

Basic Text Search Functionalities

- Text search
find matching documents
- Document ranking
calculate importance of a document according to the query
- Did you mean
calculate more important query terms than the specified one
- Highlighting
Highlight the relevant query terms in the document/summary
- Automatic summarizations
Create a summary of a document for getting an overview
- Feature extraction:
extract characteristic keywords from a document
- Fuzzy Search
search similar terms or phrases
- Natural Language Search
answer natural language queries

AdvancedText Search Functionalities

- "See Also" search:
get more documents like this
- Feature extraction:
find characteristic keywords
- Entity extraction
extract entities like proper names/company names
- Document classification:
assign a document to predefined categories
- Term search:
find better search terms; discover interesting relationships
- Document clustering:
discover sets of related documents
- Sentiment Analysis
discover the sentiments of a document about a topic

Document Analysis I

- **Crawling / document input**

get documents from web or any other source

- **Document filtering**

convert a document from any format to plain text/html/xml

- **Tokenization**

determine word, clause and sentence boundaries

- **Normalization**

upper/lowercase; spelling variants; umlauts

- **Tagging**

determine word category (noun, verb, adjective, adverb, etc.)

- **Stemming**

singular/plural; case inflections

Document Analysis II

- Entity extraction

extract entities like company names, proper names and facts based on dictionaries and rules

- Term Identification

based on word category and stopword list

- Phrase Generation (noun phrases)

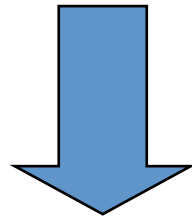
combine adjacent words of particular categories (NN, AN, NPN, ...)

- Term Selection after processing a document collection

for text mining : delete low - and high-frequency terms; delete redundant phrases

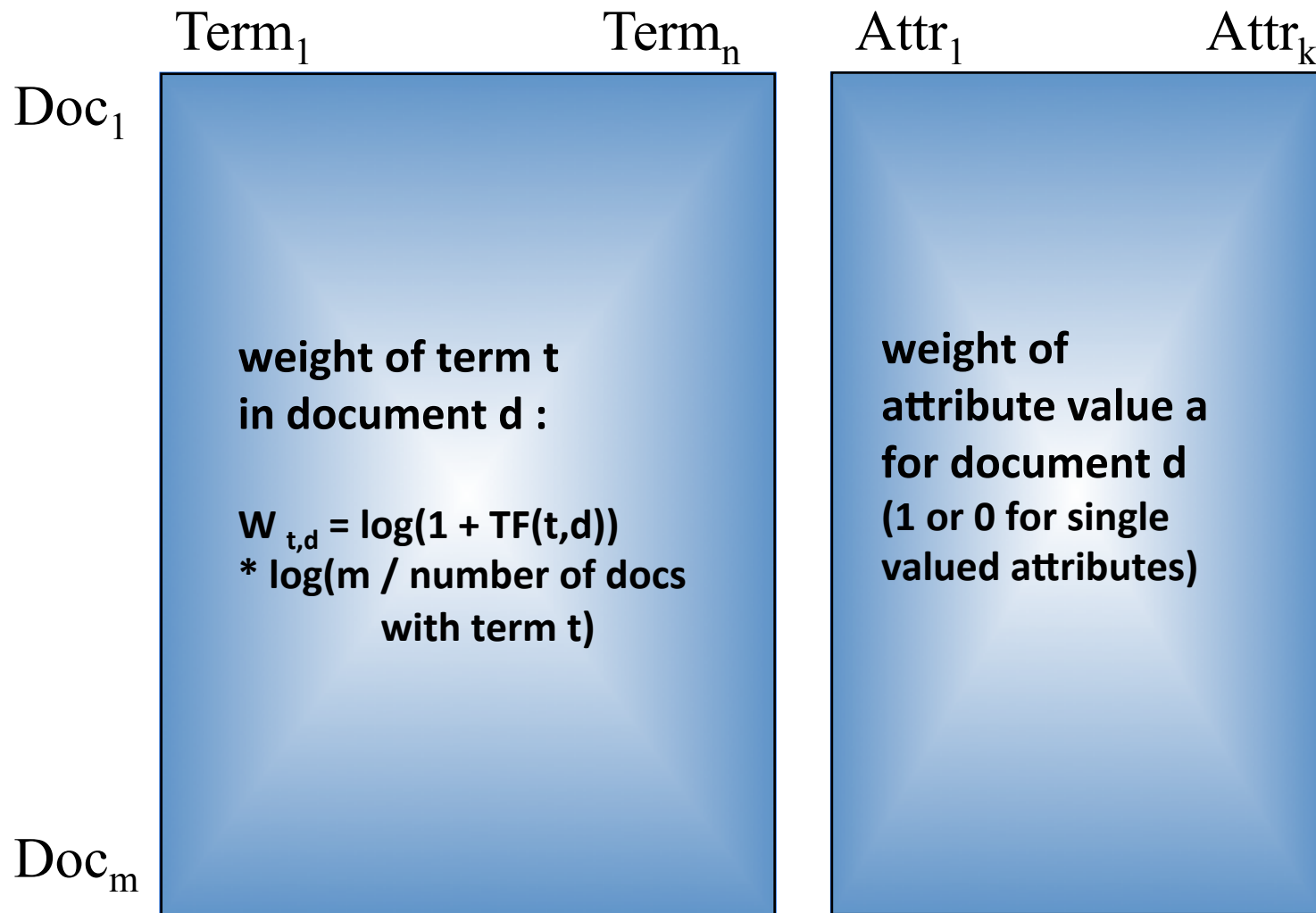
Term Generation Example

"But Lieberman's criticism of Clinton's behavior may have been more of a personal move than a political one."



**Lieberman; Lieberman's criticism; Lieberman's criticism of Clinton;
Lieberman's criticism of Clinton's behavior
criticism; criticism of Clinton; criticism of Clinton's behavior
Clinton; Clinton's behavior
behavior
personal move
move**

Vector space retrieval model



Ranking : Page Rank

- Developed by Lawrence Page and Sergey Brin
- Based on relations between websites not on the content itself
- General concept: Random surfer model
- Weight of a page : $PR(A) = (1-d) + d (PR(T1)/C(T1) + \dots + PR(Tn)/C(Tn))$
 - $PR(A)$ is the PageRank of page A
 - $PR(Ti)$ is the PageRank of Ti , which links to page A
 - $C(Ti)$ is the number of links of page Ti
 - d is a damping factor with $0 \leq d \leq 1$

Example :

$$PR(A) = 0.5 + 0.5 PR(C)$$

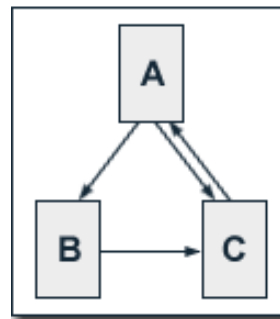
$$PR(B) = 0.5 + 0.5 (PR(A) / 2)$$

$$PR(C) = 0.5 + 0.5 (PR(A) / 2 + PR(B))$$

$$PR(A) = 14/13 = 1.07692308$$

$$PR(B) = 10/13 = 0.76923077$$

$$PR(C) = 15/13 = 1.15384615$$



Ranking : PAGE Rank

Iteration	PR(A)	PR(B)	PR(C)
0	1	1	1
1	1	0.75	1.125
2	1.0625	0.765625	1.1484375
3	1.07421875	0.76855469	1.15283203
4	1.07641602	0.76910400	1.15365601
5	1.07682800	0.76920700	1.15381050
6	1.07690525	0.76922631	1.15383947
7	1.07691973	0.76922993	1.15384490
8	1.07692245	0.76923061	1.15384592
9	1.07692296	0.76923074	1.15384611
10	1.07692305	0.76923076	1.15384615
11	1.07692307	0.76923077	1.15384615
12	1.07692308	0.76923077	1.15384615

