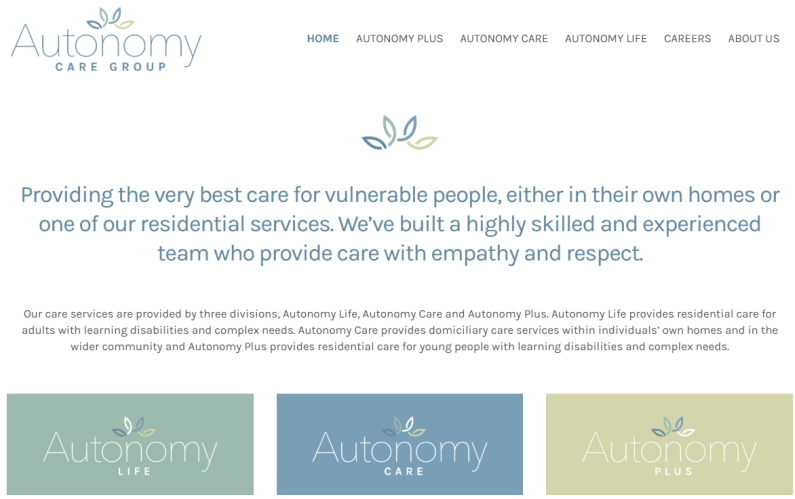


Overview

Contents

1 Motivation

Motivation

Where is the search box? Information systems need **Search** feature

2 Definition

Definition

Enterprise search

- is the practice of identifying and enabling specific content across the enterprise to be **indexed**, **searched**, and **displayed** to **authorized users**.
- is the organized retrieval of **structured** and **unstructured** data within your application.

3 Differences from Normal Web Search

Enterprise vs. Web search (Intranet vs. Internet)

- **Multiple data sources** Websites, files, email, etc.
- **Collecting and indexing data** Missed a key page?
- **Relevance and ranking algorithms** Popular hits and page rank
- **Users**
  - Searchers are Knowledge workers
  - Context available: department, job, location...
- **Security** Authenticated users
- **Single site, Single best document** Federated search

4 Enterprise Search Components

Enterprise Search Components

- Content awareness and collecting data
- Content processing and analysis
- Indexing
- Query processing
- Matching

Collecting Data

- Finding content and pulling it into the system
- **Crawlers** retrieve documents and other content
  - Over protocols like HTTP
  - Use adapters to connect to relational databases, document management systems, etc.

Content Processing

Identification Sentences determined by periods or other punctuation marks

The operator operates successfully!

Tokenization Breaking up text into tokens (words, phrases, symbols, etc.)

[The] [operator] [operates] [successfully]

Normalization Tokens to lower case to provide case-insensitive search

[the] [operator] [operates] [successfully]

Content processing II

Stop-words removing meaningless tokens, (there, so, other, etc.)

- *[operator] [operates] [successfully]*

Stemming and lemmatization to get the normal form of the word

- *[operate] [operate] [success]*

.

.

.

Synonym expansion Controlled vocabulary, manually or automatically derived thesaurus, etc. **Wordnet**

Part-of-speech tagging the **book** on the table (noun), to **book** a flight (verb)

Indexing

- The resulting terms are stored in an index, instead of storing the full text of the document
- Contains the dictionary of all unique words in the corpus
- Groups information into logical categories that in turn can be searched and return results to users
- TF-IDF

Indexing - TF-IDF

- **TF: Term Frequency**, how frequently a term occurs in **one document**.

