions?

/* Comments */

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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.