Search Algorithms and Data Structures

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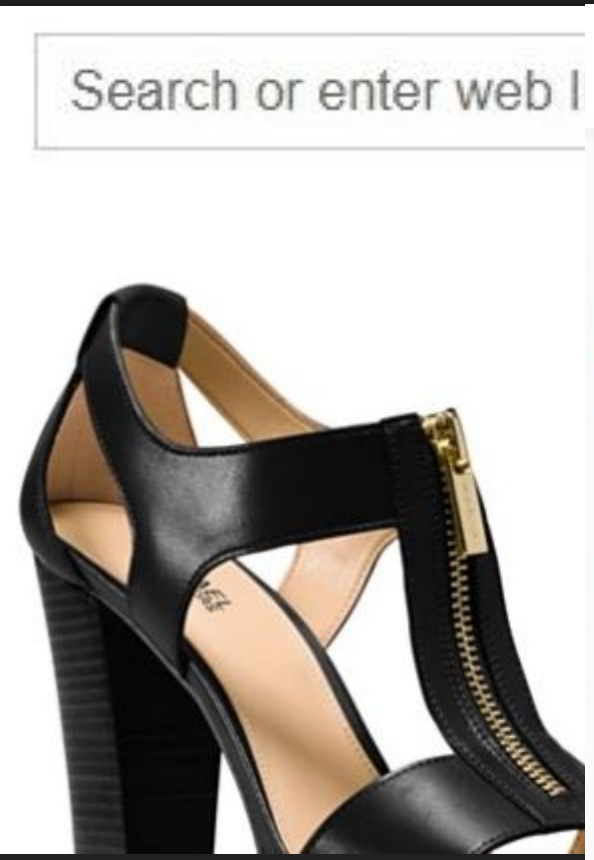
Khabarovsk'19

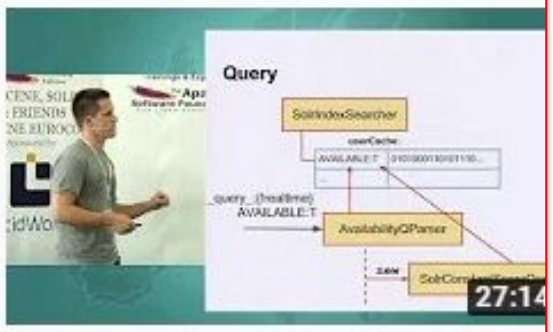
About Me



Search or enter web I

Mikhail

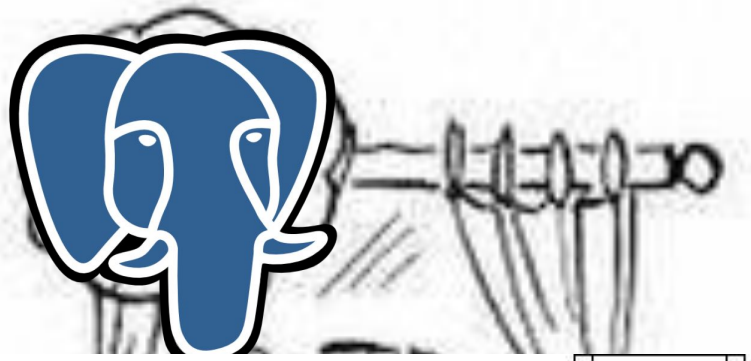
FILTER



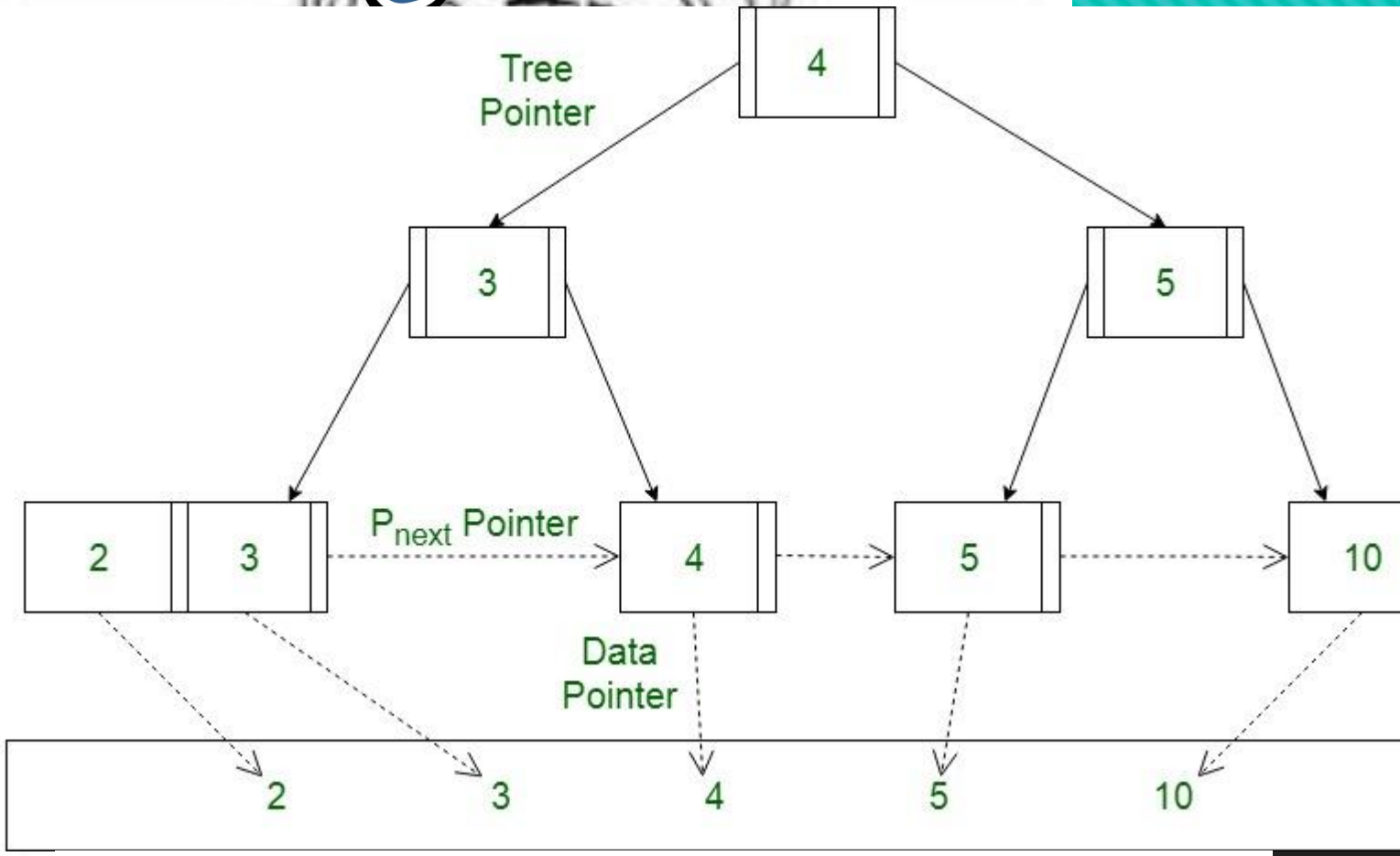
Indices: 3,705

Documents	87,310,395,558
Disk Usage	154.3 TB
Primary Shards	8,222
Replica Shards	13,124

RDBMS is …



Outcome					
ID	ESNum	Type	TxN	CgN	ES
100	1	1	24	24	-0.39
100	2	1	24	24	0
100	3	1	24	24	0.09
100	4	1	24	24	-1.05
100	5	1	24	24	-0.44
7049	1	2	30	30	0.34
7049	2	4	30	30	0.78
7049	3	1	30	30	0



https://www.geeksforgeeks.org/database-file-indexing-b-tree-introduction/

Composite Index

CREATE INDEX class_pos_index ON users **(class, position)**;

896 items in Heels & Pumps

Size

Heel Height

- Low 1-2" (120)
- Mid 2-3" (399)
- High 3-4" (415)
- Ultra High 4" & Over (157)

Heel Type

- Block (306)
- Cone (16)
- Kitten (117)
- Sculpted (10)
- Stacked (152)
- Stiletto (352)
- Wedge (42)

Brand

Search by brand

- Adrianna Papell (17)
- Adrienne Vittadini (8)
- Aerosoles (14)

