🔍 Information Retrieval

The Ultimate Guide 💯

➡️ Inverted Index, Lucene, Elasticsearch and Kibana

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About Me:

- Soulaymen Chouri
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- Interests:
  - Aritificial Intelligence
  - Game Development
  - Information Retrieval ✅
  - Data visualization ✅

I. Inverted Index

Let's get started!

💭 **Imagine:**

- We have a lot of documents
- We need to search for a document by some of its content

Let's make a Google-like seach engine!

I know what you're thinking

```
let words: String[] = query.split(" ")
let documents: Array<Document> = getDocuments()
let results: Array<UInt32> = new Array<>(defaultValue: 0,
                                         size: documents.size)

let i: UInt32 = 0

for i = 0, i < documents.size(), i++{
   let content = documents[i].getContent()

   foreach w: String in words {
      if content.find(w) > 0 {
         results[i]++
      }
   }
}
```

Let's measure performance! 📉

- Comparing two Strings takes `t = 100µs` (real life example)
- `n` : number of documents
- `m` : average number of words in all documents
- `w` : number of words in our query

➡️ Complexity: `O(n*m*w)` Total time: `n*m*w*t`

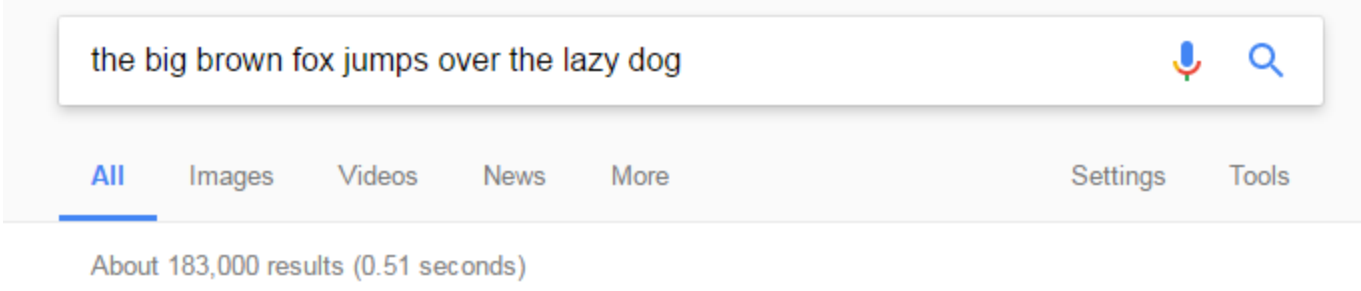
Let's measure performance! 📚

- For `n = 1k`
- For `m = 10k`
- For `w = 5`

➡️ Total time: `n*m*w*t = 1k*10k*5*t = 50k²t = 50.000.000t`

➡️ Total time: `50.000.000 * 100µs = 1.38 hours` ⌚

Google be like 😂 😂 😂



Magic!

- We don't even have as many documents as google (obviously)
- Yet, we're too far away!

The secret

index

A look-up table! 😱

Indexing the document:

- Creating a list of `Inverted Indexes`

Process:

1. Extract document's content
2. Each **term** in the content will be mapped in an **inverted index** as a `term` and a `posting list`
    - As in **map-reduce**
3. When Search for a word, we search in our look-up table

Inverted Index:

Term	Posting List
`Lucene`	`{1, 5, 3}`
`Java`	`{1, 6}`

Example:

- Document[1]: `The big brown fox jumped over the lazy dog`
- Document[2]: `The brown fox is Firefox`

Inverted Index:

Term	Posting List
`The`	`{1, 2}`
`big`	`{1}`
`brown`	`{1, 2}`
`fox`	`{1, 2}`
`jumped`	`{1}`
`over`	`{1}`
`lazy`	`{1}`
`dog`	`{1}`
`is`	`{2}`
`Firefox`	`{2}`

Enhance IR: ⭐

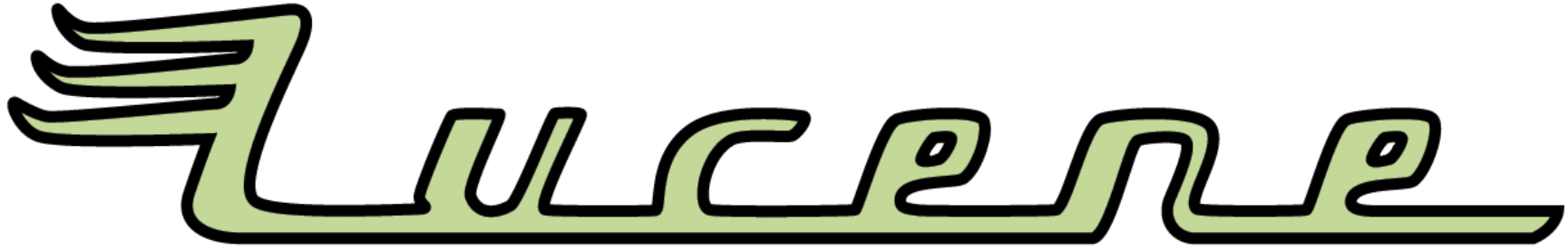
- Add position to the posting list
- Add number of occurrences
- Sort the Inverted Index by alphabet on the term's field!
- Remove non-sense words like `the`, `a`, `at`, ... (language specific)

Scoring 🌟

- TF: Term Frequence: The more terms(in our query) our document has, the better it is (higher score)
- DF: Document Frequence: The more documents containing that term, the less special this document is (lower score)
- `IDF = 1 / DF`

➡️ `Score = TF*IDF`

II. Lucene



About Lucene

- Open Source IR Library written in Java
- Maintained by the Apache Software Foundation
- The kernel of Solr and Elasticsearch

A Lucene Document

- Lucene is able to index and store document for fast retrieval via inverted indexes.
- In lucene a document is a data structure in the form of `key, value`.

Example:

Email document:

- `sender: String`
- `subject: String`
- `sendDate: Date`
- `body: String`

Lucene ABCs

When creating a document:

- Specify every field type
- If the field is for indexing or not
- If the field is stored or not

➡️ You may want to store a field `send` but you do not want users to search for it.
➡️ You may want to index a field `subject` but you do not want its content to be visible to the user.

Lucene ABCs

A document is indexed in a **directory**.

➡️ Need to manually create the directory used to store the indexes.

- Lucene stores indexes in the form of segments
- Each segment

III. Elasticsearch

About Elasticsearch

- Lucene-based Search Engine
- Scalable and distributed
- HTTP web interface
- JSON-based documents
- Apache Licensed

Installing Elasticsearch

⚠️ Requires at least Java 8

1. Download ES: https://www.elastic.co/downloads/elasticsearch
2. Extract Zip
3. cmd: `bin\elasticsearch`

Creating our first document 📖

```
curl -XPUT http://localhost:9200/users/user/1 -d `
{
   "name": "James",
   "age": 35,
   "lastlogin": "2017-02-01",
   "bio": "A Secret agent known as James Bond.
           He is simply the man to get the job done"
}
```

Retrieving our first document

```
curl -XGET /user/users/_search?q="name":"james"&pretty
```

First impressions:

- Elasticsearch is Schema-free
  - Automatically deduct field types
  - Can update mapping if miss detected
- Can be used from any programming language that can send Http Requests
- Very scalable: from personal computers to data centers.