Ranking : BM25 / OKAPI distance

- Concept

- Document weight is based on $f * IDF$

- Formulas

$$bm25(q, d) = \sum_{t \in q} IDF \times \frac{(k_1 + 1) f(d, t)}{K + f(d, t)}$$

$$IDF = \log \left(\frac{N - f(t) + 0.5}{f(t) + 0.5} \right)$$

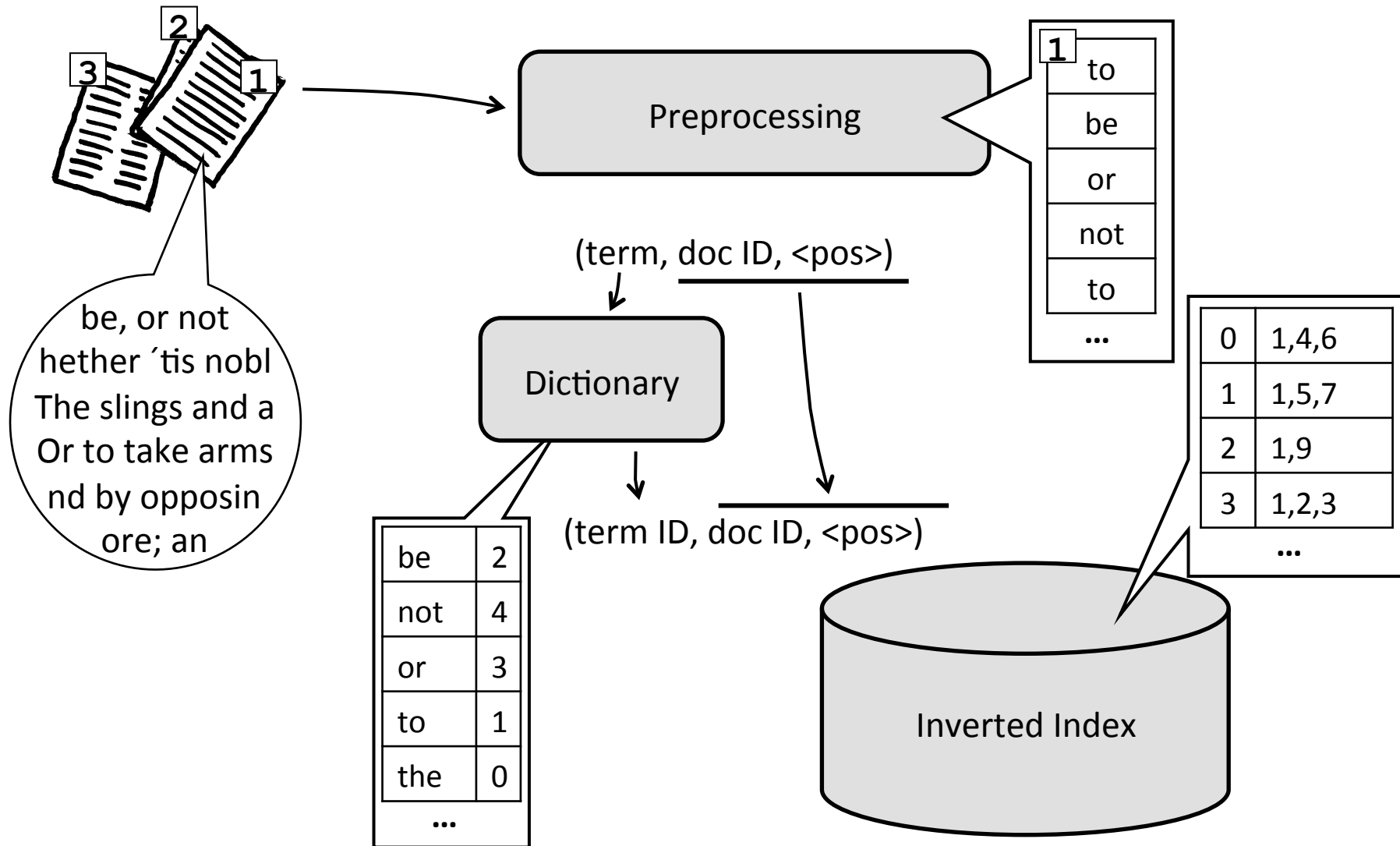
$f(d, t)$ is the term frequency of term t in document d ,

N is the number of documents

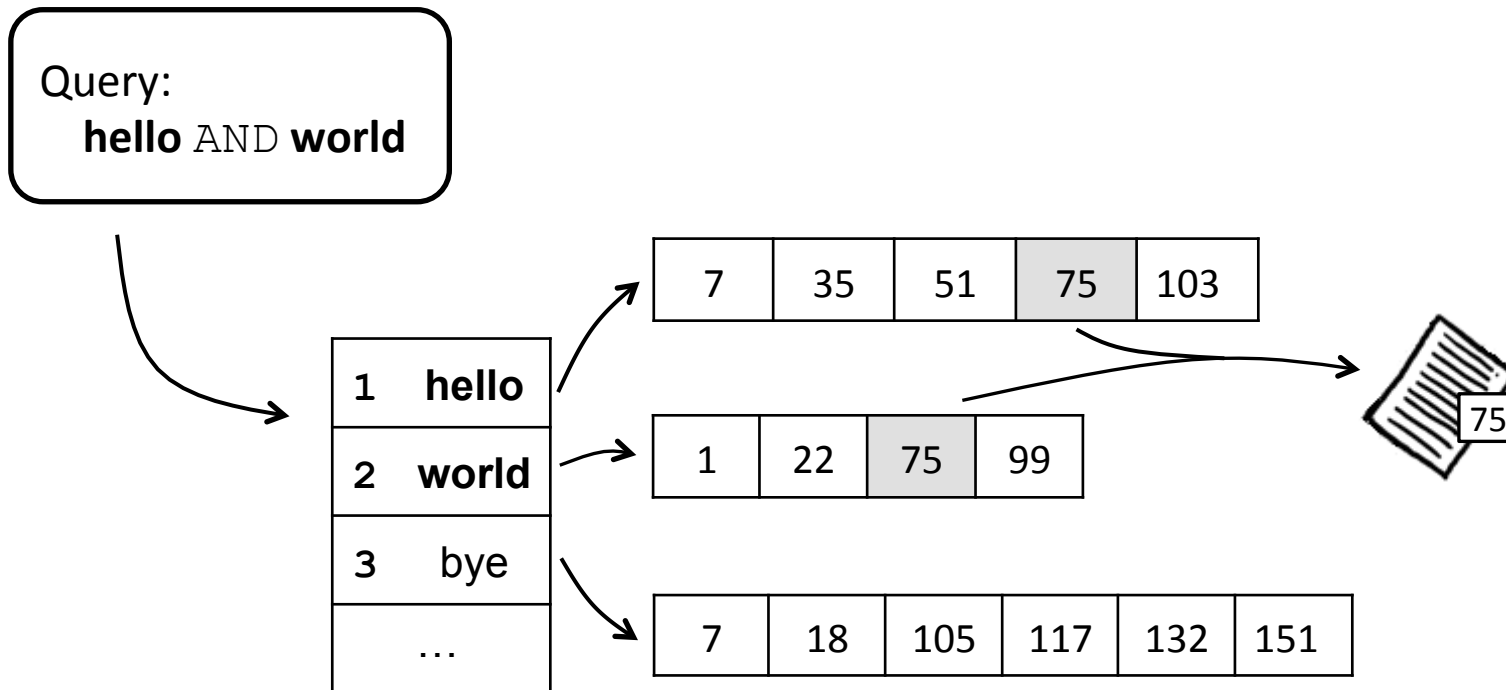
$f(t)$ is the document frequency of term t