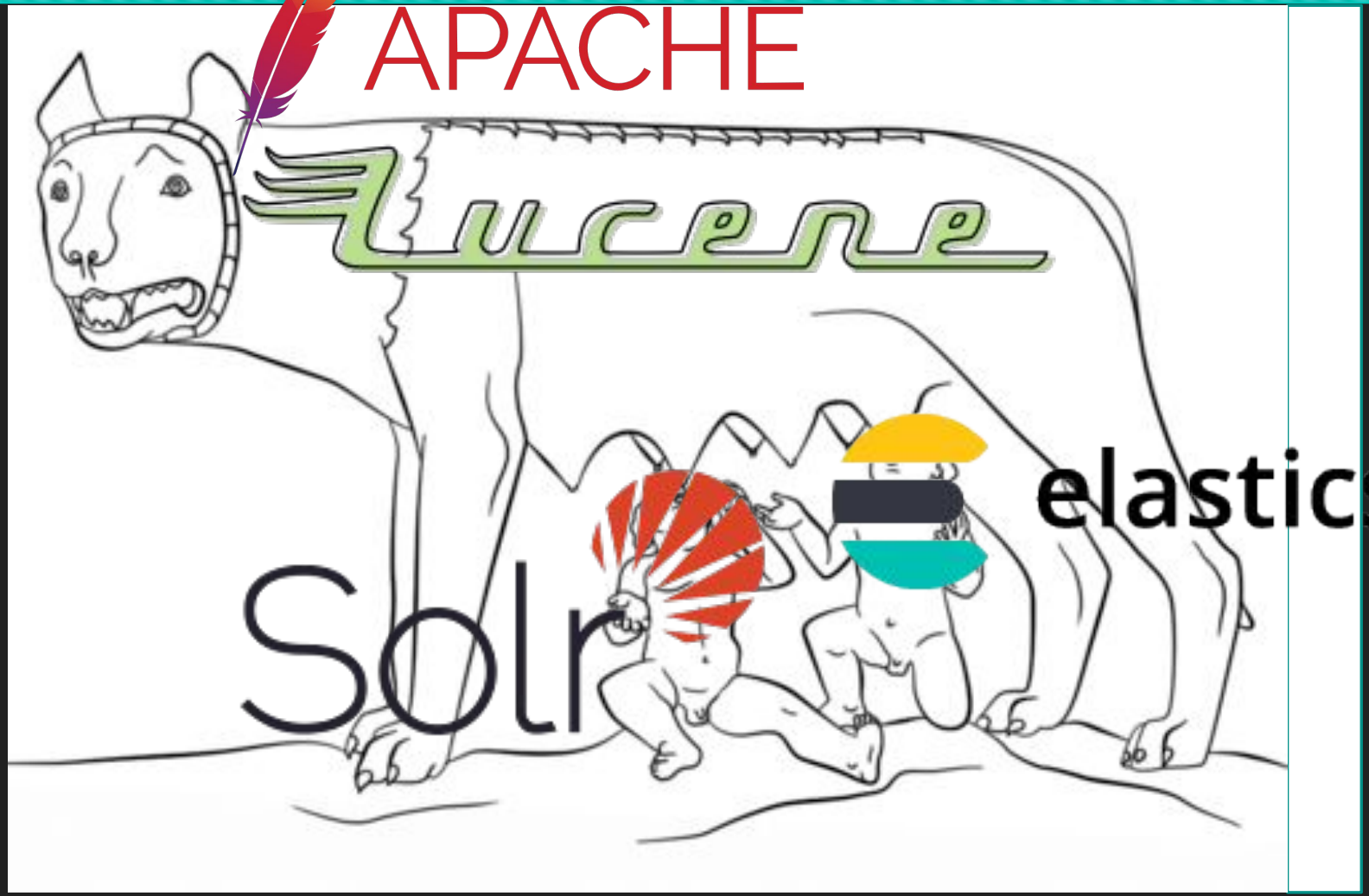
Free Pickup Today Macy's Jersey City

Extended Widths

MICHAEL Michael Kors Berkley T-Strap Platform

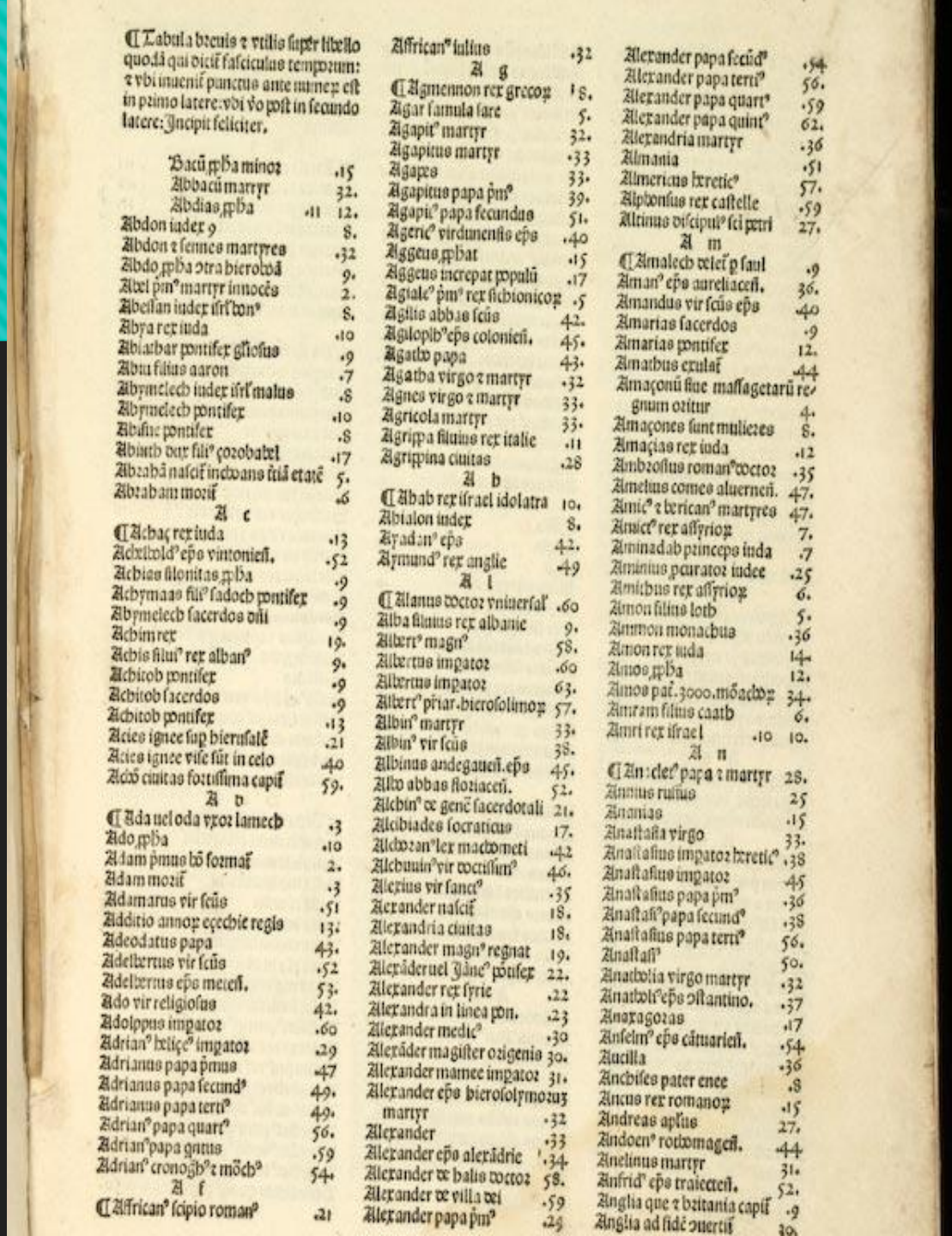
Inverted Index

Lucene, Solr and Elasticsearch



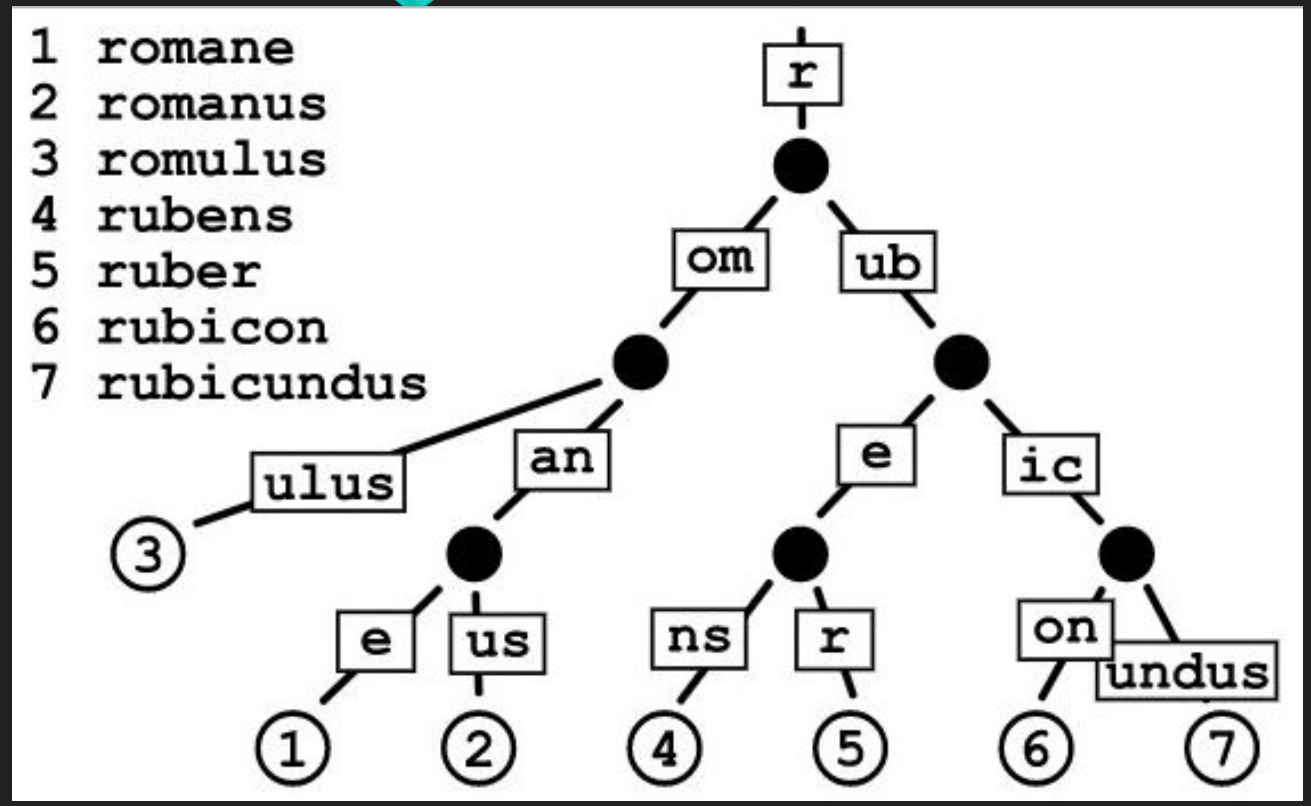
http://www.supercoloring.com/coloring-pages/romulus-and-remus-with-the-she-wolf.

The First Indices



¶ Tabula breuis ⁊ utilis super libello quodã qui dicit fasciculus temporum: ⁊ vbi inuenit punctus ante numer est in primo latere: vbi vo post in secundo latere: Incipit feliciter.

