Text Retrieval & Search Engines

System Implementation: Fast Search

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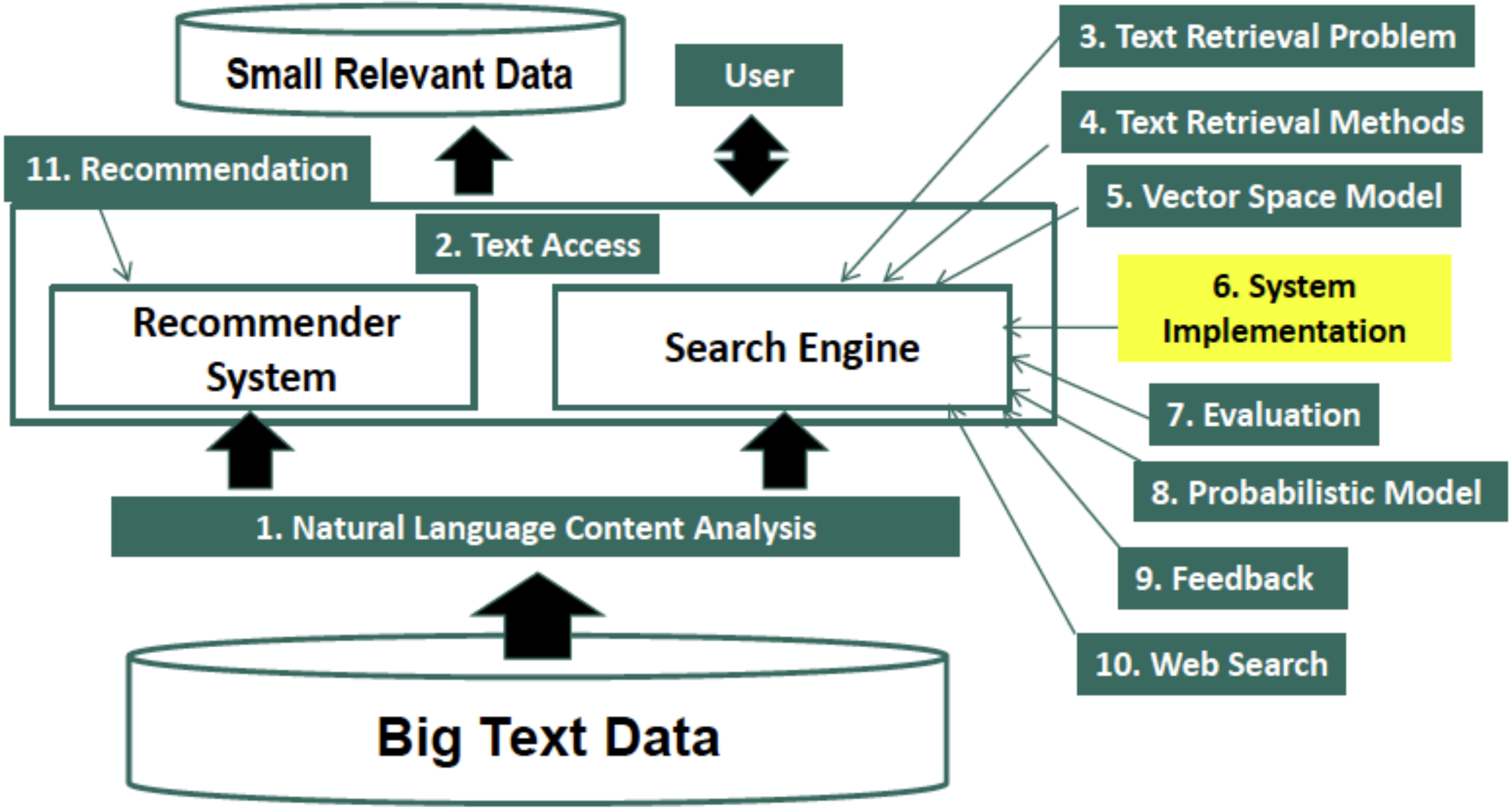
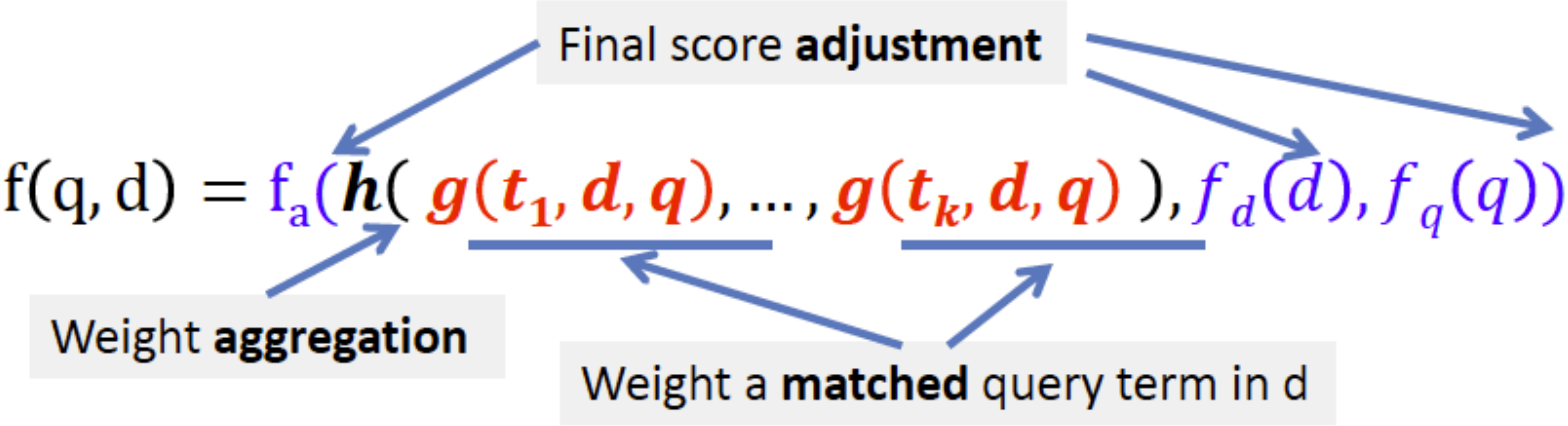
Implementation of Text Retrieval Systems