  TF = (Number of times term t appears in a document / Total number of terms in the document)

- **IDF: Inverse Document Frequency**, how important a term is in the **corpus**
  IDF = log (Total number of documents / Number of documents with term t in it)

Indexing - TF-IDF

$$TF - IDF(w) = TF(w) \times \frac{1}{DF(w)}$$

The word is more popular when it appears several times in a document

The word is more important if it appears in fewer documents

- $TF(w) \rightarrow$ term frequency (number of times a term occurs in a single document)
- $DF(w) \rightarrow$ document frequency (number of documents a term occurs in within the corpus)
- $TF - IDF \rightarrow$ relative importance of the word in the document

Indexing - TF-IDF

Consider a document containing 100 words wherein the word `Example` appears 3 times. The term frequency (i.e., TF) for `Example` is calculated as follows:

$$TF_{example} = \frac{3}{100} = 0.03$$

Assume we have 10 million documents and the word `Example` appears in one thousand of these. Then, the inverse document frequency (i.e., IDF) is calculated as follows:

$$IDF_{example} = log(\frac{10\,000\,000}{1\,000}) = 4$$

. TF-IDF weight is the product of these quantities:

$$TF - IDF = 0.03 \times 4 = 0.12$$

Searching

Enterprise search applications may allow

- General free-form keyword searching
- Specialized query syntax to allow more specific queries
- A standardized query language like SQL or SPARQL

The query parser converts the query into a representation which can be used, along with the index, to determine matching results.

Query expansion for better performance (recall and precision)

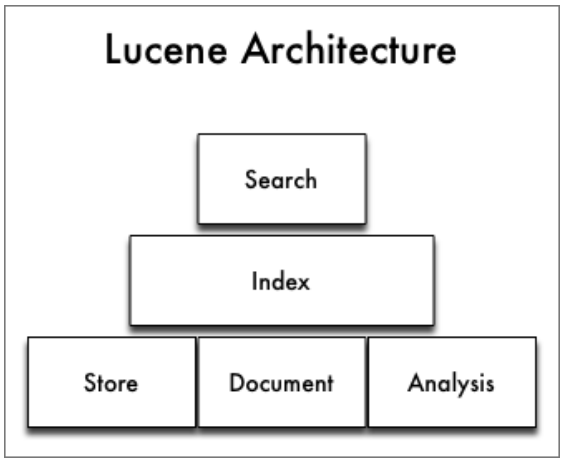
Next Level

- Search by term instead of keyword
  - Term has semantics, keyword is just a word
  - *Construction* – process of constructing something vs. *Construction* – structure (physical or logical)

5 Examples of Enterprise Search Platforms and Libraries

Lucene

- A powerful open-source Java full-text search library
- Makes it easy to add full-text search capability to applications
- **Not** a complete application **but** a code library and API



Lucene - Simple Indexing Example

- In-memory index from some strings.

Indexing

```
StandardAnalyzer analyzer = new StandardAnalyzer();
Directory index = new RAMDirectory();

IndexWriterConfig config = new IndexWriterConfig(analyzer);

IndexWriter w = new IndexWriter(index, config);
addDoc(w, "Lucene in Action", "193398817");
addDoc(w, "Lucene for Dummies", "55320055Z");
addDoc(w, "Managing Gigabytes", "55063554A");
addDoc(w, "The Art of Computer Science", "9900333X");
w.close();
```

Lucene - Simple Indexing Example II

- `addDoc()` is what actually adds documents to the index
- Use of `TextField` for content we want tokenized, and `StringField` for id fields and the like, which we don't want tokenized.

Indexing - addDoc()

```
private static void addDoc(IndexWriter w, String title, String isbn) throws
  IOException {
   Document doc = new Document();
   doc.add(new TextField("title", title, Field.Store.YES));
   doc.add(new StringField("isbn", isbn, Field.Store.YES));
   w.addDocument(doc);
}
```

Lucene - Simple Query Example

- We read the query from stdin, parse it and build a Lucene `Query` out of it.

Query

```
String querystr = "your query keywords";
Query query = new QueryParser("title", analyzer).parse(querystr);
```

Lucene - Simple Search Example

- Using the `Query` we create a `Searcher` to search the index. Then a `TopScoreDocCollector` is instantiated to collect the top 10 scoring hits.