Term Dictionary

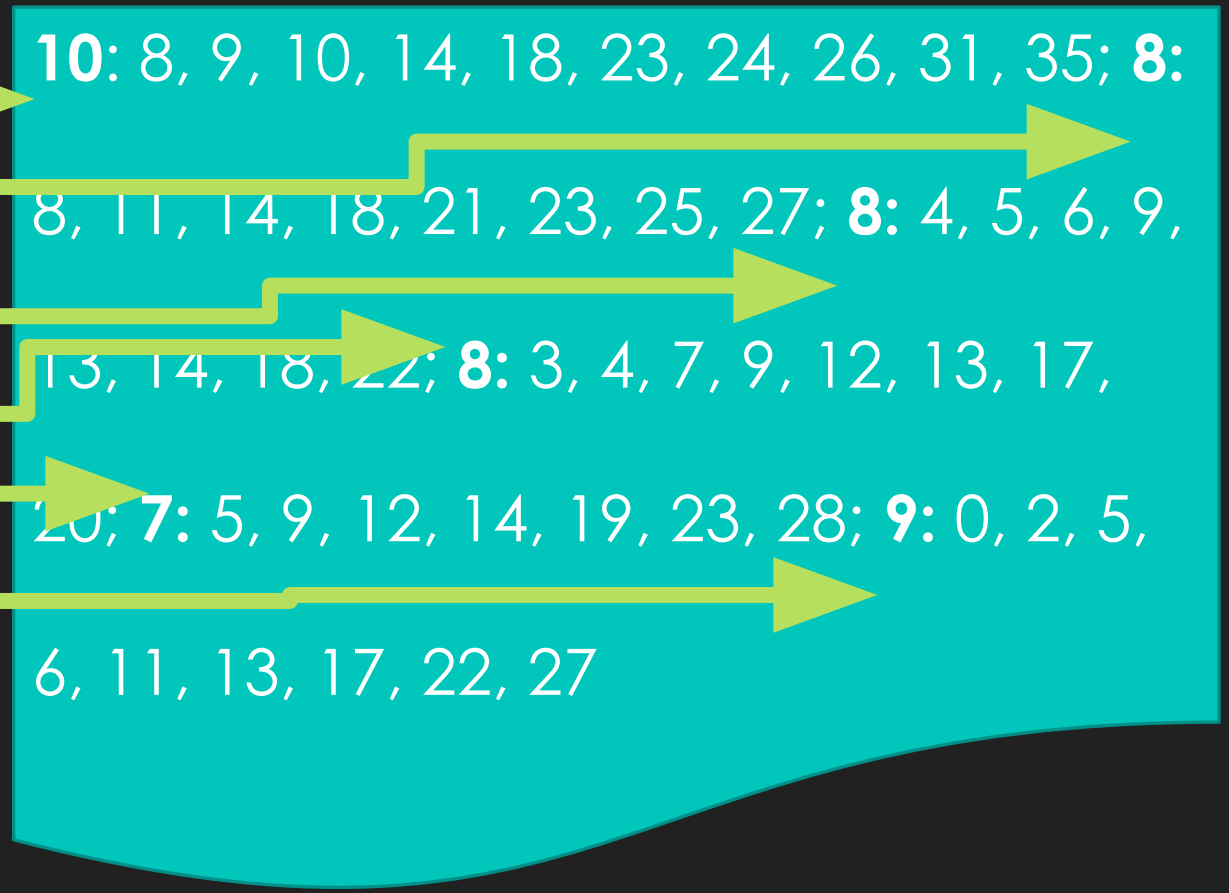


By Claudio Rocchini - Own work, CC BY 2.5, https://commons.wikimedia.org/w/index.php?curid=2118795

- rubens
- rub*
- [rome TO rustic]
- *uber
- *man*

Offsets to Postings List File

romane	0
romanus	23
romalus	78
rubens	124
rubicon	175
rubicundus	183

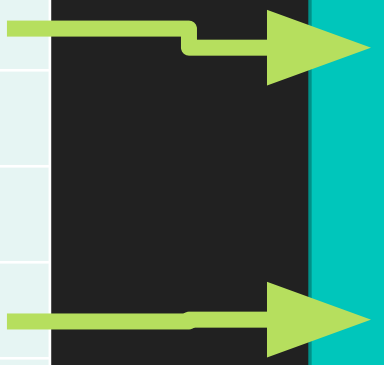


Postings Codecs

- delta 8, 9, 10, 14, 18, 23 => 1,1,1,4,4,5
- vint 5 => 00000101_2 129 => 10000001_2 00000001_2
- PFOR 001_2 001_2 001_2 100_2 100_2 101_2