K, k_1 are constants

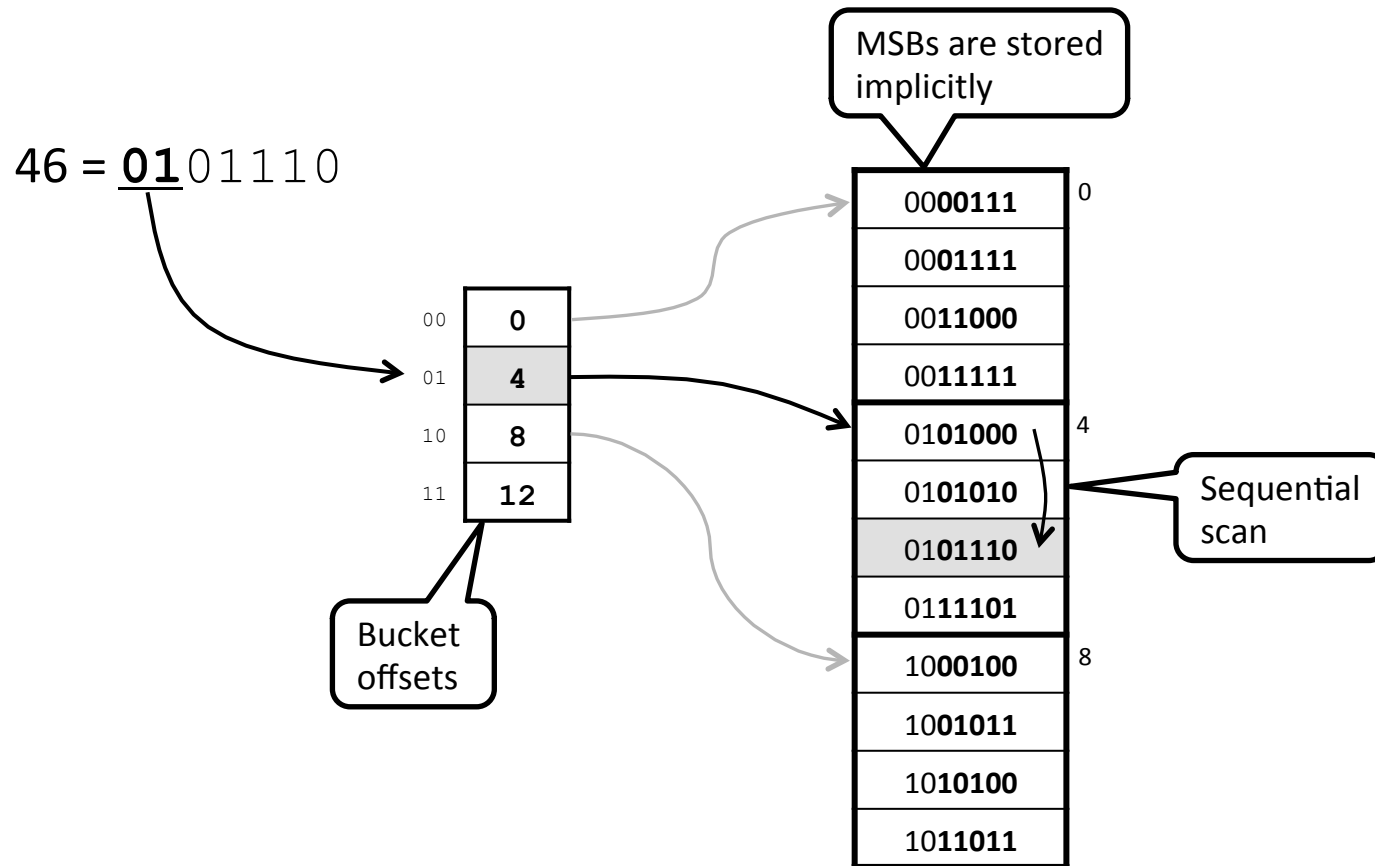
Indexing Process



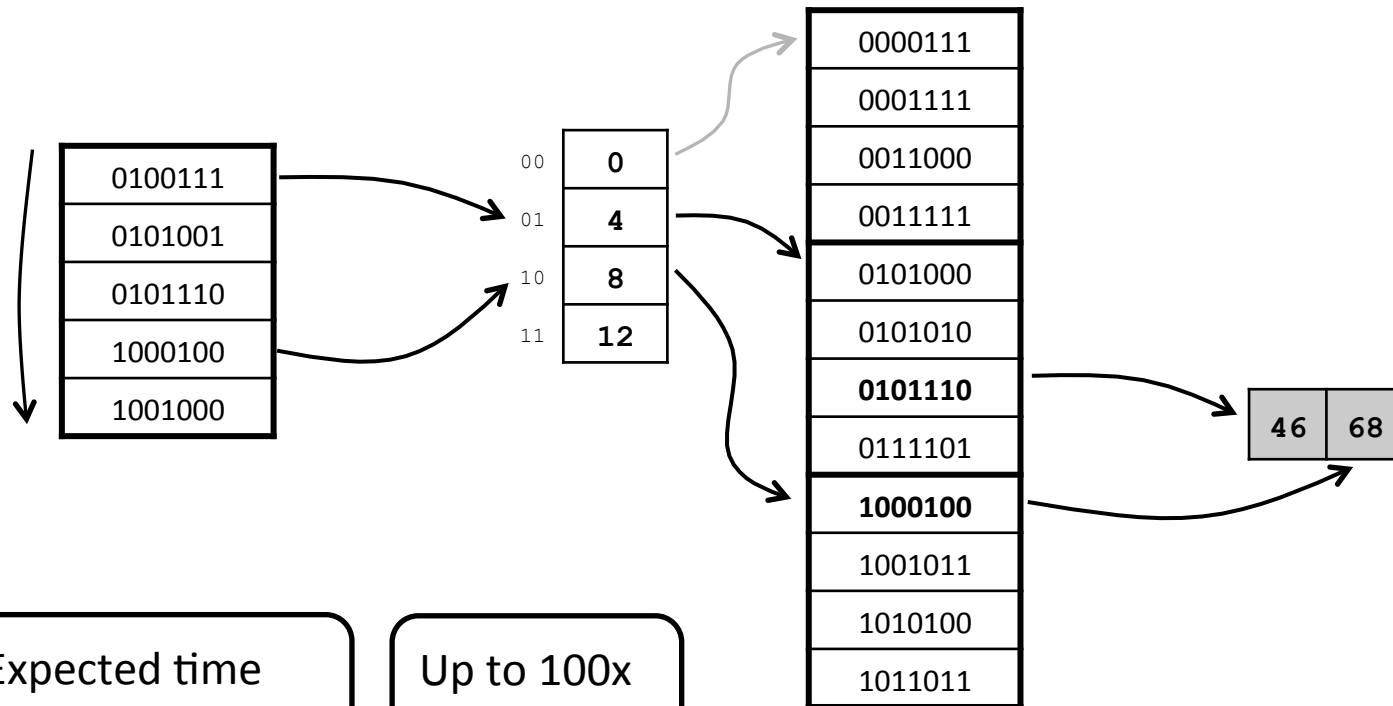
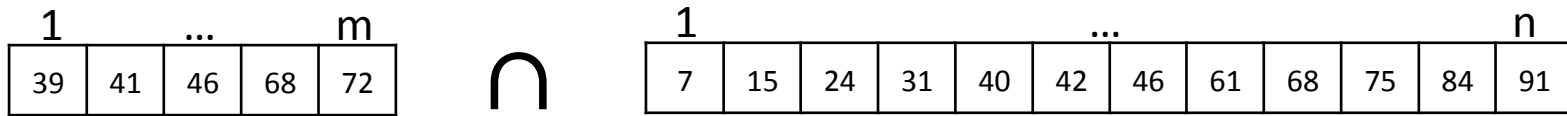
Inverted Index