Search

```
int hitsPerPage = 10;
IndexReader reader = DirectoryReader.open(index);
IndexSearcher searcher = new IndexSearcher(reader);
TopDocs docs = searcher.search(query, hitsPerPage);
ScoreDoc[] hits = docs.scoreDocs;
```

Elasticsearch

- Open source search server powered by Lucene under the hood
- Written in Java
- Cross platform
- Scalability and distributed architecture
- HTTP REST API
- Schema-less JSON documents
- Developed by *Elastic NV*
- Near real-time search

Elasticsearch Users

- Wikimedia
- Quora
- SoundCloud
- GitHub
- Netflix
- Uber
- Slack . . .

Elasticsearch - Introduction Example

- **Download** the latest distribution from `https://www.elastic.co/downloads/elasticsearch`
- **Unpack** it on your machine
- **Run** it, by launching **elasticsearch**
- **Launch** it from the web browser `http://localhost:9200`

Introduction Example

Elasticsearch - Introduction Example

Result in the Browser

```
{
  "name" : "LAPTOP-1B98U3HM",
  "cluster_name" : "elasticsearch",
  "version" : {
    "number" : "7.5.0",
    "build_flavor" : "default",
    "build_hash" : "e9ccaed468e2fac2275a3761849cbee64b39519f",
    "build_date" : "2019-11-26T01:06:52.518245Z",
    "lucene_version" : "8.3.0",
  },
  "tagline" : "You Know, for Search"
}
```

Building a Basic Search App

Elasticsearch - Building a Basic Search App

Create an Index

```
PUT /myapp?pretty
```

Index a Document

```
PUT /myapp/tweet/1?pretty
{
   "name": "Jane Doe",
   "tweet": "I think elasticsearch is AWESOME",
   "date": "2013-06-03",
   "loc": {
      "lat": 13.4,
      "lon": 52.5
   }
}
```

Create an Index – Response

```
{
  "_index" : "myapp",
  "_type" : "tweet",
  "_id" : "1",
  "_version" : 1,
  "result" : "created",
  "_seq_no" : 0,
  "_primary_term" : 1
}
```

Get the Document

```
GET /myapp/tweet/1?pretty
```

Get the Document – Response

```
{
  "_index" : "myapp",
  "_type" : "tweet",
  "_id" : "1",
  "_version" : 1,
  "found" : true,
  "_source" : { ...OUR TWEET... }
}
```

Update the Document

```
PUT /myapp/tweet/1?pretty
{
   "name": "Jane Doe",
   "tweet": "I think elasticsearch is AWESOME",
   "date": "2013-06-03",
   "loc": {
      "lat": 13.4,
      "lon": 52.5
   }
}
```

Delete the Document – Response

```
Delete /myapp/tweet/1?pretty
```

Inverted Index

- Elasticsearch uses *inverted index* of terms
- Terms point to the documents in which they appear

$$Doc\#1 \rightarrow \ \_ \ [operate]\ [operate]\ [success]$$

```
inverted_index = {
   "operate": [1, 47, 72],
   "success": [1, 55, 92, 107],
   "search": [34, 92, 119],
   "zebra": [15, 34, 55, 107],
}
```

Index Info – Mapping

GET /myapp?pretty

```
{
   "date": {"type": "date"},
   "loc": {
      "properties": {
         "lat": {"type": "float"},
         "lon": {"type": "float"}
      }
   },
   "name": {"type": "text"},
   "tweet": {"type": "text"}
   }
}
```

- Possible to upload mapping for new fields
- Do not change the mapping of existing fields

Mapping

Full text: (default)

```
{ "type": "text", index: true }
```

Exact value only:

```
{ "type": "keyword", index: true }
```

Not searchable

```
{ "type": "text", index: false }
```

Search the Index – Empty Search

```
GET /myapp/_search
{
  "query": { "match_all": {} }
}
```

POST can be used as well

Response

```
{
  "took" : 2,
  "timed_out" : false,
  "_shards" : {
    "total" : 5,
    "successful" : 5,
    "failed" : 0
  },
  "hits" : {
      "total" : 14,
    "max_score" : 1.0,
    "hits" : [ {...}]
}}
```