Query Execution

romane	0
romanus	**23**
romalus	78
rubens	124
rubicon	**175**
rubicundus	183



8, 9, 10, 14, 18, 23, 24, 26, 31, 35

8, 11, 14, 18, 21, 23, 25, 27

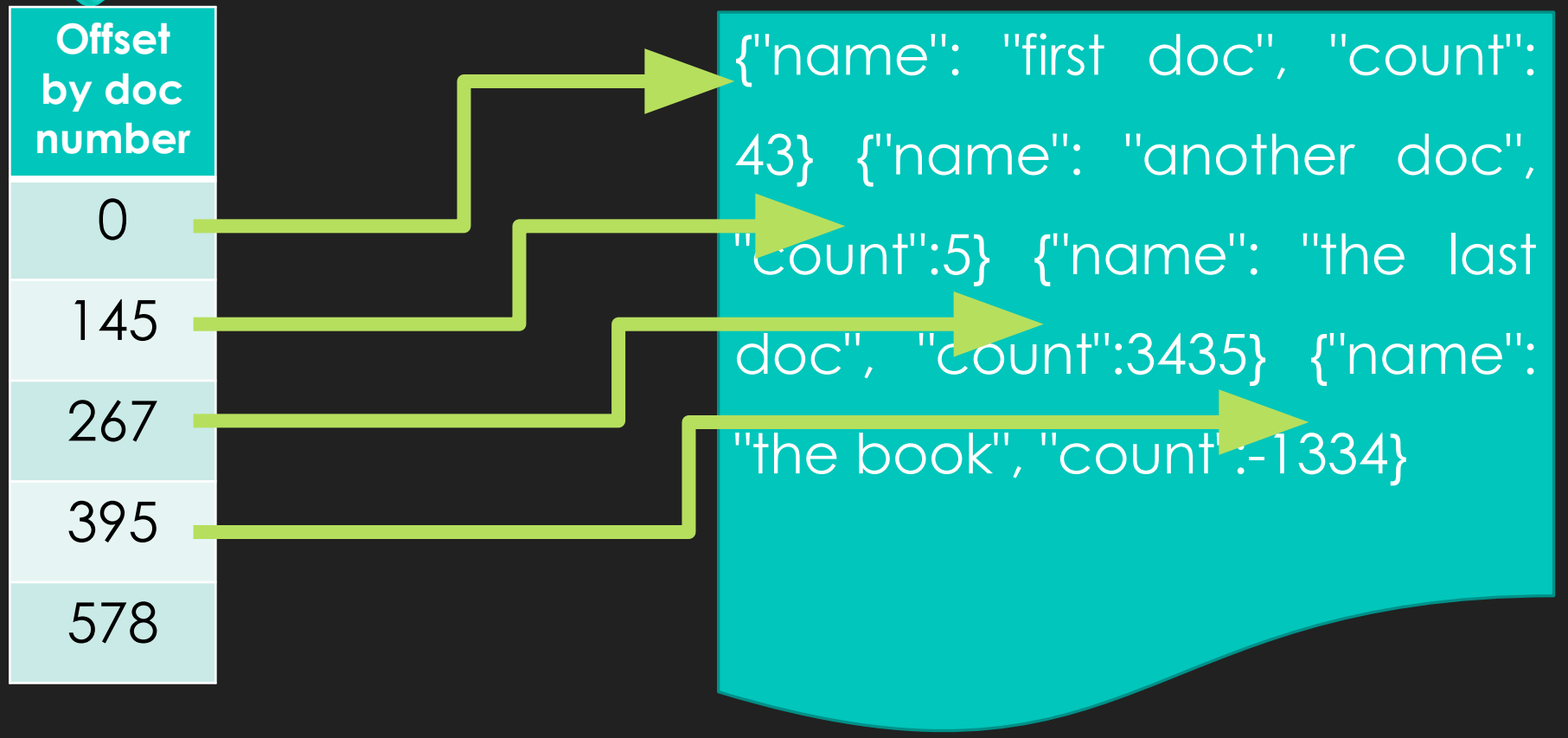
4, 5, 6, 9, 13, 14, 18, 22

3, 4, 7, 9, 12, 13, 17, 20

5, 9, 12, 14, 19, 23, 28

0, 2, 5, 6, 11, 13, 17, 22, 27

Stored Field Retrieval



Indexing

Index Document

PUT localhost:9200/twitter/tweet/1

Authorization Headers (1) Body Pre-request Script Tests

form-data x-www-form-urlencoded raw binary JSON (application/json)

```
{
    "user" : "kimchy",
    "post_date" : "2009-11-15T14:12:12",
    "message" : "trying out Elasticsearch"
}
```

Mapping

PUT localhost:9200/my_index

Authorization Headers (1) Body Pre-request Script Tests

form-data x-www-form-urlencoded raw binary JSON (application/json)

```
{
  "mappings": {
    "properties": {
      "title":    { "type": "text"  },
      "name":     { "type": "text"  },
      "age":      { "type": "integer" },
      "created":  {
        "type":   "date",
        "format": "strict_date_optional_time||epoch_millis"
      }
```

Analysis

curl -X PUT "localhost:9200/my_index" -H 'Content-Type: application/json' -d'

{ "settings": { "analysis": {

"analyzer": {

"**my_custom_analyze**r": { "type": "custom",

"tokenizer": "standard",

"**filter**": [

"**lowercase**"

]

} } } }

In-memory Buffer

```
{
    "user" : "kimchy",
     "message" : "trying out
                  Elasticsearch"
}
```