Two-Level Inverted List



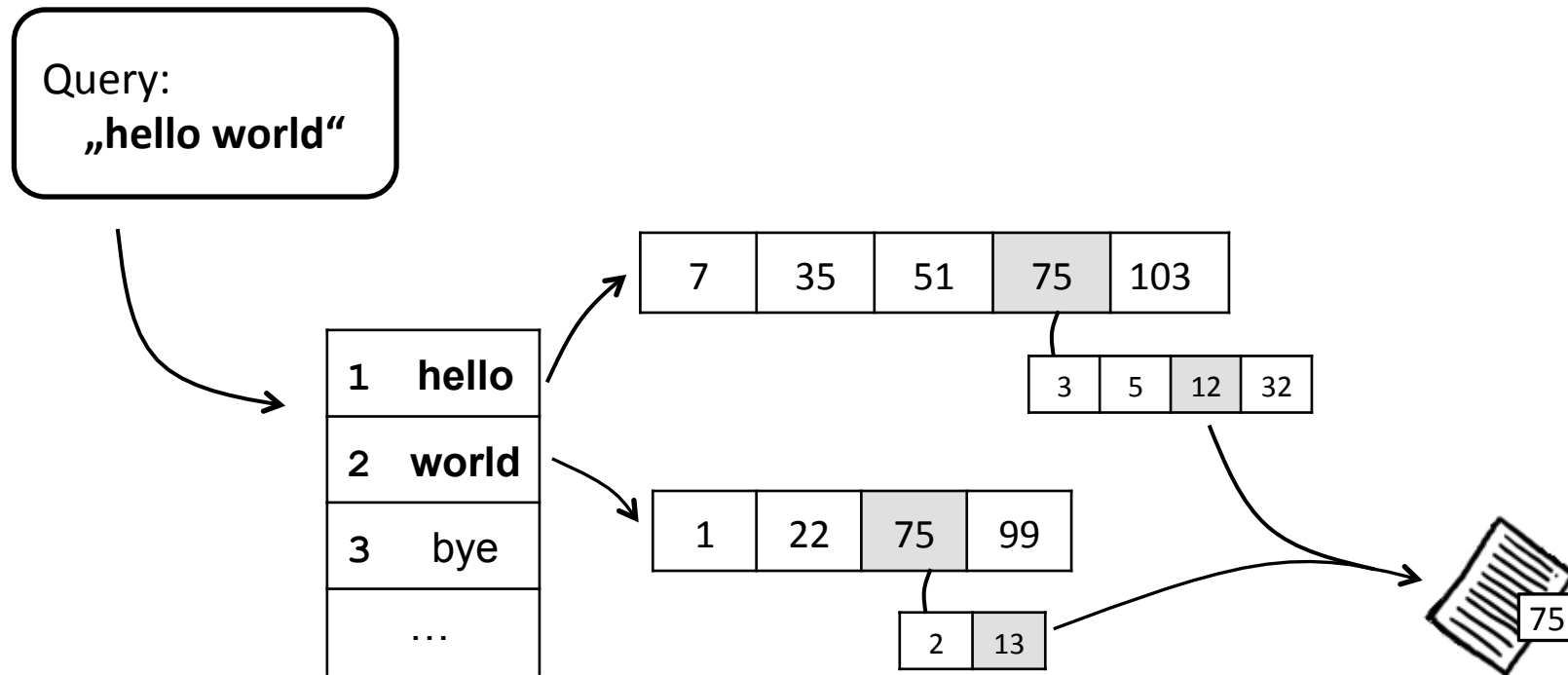
Inverted List Intersection



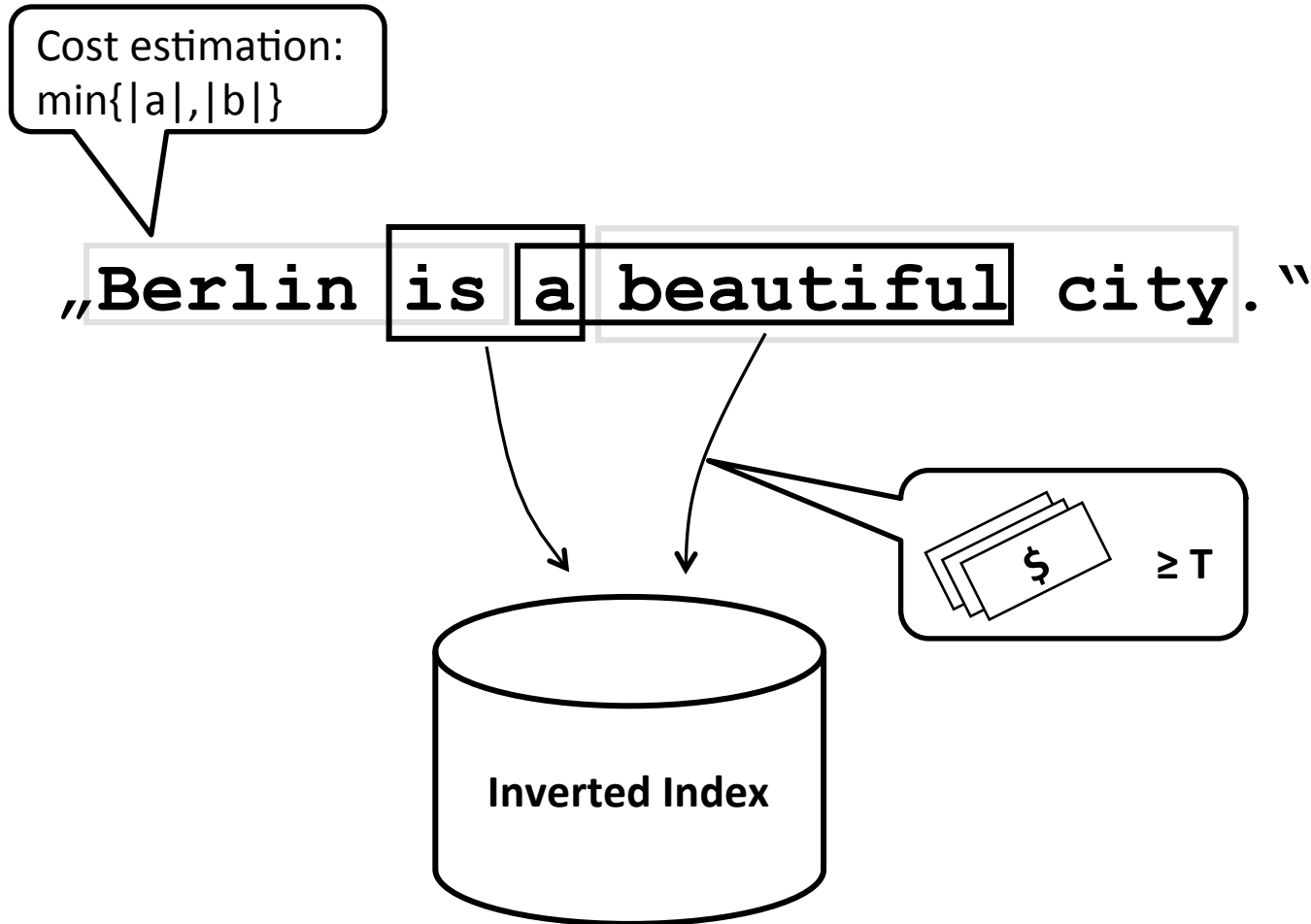
Expected time
 $O(m + \min\{n, Bm\})$

Up to 100x
 faster!