How to Score Documents Quickly

General Form of Scoring Function



Final score **adjustment**

$$f(q,d) = f_a(h(\underline{g(t_1,d,q)},\ldots,\underline{g(t_k,d,q)}),f_d(d),f_q(q))$$

Weight **aggregation**

Weight a **matched** query term in d

A General Algorithm for Ranking Documents

$$f(q, d) = f_a(\boldsymbol{h}(\boldsymbol{g}(\boldsymbol{t_1}, \boldsymbol{d}, \boldsymbol{q}), \ldots, \boldsymbol{g}(\boldsymbol{t_k}, \boldsymbol{d}, \boldsymbol{q})), f_d(d), f_q(q))$$

- $f_d(d)$ and $f_q(q)$ are pre-computed
- Maintain a score accumulator for each **d** to compute ***h***
- For each query term $\boldsymbol{t_i}$
  - Fetch the inverted list $\{(d_1,f_1),\ldots,(d_n,f_n)\}$
  - For each entry (d_j,f_j), compute **$g(t_i,d_j,q)$**, and update score accumulator for doc d_i to incrementally compute ***h***
- Adjust the score to compute **f_a**, and sort

An Example: Ranking Based on TF Sum

$f(d,q)=g(t_1,d,q)+\ldots+g(t_k,d,q)$ where $g(t_i,d,q) = c(t_i,d)$

Query = **"info security"**

Info: (d1, 3), (d2, 4), (d3, 1), (d4, 5)
Security: (d2, 3), (d4,1), (d5, 3)

	Accumulators:	**d1**	**d2**	**d3**	**d4**	**d5**
		0	0	0	0	0
info	(d1,3) =>	**3**	0	0	0	0
	(d2,4) =>	3	**4**	0	0	0
	(d3,1) =>	3	4	**1**	0	0
	(d4,5) =>	3	4	1	**5**	0
security	(d2,3) =>	3	**7**	1	5	0
	(d4,1) =>	3	7	1	**6**	0
	(d5,3) =>	3	7	1	6	**3**

For each term, fetch the corresponding entries (frequency counts) in the inverted index. Create document score accumulators as needed (variables that hold the accumulated score for each document). Scan the inverted index entries for the current term and for each entry (corresponding to a document containing the term), update its score accumulator based on some term weighting method (the *score_term* function). This could be (for example) Okapi BM25. As we finish processing all the query terms, the score accumulators should have the final scores for all the documents that contain at least one query term. Note that we don't need to create a score accumulator if the document doesn't match any query term.

Further Improving Efficiency

- Caching (e.g., query results, list of inverted index)
- Keep only the most promising accumulators
- Scaling up to the Web-scale? (need parallel processing) Map-Reduce

Some Text Retrieval Toolkits

- Lucene: http://lucene.apache.org/
- Lemur/Indri: http://www.lemurproject.org/
- Terrier: http://terrier.org/
- MeTA: http://meta-toolkit.github.io/meta/
- More can be found at http://timan.cs.uiuc.edu/resources

https://searchtools.com/tools/tools-opensource.html

https://nlp.stanford.edu/IR-book/information-retrieval.html

Summary of System Implementation

- Inverted index and its construction
  - Preprocess data as much as we can
  - Compression when appropriate
- Fast search using inverted index
  - Exploit inverted index to accumulate scores for documents matching a query term
  - Exploit Zipf’s law to avoid touching many documents not matching any query term
  - Can support a wide range of ranking algorithms
- Great potential for further scaling up using distributed file system, parallel processing, and caching

Additional Readings

- Ian H. Witten, Alistair Moffat, Timothy C. Bell: Managing Gigabytes: Compressing and Indexing Documents and Images, Second Edition. Morgan Kaufmann, 1999.
- Stefan Büttcher, Charles L. A. Clarke, Gordon V. Cormack: Information Retrieval - Implementing and Evaluating Search Engines. MIT Press, 2010.

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