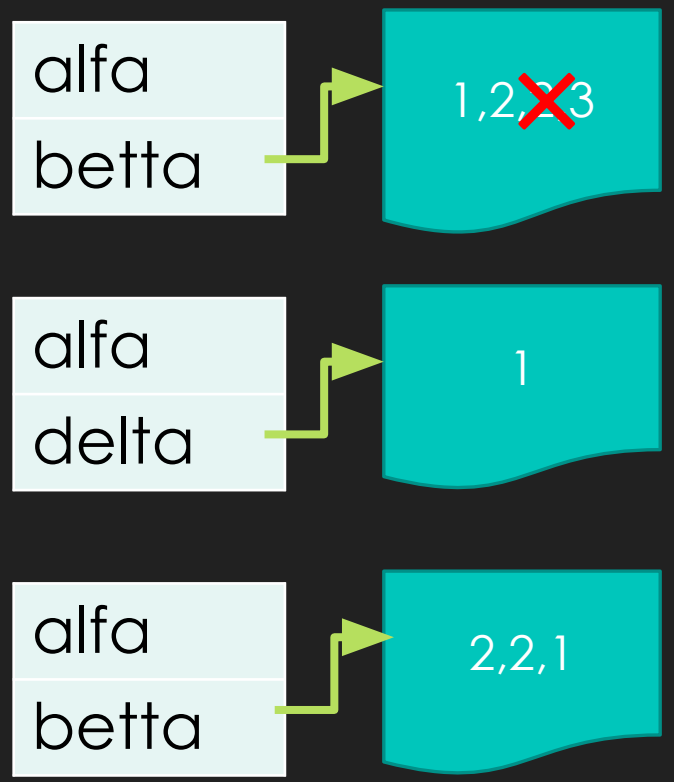
user

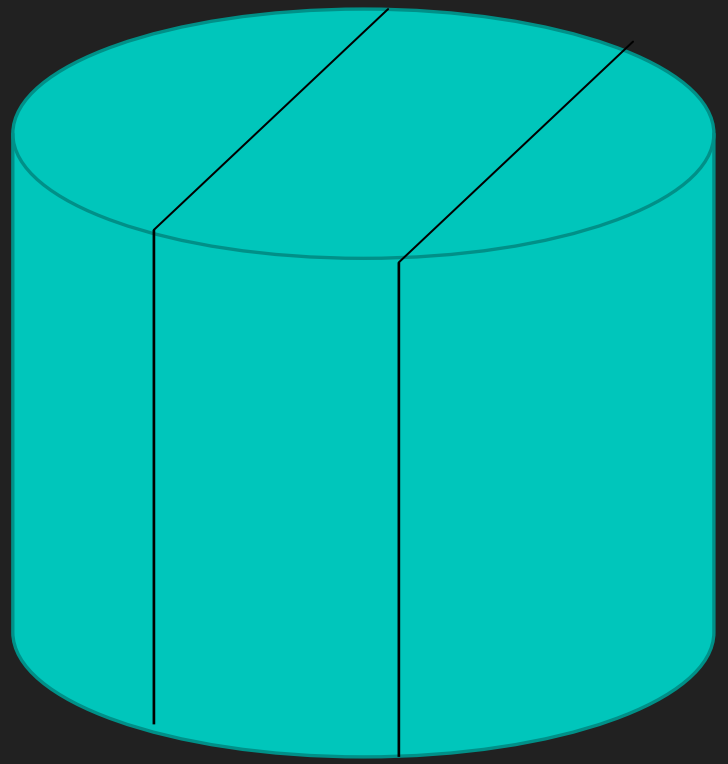
kimchy	1	…

message

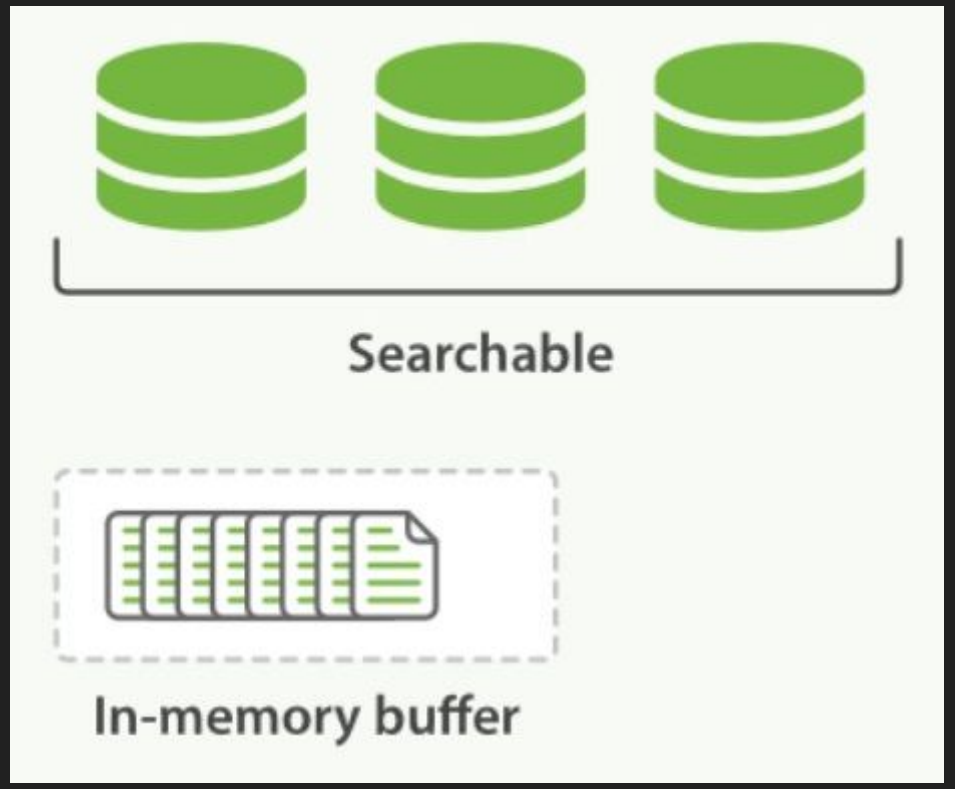
elasticsearch	1	…
trying	1	…
out	1	…

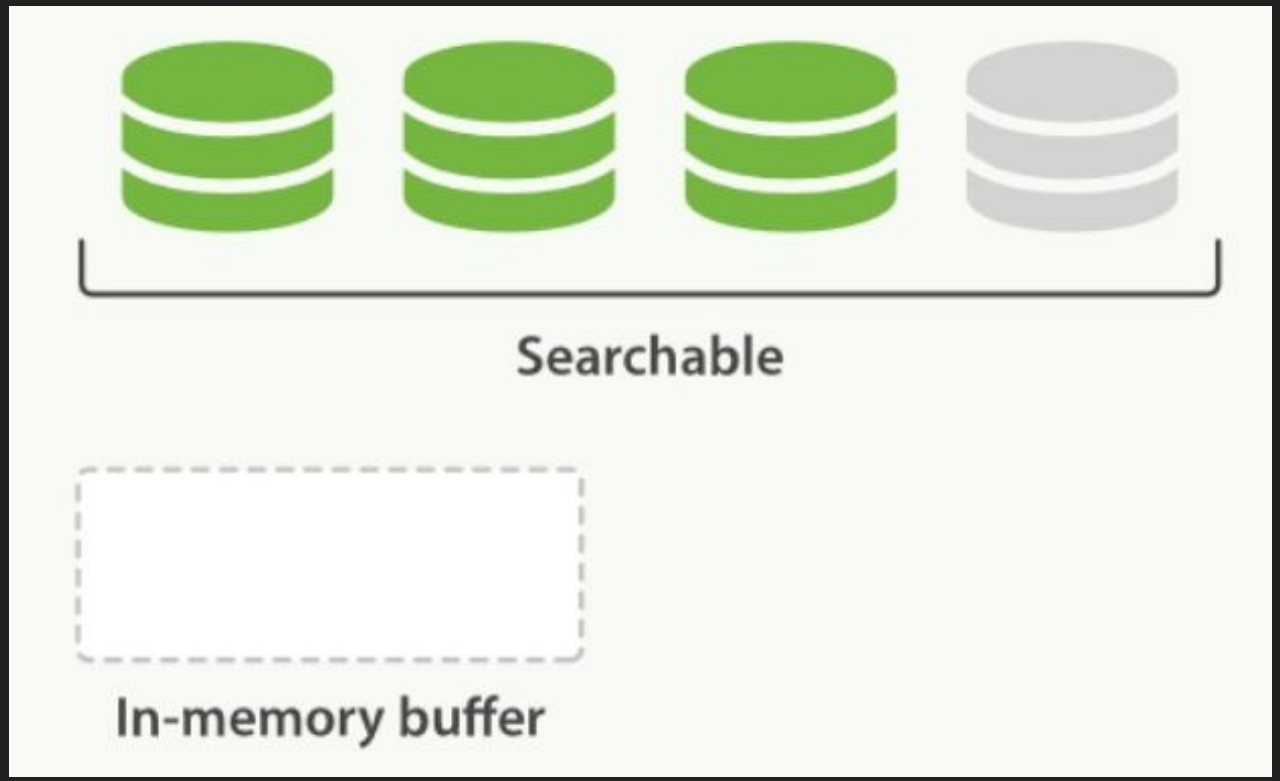
Segments



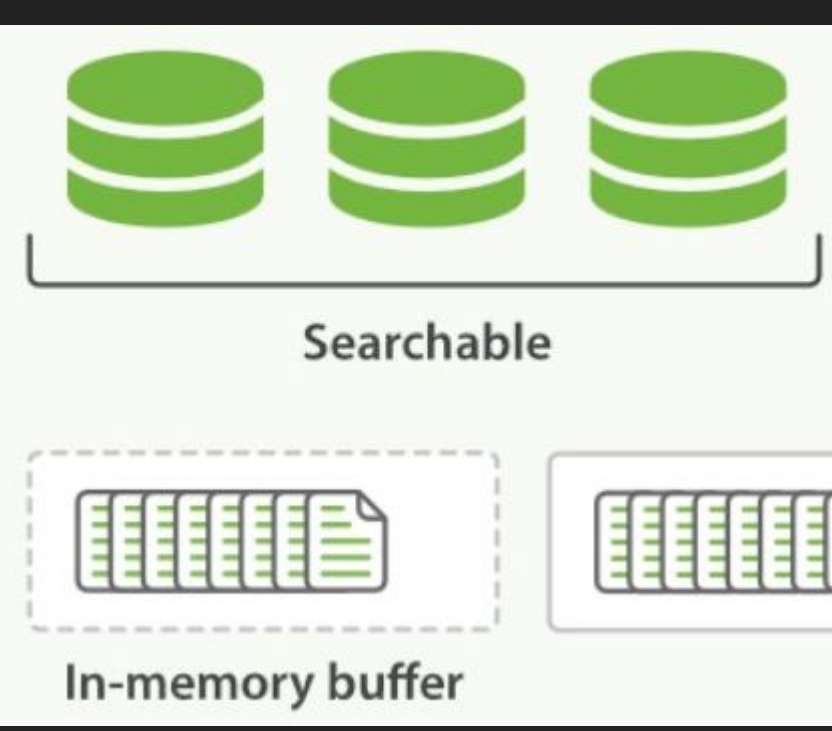


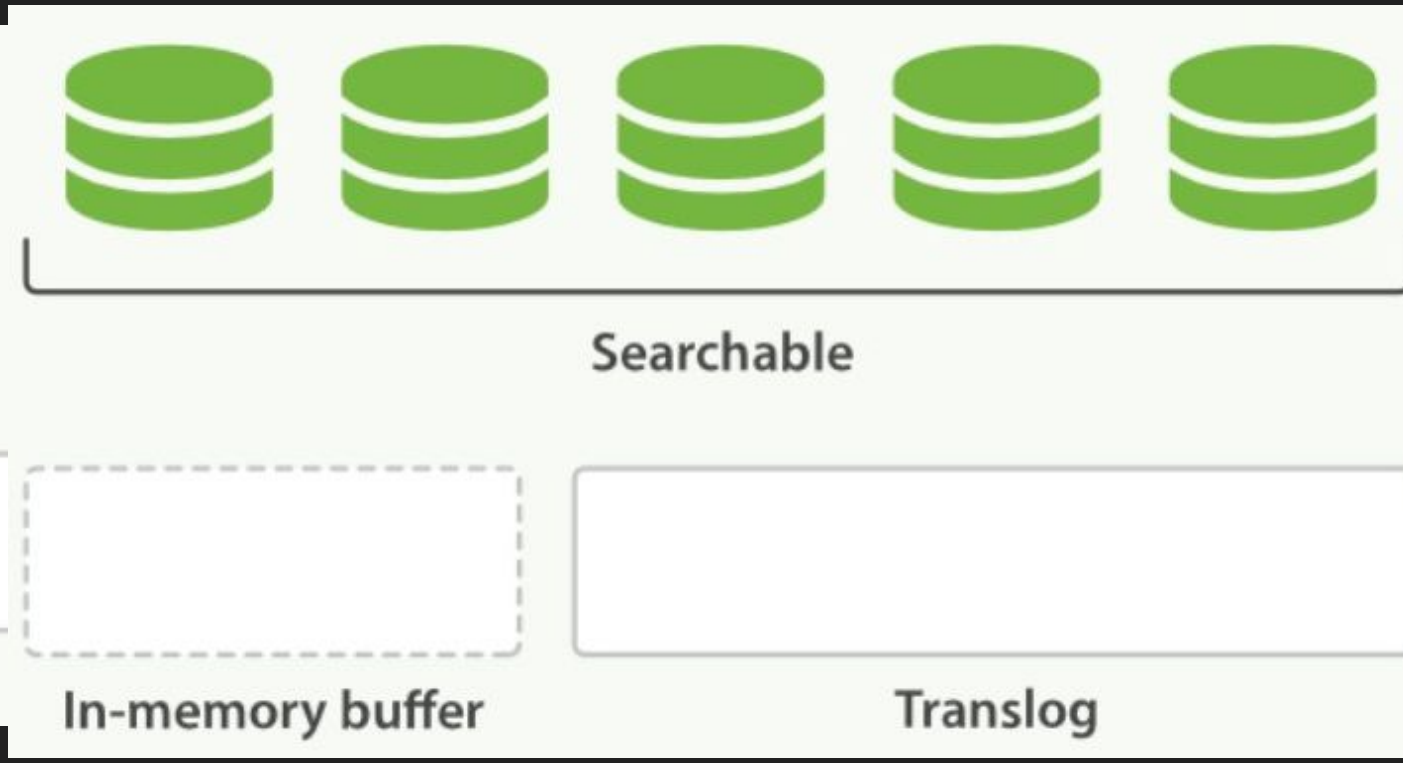
_refresh





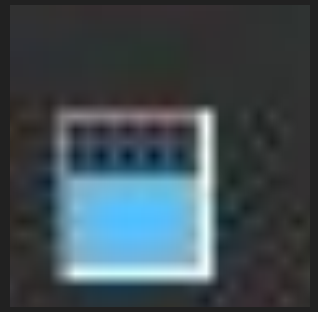
_refresh vs _flush





Elasticsearch: The De□nitive Guide

Indexing Performance



- _bulk
- Threads
- ETL is hard

Searching

Result Page


```
    "failed" : 0
  },
  "hits":{
    "total" : {
      "value": 23539,
      "relation": "eq"
    },
    "max_score": 1.3862944,

    "hits" : [
      {
        "_index" : "twitter",
        "_type" : "_doc",
        "_id" : "0",
        "_score": 1.3862944,
        "_source" : {
          "user" : "kimchy",
          "date" : "2009-11-15T14:12:12",
          "message" : "trying out Elasticsearch",
          "likes": 0
        }
```

Result Page Cropping

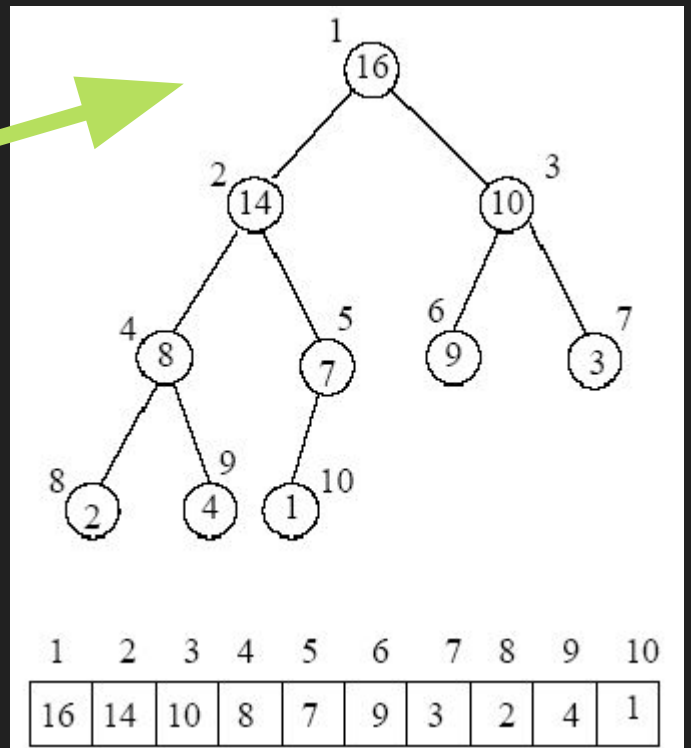
10: 8, 9, 10, 14, 18, 23, 24, 26,

31, 35; **8:** 8, 11, 14, 18, 21, 23,

25, 27; **8:** 4, 5, 6, 9, 13, 14, 18,

28; **8:** 3, 4, 7, 9, 12, 13, 17, 20;