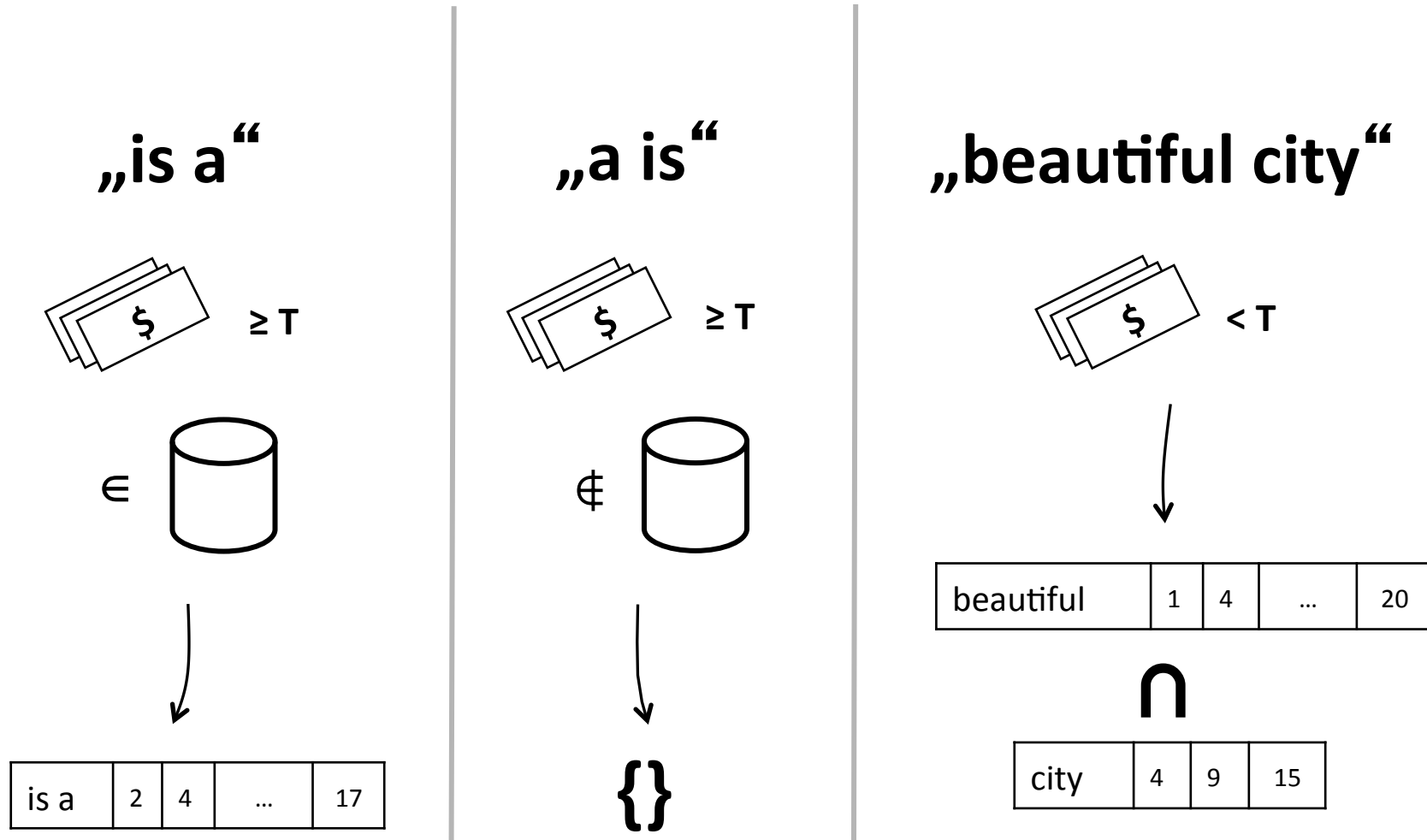
Phrase Search



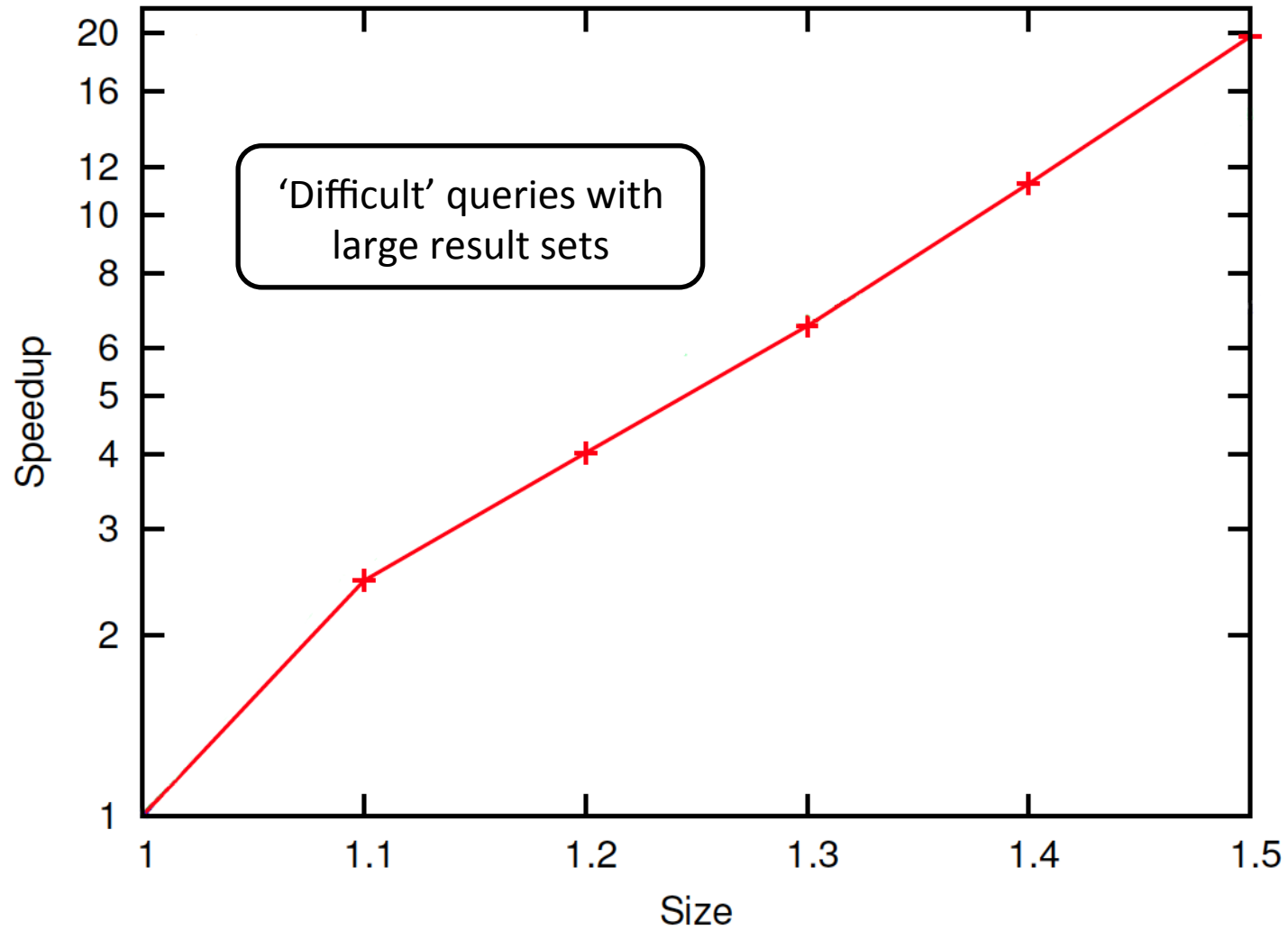
Two-Word Phrase Index



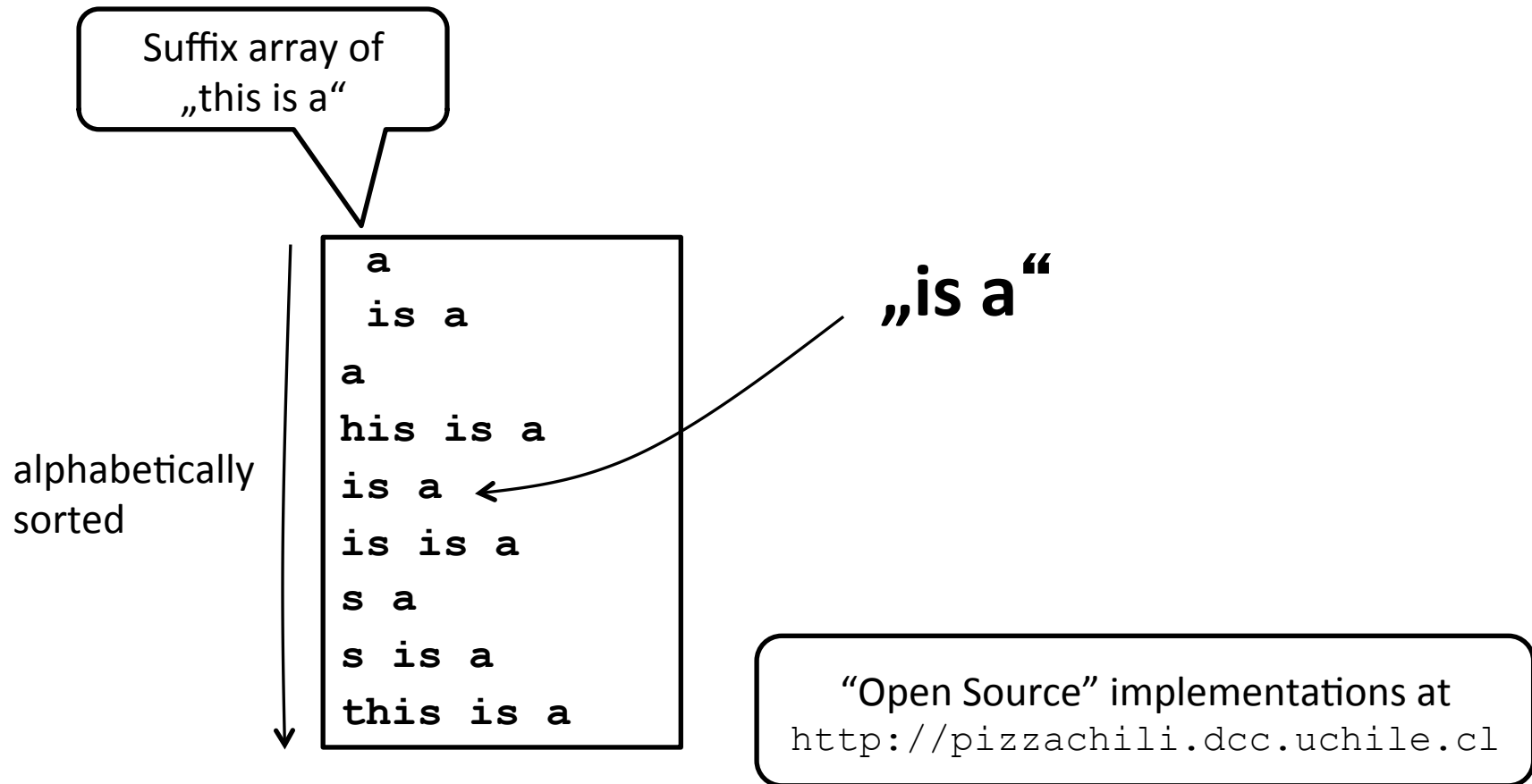