Filters vs. Queries

Filters

- Exact matching
- Binary yes/no
- Fast
- Cacheable

Queries

- Full text search
- Relevance scoring
- More difficult
- Not cacheable

Query:

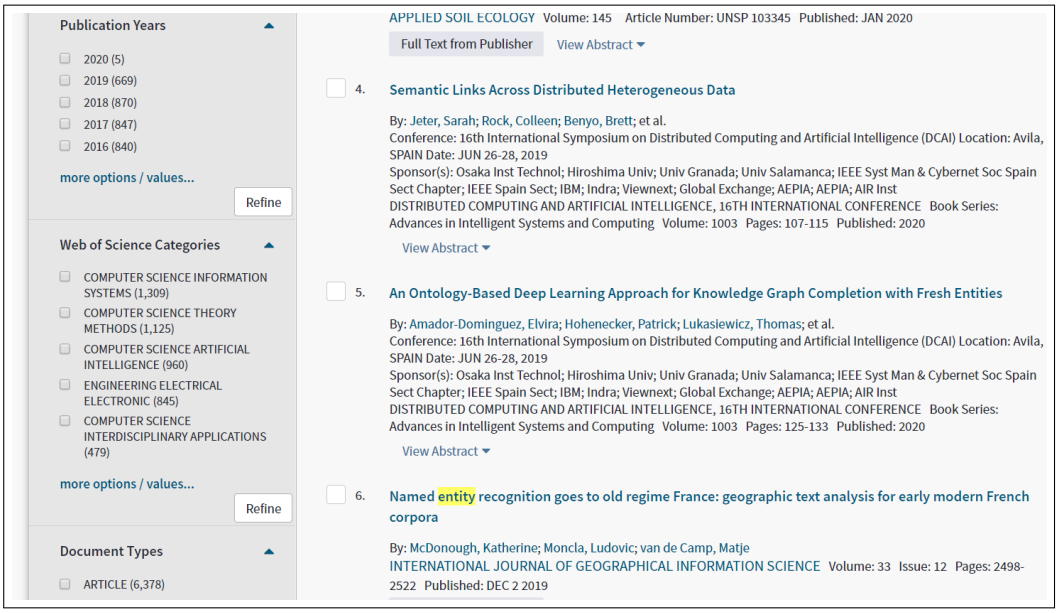
```
{ "match": {"tweet": "search" }}
```

Filter:

```
{ "term": {"date": "2013-06-03" }}
```

Filtered Queries & Boolean Queries

- Boolean queries allow to combine search criteria
  - `must` – criterion must match
  - `should` – criterion should match
  - `must_not` – criterion must not match



- `filter` to filter query results

```
GET /myapp/_search
{
   "query": {
      "bool": {
         "must": {
            "term": {"date": "2013-06-03"}
         },
         "filter": {
            "range": {
               "loc.lat": { "gte": 10, "lte": 15 }
            }
         }
      }
   }
}
```