U



O(n log (p))

http://www.cse.hut.fi/en/research/SVG/TRAKLA2/tutorials/heap_tutorial/taulukkona.html

Электроника • Телефоны и аксессуары к ним • Мобильные телефоны

Мобильные телефоны

Сортировать: по по цене меру скидки по новизне Сначала предложения в моём

Телефон Digma LINX A105N 2G

390 ₽

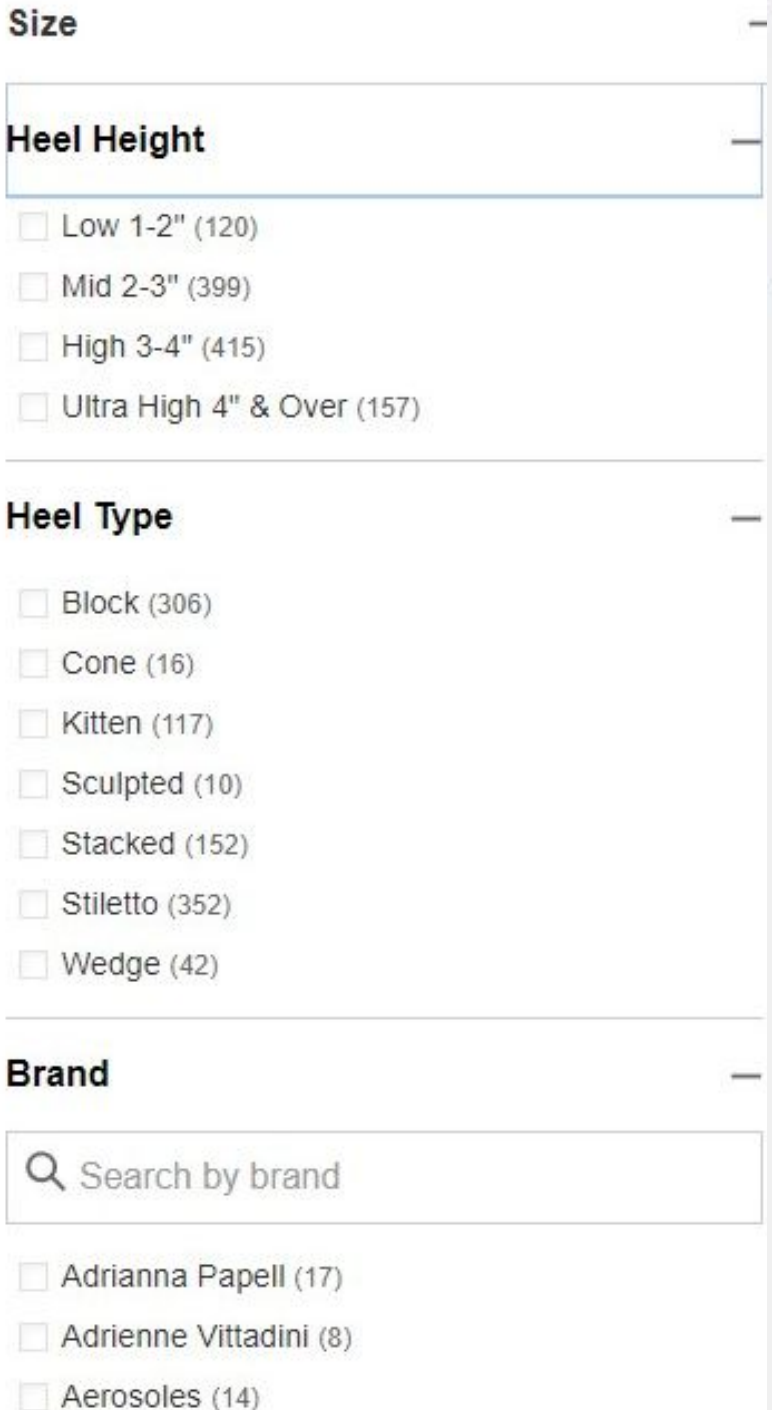
Телефон Ji

390 ₽

Телефон Digma LINX A105 2G

396 ₽

Price by Doc Number
390
4466
12453
390
2342
390
390
2341




```
{
    "aggs" : {
        "genres" : {
            "terms" : { "field" : "genre" } ❶
{
    ...
    "aggregations" : {
        "genres" : {
            "doc_count_error_upper_bound": 0, ❶
            "sum_other_doc_count": 0, ❷
            "buckets" : [ ❸
                {
                    "key" : "electronic",
                    "doc_count" : 6
                },
                {
                    "key" : "rock",
                    "doc_count" : 3
                },
                {
                    "key" : "jazz",
                    "doc_count" : 2
```

https://www.elastic.co/guide/en/elasticsearch/reference/current/search-aggregations-bucket-terms-aggregation.html