Querying the Phrase Index



Phrase Index: Speed-Up

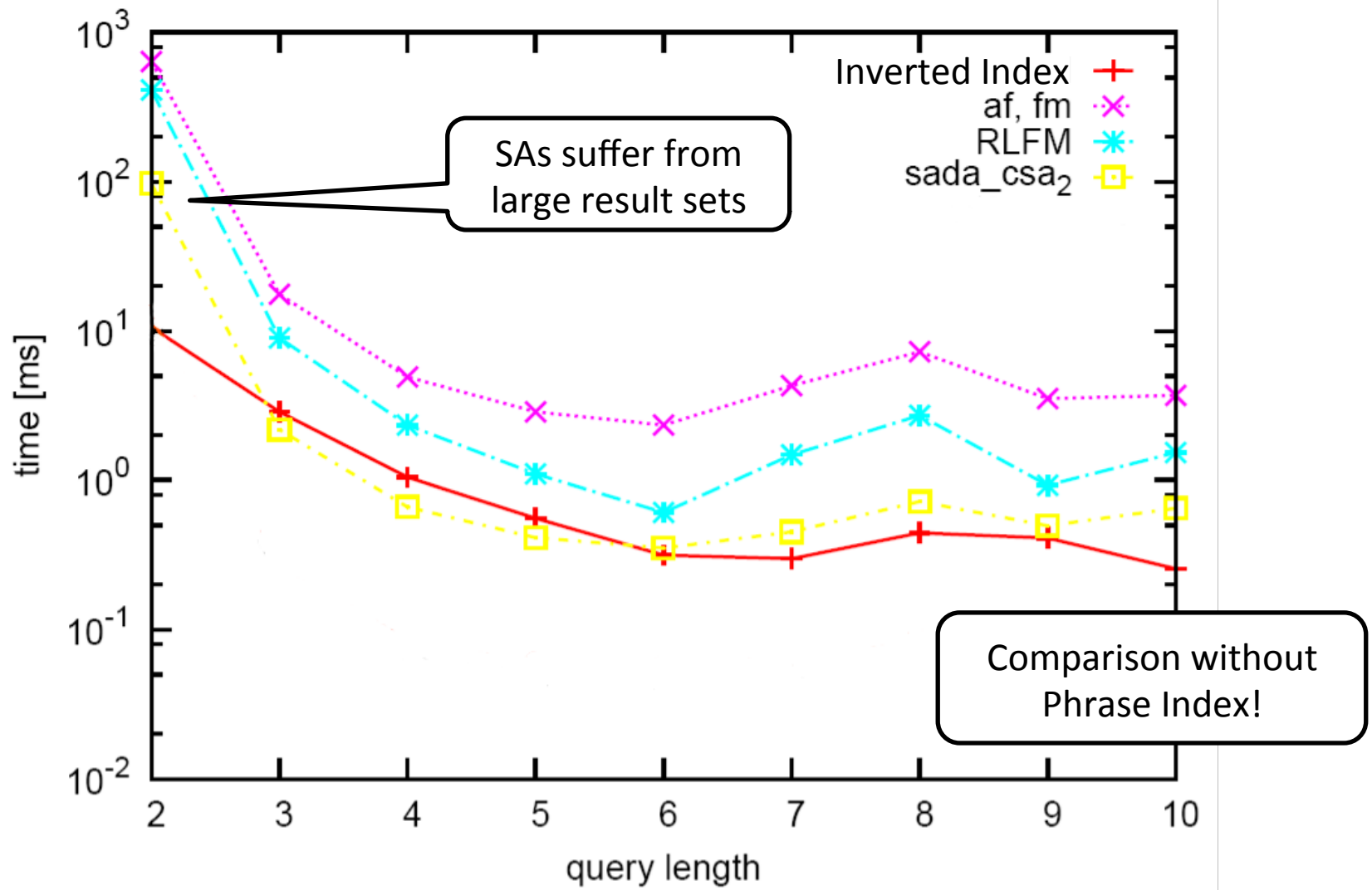


Suffix Arrays



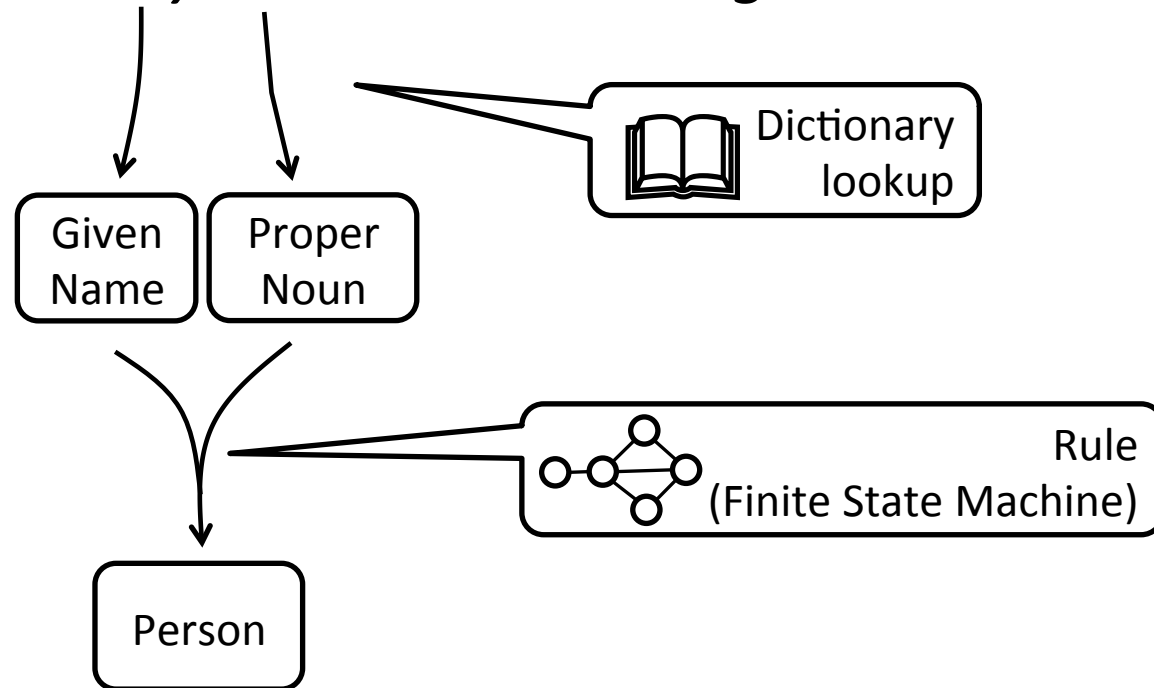
Phrase Search