Aggregations

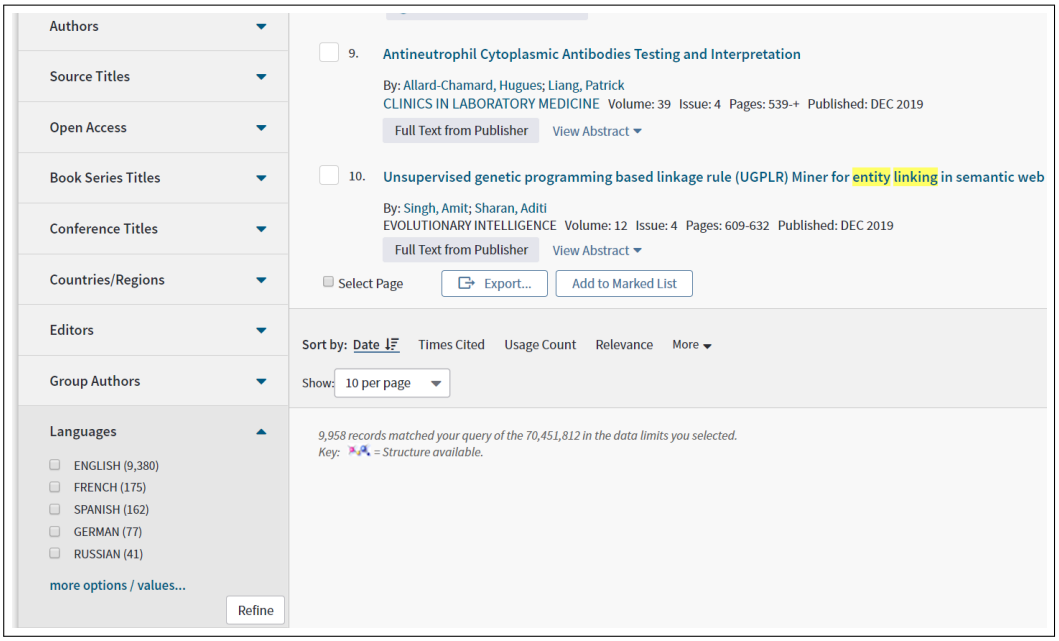
Web of Science

Aggregations

Web of Science

Aggregations

```
GET /bank/_search
{
  "size": 0,
  "aggs": {
    "group_by_state": {
```




```
      "terms": {
        "field": "state"
      }
    }
  }
}
```

Aggregations

```
GET /bank/_search

{
  "size": 0,
  "aggs": {
    "group_by_age": {
      "range": {
        "field": "age",
        "ranges": [
          {
            "from": 20,
            "to": 30
          },
          {
            "from": 30,
            "to": 40
          },
          {
            "from": 40,
            "to": 50
          }
        ] },
```

```
"aggs": {
```

```
      "group_by_gender": {
        "terms": {
          "field": "gender.keyword"
        },
        "aggs": {
          "average_balance": {
            "avg": {
              "field": "balance"
            }
          }
        }
      }
    }
  }
}
```

Solr

- Also built on Lucene
  - Similar feature set
  - Also exposes Lucene functionality, like Elasticsearch, so easy to extend.
- A part of the Apache Lucene project
- Perfect for single server search
- Clustering is there. But it's definitely not as simple as ElasticSearch
- Solr is for text search while Elasticsearch is for filtering and grouping, the analytical query workload, and not just text search.

Evaluation of Search System

Evaluation of Search System

$$\text{precision} = \frac{|\{\text{relevant documents}\} \cap \{\text{retrieved documents}\}|}{|\{\text{retrieved documents}\}|}$$

$$\text{recall} = \frac{|\{\text{relevant documents}\} \cap \{\text{retrieved documents}\}|}{|\{\text{relevant documents}\}|}$$

$$\text{Precision} = \frac{tp}{tp + fp}$$

$$\text{Recall} = \frac{tp}{tp + fn}$$

	Documents Retrieved (search results)		
Actual Documents (Should be retrieved)		Class = Yes	Class = No
	Class = Yes	True Positive	False Negative
	Class = No	False Positive	True Negative

What is Bad Search?

- No search box
- Too many hits: Return 10 000 hits when the average user looks at the top 20 only
- Bad scoring: The most relevant item is not at the top of the list
- Poor duplicate detection: Too many similar documents
- Inability to judge user's intent: spell checking, recommendation system, auto complete.

The End

Thank You

Resources

- Enterprise Search - David Hawking in Ricardo Baeza-Yates and Berthier Ribeiro-Neto (Ed.s), Modern Information Retrieval, 2nd Ed.. Pearson Educational, pp. 641-684.
- `https://lucene.apache.org/`
- `https://www.elastic.co/guide/en/elasticsearch/reference/current/getting-started.html`
- `https://lucene.apache.org/solr/`