Real Life Usage

68 hits

New Save Open Share Reporting Last 15 minutes

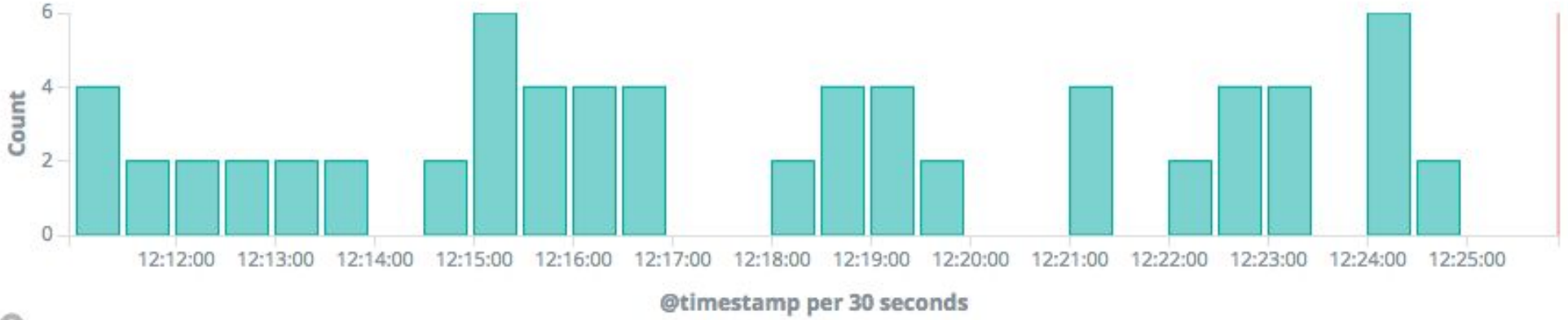
type: http AND http.code: 302

Uses lucene query syntax

Add a filter +

packetbeat-*

March 14th 2018, 12:10:55.313 - March 14th 2018, 12:25:55.313 — Auto



Selected Fields

? _source

Available Fields

@timestamp
t _id
t _index
_score
t _type
bytes_out
t client_ip
client_location
client_port
t client_server
count

Time	_source
March 14th 2018, 12:24:59.000	type: http status: Error client_ip: 127.0.0.1 http.content_length: 209 http.phrase: FOUND http.code: 302 http.response_headers.content_type: text/html; charset=utf-8 http.request_headers.host: packetbeat.com timestamp: February 10th 2014, 11:27:38.276 @timestamp: March 14th 2018, 12:24:59.000 client_port: 56,341 query: GET /logout HTTP/1.1 path: /logout server: app.server4 response: HTTP/
March 14th 2018, 12:24:59.000	type: http status: Error client_ip: 186.216.161.91 http.content_length: 209 http.phrase: FOUND http.code: 302 http.response_headers.content_type: text/html; charset=utf-8 http.request_headers.host: packetbeat.com timestamp: February 10th 2014, 11:27:38.276 @timestamp: March 14th 2018, 12:24:59.000 client_port: 56,341 query: GET /logout HTTP/1.1 path: /logout server: nginx-proxy2 response:

Scaling

Original Table

CUSTOMER ID	FIRST NAME	LAST NAME	FAVORITE COLOR
1	TAEKO	OHNUKI	BLUE
2	O.V.	WRIGHT	GREEN
3	SELDA	BAĞCAN	PURPLE
4	JIM	PEPPER	AUBERGINE

Vertical Partitions

VP1

CUSTOMER ID	FIRST NAME	LAST NAME
1	TAEKO	OHNUKI
2	O.V.	WRIGHT
3	SELDA	BAĞCAN
4	JIM	PEPPER

VP2

CUSTOMER ID	FAVORITE COLOR
1	BLUE
2	GREEN
3	PURPLE
4	AUBERGINE

Horizontal Partitions

HP1

CUSTOMER ID	FIRST NAME	LAST NAME	FAVORITE COLOR
1	TAEKO	OHNUKI	BLUE
2	O.V.	WRIGHT	GREEN

HP2

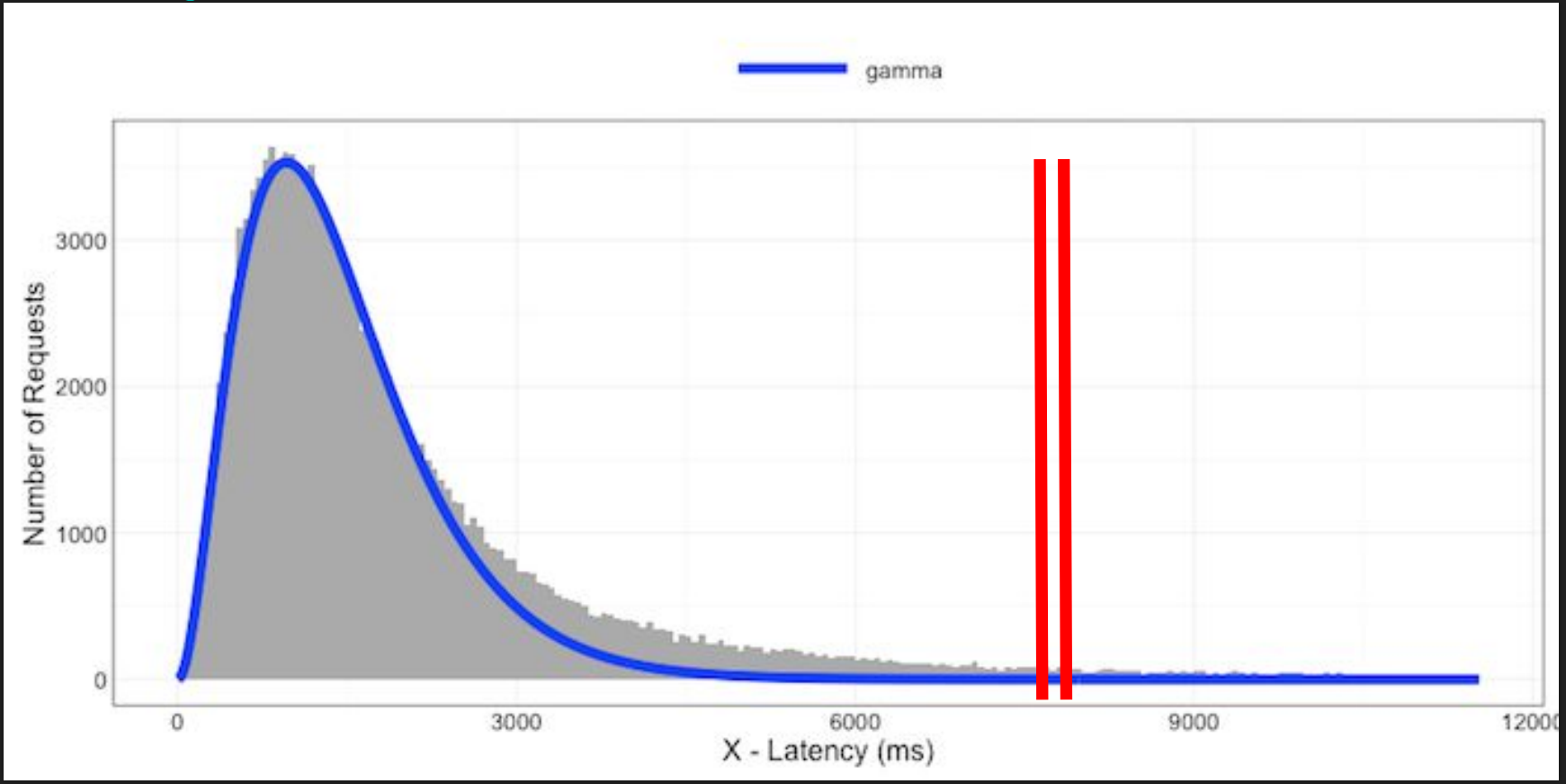
CUSTOMER ID	FIRST NAME	LAST NAME	FAVORITE COLOR
3	SELDA	BAĞCAN	PURPLE
4	JIM	PEPPER	AUBERGINE