Inverted Index vs. Suffix Arrays

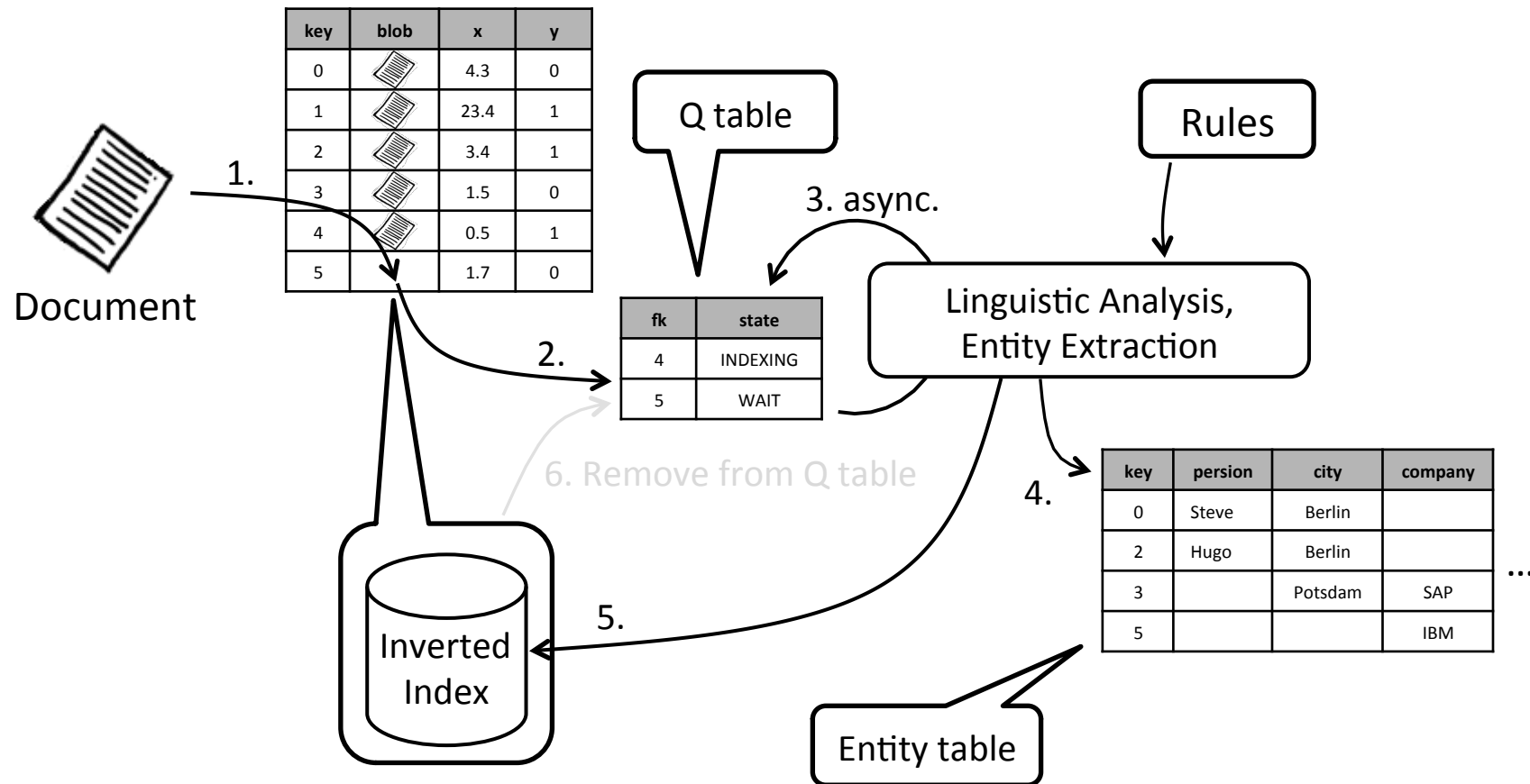


Text Analysis: Entity Extraction

"I saw Ricky Lake while visiting New York."