https://www.digitalocean.com/community/tutorials/understanding-database-sharding

Summary

- Why search?
- Inverted Index
- Indexing
- Searching
- Scaling
- ELK

200 threads

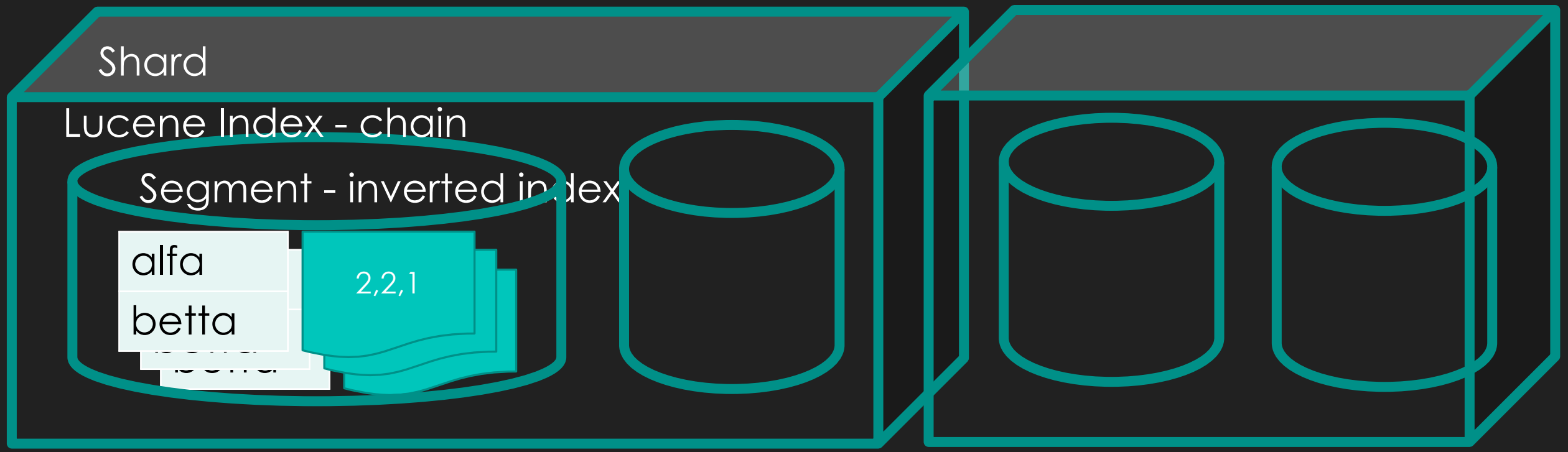


https://blog.newrelic.com/engineering/expected-distributions-website-response-times/

Index Hierarchy

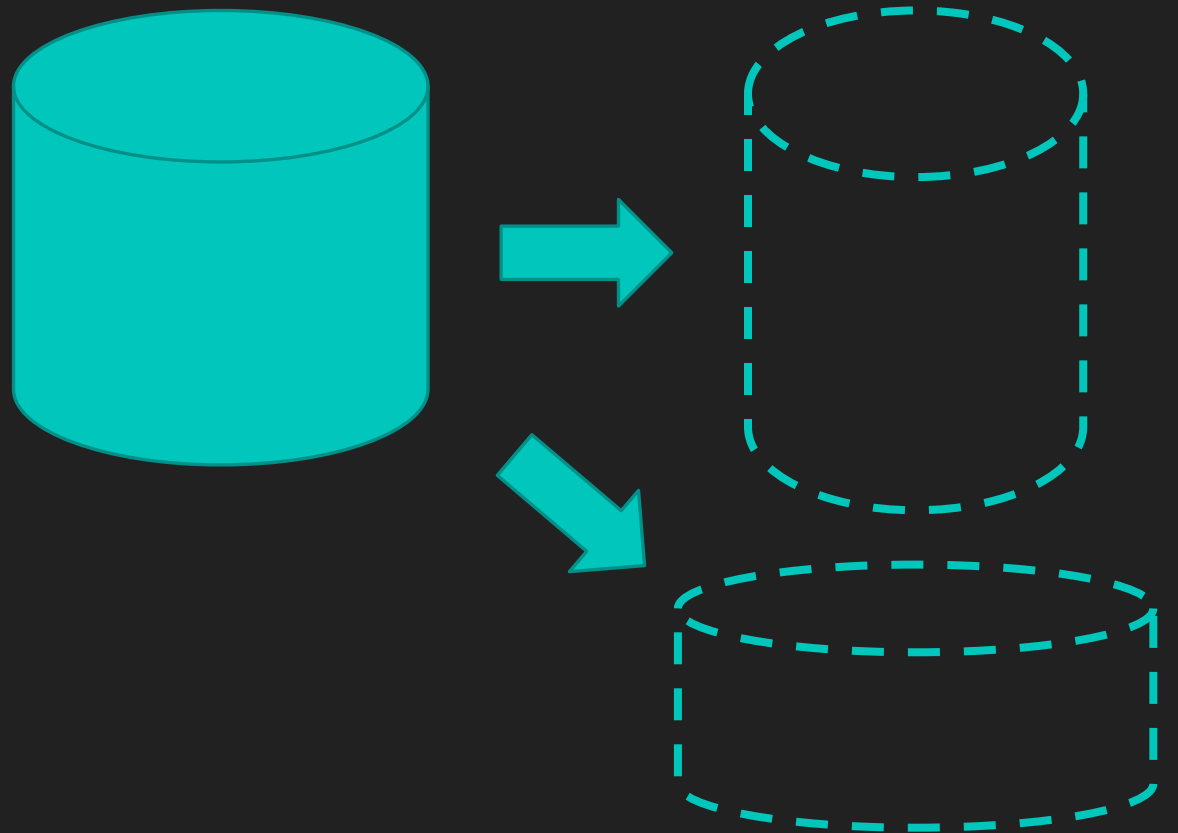
Index pattern: access-log-*

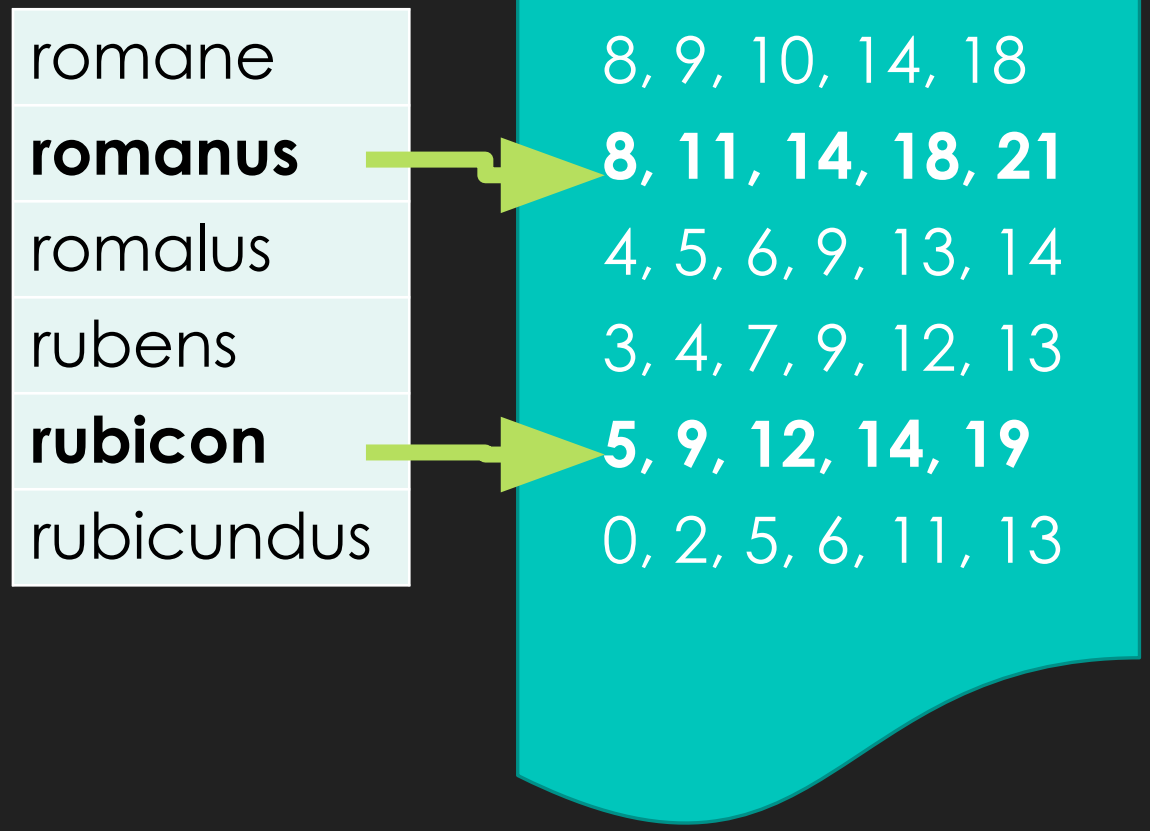
access-log-2019-08-06
access-log-2019-08-07
access-log-2019-08-08
....



An Index is …

- an **derived** data structure




romane
romanus
romalus
rubens
rubicon
rubicundus
8, 9, 10, 14, 18
8, 11, 14, 18, 21
4, 5, 6, 9, 13, 14
3, 4, 7, 9, 12, 13
5, 9, 12, 14, 19
0, 2, 5, 6, 11, 13

Term Frequency

red bar

red red
red bar
red

Inverse Document Frequency

red bull Search

Chicago Bulls

Red Socks

Computing is too important to be left to men

Karen Spärck-Jones