Indexing Unstructured Data



Entity tables

Multi-values

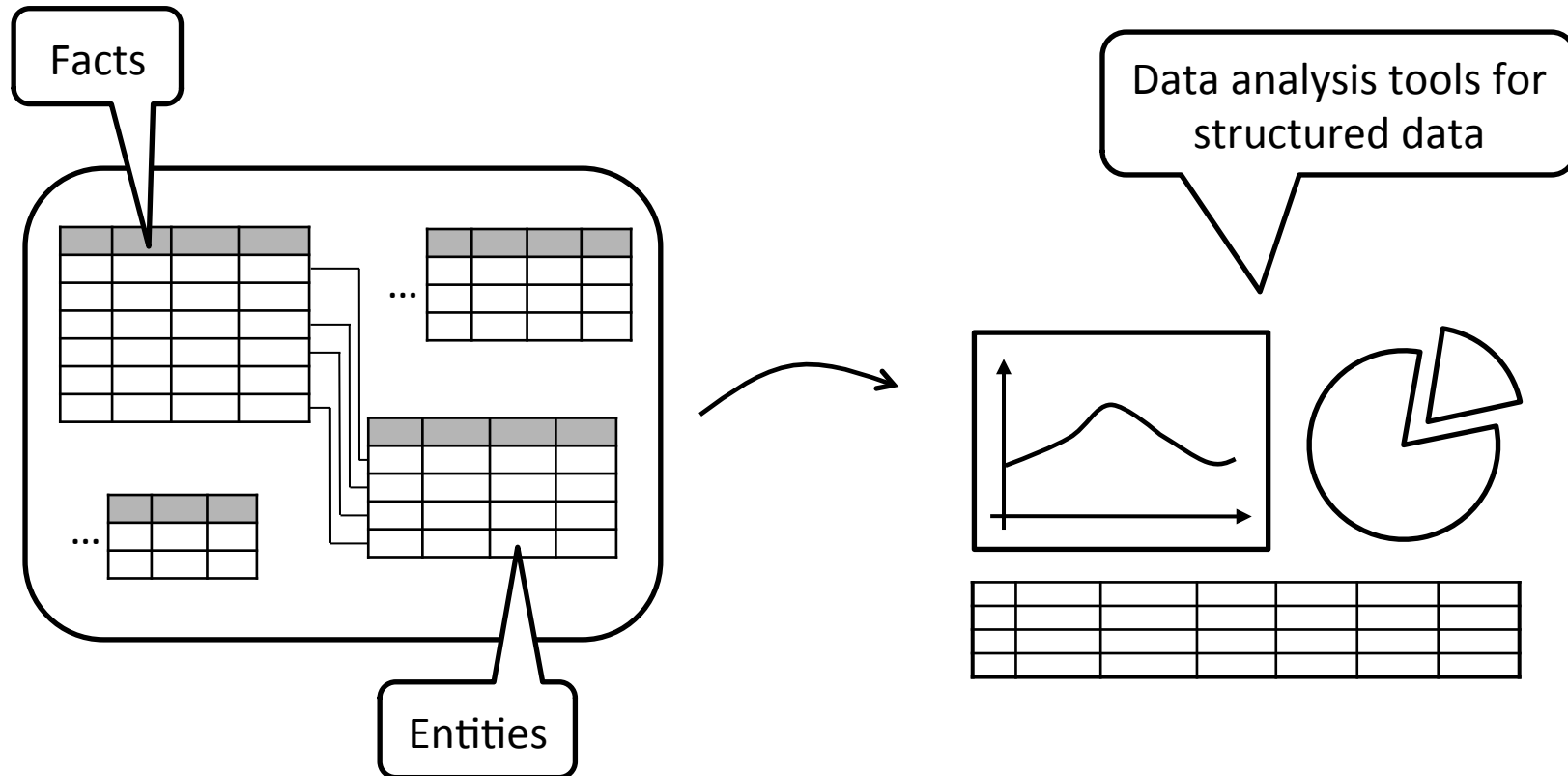
key	name	city	company
0	Steve	Berlin Potsdam	
2	Hugo Peter	Berlin	...
3		Potsdam	SAP
5			IBM Intel

Dynamic columns

Entity/value pairs

key	entity	value
0	name	Steve
0	city	Berlin
0	city	Potsdam
2	name	Hugo
2	name	Peter
2	city	Berlin
3	city	Potsdam
3	company	SAP
5	company	IBM
5	company	Intel

Analytical View combining Structured and Unstructured Data

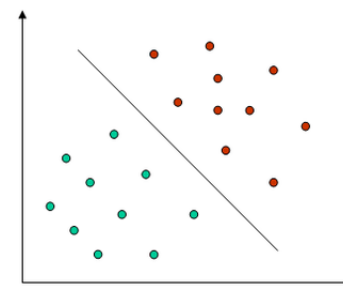
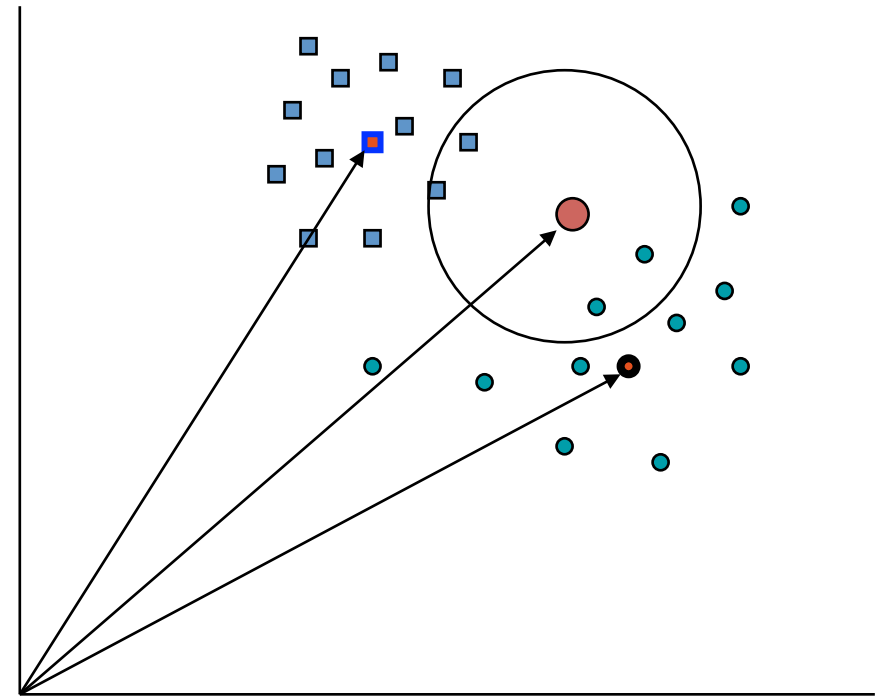


Property Table

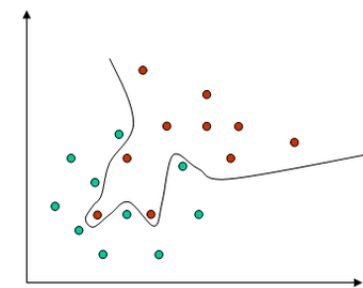
- Infinite number of fields
- Multi value support
- Included into relational model
- Field creation is a DML operation
- Internal optimization for efficient processing
- Support of range fields
- Validity support

Document Classification

- **KNN Classifier**
 - compute the k most similar documents to query document
 - compute class weights according to classes assigned to those k nearest neighbours
- **Simple Centroid Classifier**
 - compute centroid (average) vector for each class
 - compute similarity between query vector and centroids
- **Weighted Centroid Classifier**
 - Compute a weight for each document based on how well it distinguishes between classes
 - compute the weighted centroids
 - compute similarity between query vector and centroids
- **Kernel method**
 - support vector machine



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