# Elasticsearch Workshop

December 2022, Niš

deavensoft

# Agenda

Introduction

What is a Document?

Basic Searching

Mapping and Analysis

Query DSL

Sorting & Relevance

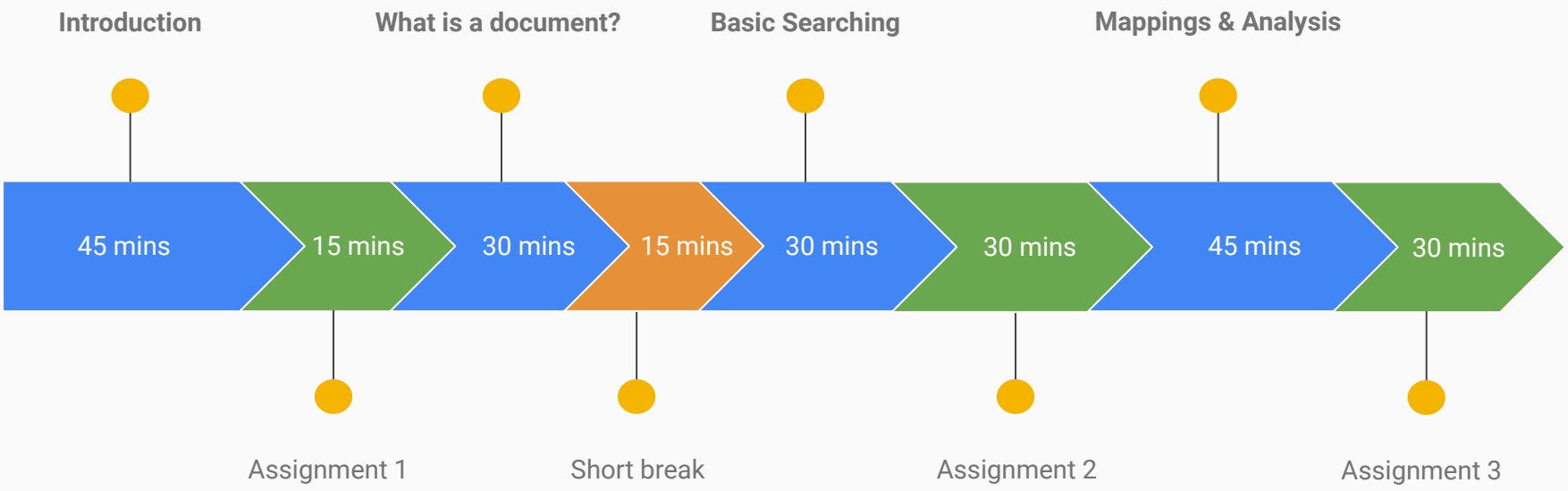
Dealing with Human Language

Aggregations

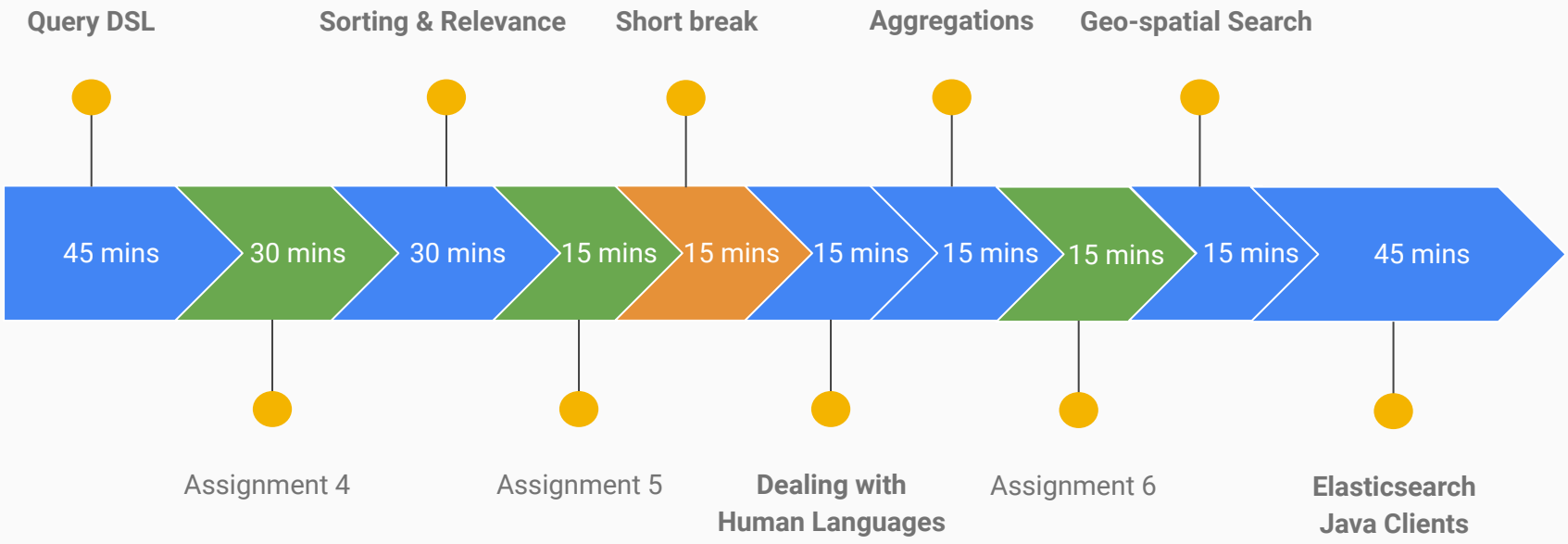
Geo-spatial Search

Elasticsearch Java Client

# Morning


Introduction
What is a document?
Basic Searching
Mappings & Analysis
45 mins
15 mins
30 mins
15 mins
30 mins
30 mins
45 mins
30 mins
Assignment 1
Short break
Assignment 2
Assignment 3

# Afternoon


Query DSL
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Short break
Aggregations
Geo-spatial Search
45 mins
30 mins
30 mins
15 mins
15 mins
15 mins
15 mins
15 mins
15 mins
45 mins
Assignment 4
Assignment 5
Dealing with Human Languages
Assignment 6
Elasticsearch Java Clients

# Introduction

# What is Elasticsearch?

**Elasticsearch** is an open-source, RESTful, distributed search and analytics engine built on Apache Lucene

Released in 2010 and quickly became the most popular search engine

Commonly used for log analytics, full-text search and operational intelligence

Easy-to-use search APIs

# Elasticsearch Benefits

Fast

Easy-to-use APIs

Complementary Tooling and Plug-ins

Near Real-time Index Updates

Support for your Favorite Development Language

# Introduction

## *Basic Concepts*

## Cluster

Collection of one or more nodes (servers) holding entire data and providing federated indexing and search capabilities

Identified by unique cluster name (default name: `elasticsearch`)

## Node

A single *server* that is part of a cluster

Identified by a name (default: *random UUID*). Name is important for admin purposes and to know which server in a network corresponds to which node

Can join only one *Cluster* (if not set, auto-joins `elasticsearch` cluster)

## Index

*Elasticsearch index* is a collection of documents that have somewhat similar characteristics

E.g. you can have index for customer data, another index for a product catalog etc.

Identified by name (all lowercase)

In a single cluster, you can define as many indexes as you want

## Document

A document is a basic unit of information that can be indexed

E.g. you can have document for a single customer, another document for a single product

Documents expressed as JSON

Within an index you can store as many documents as you want

## Shards

An *Index* can store a large amount of data, which could not fit into a single node (server)

Another problem: single node could be too slow to serve search requests

*Shards* adds ability to subdivide index into multiple pieces, where each Shard is an “independent” index (Lucene)

Shards can run on any *Node*

Sharding benefits:

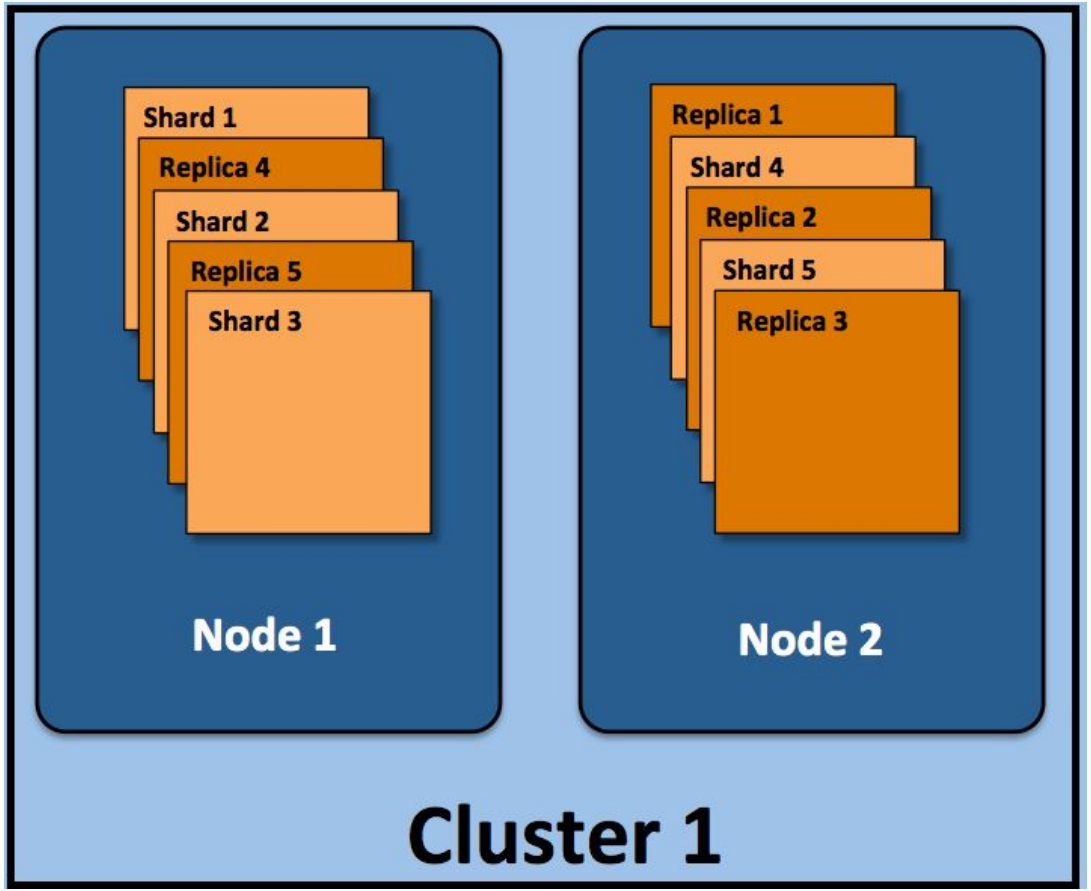
- Allows to horizontally split/scale your content volume
- Allows to distribute and parallelize operations across Shards

## Replicas

To handle failures and high availability Elasticsearch can make one or more copies of Index’s Shards called *Replicas*

Replica shard is never allocated on the same Node as original/primary Shard

# Basic Concepts



## Near-real time (NRT)

Elasticsearch is a near real time search platform (as Apache Lucene)

There is a slight latency from when you index a document until it becomes searchable

Normally one second

## Type

A Type used to be a logical category/partition of your index to allow you to store different types of documents in the same index

Deprecated in 6.0.0

Indices created in Elasticsearch 6.0.0 or later may only contain a single mapping type

Will be removed in future versions

# Introduction

***Apache Lucene***

# About Apache Lucene?

**Apache Lucene** is a high-performance, full-featured text search engine library written entirely in Java.

It is a technology suitable for nearly any application that requires full-text search, especially cross-platform

## Scalable, High-Performance Indexing

- over 150GB/hour on modern hardware
- small RAM requirements -- only 1MB heap
- incremental indexing as fast as batch indexing
- index size roughly 20-30% the size of text indexed

# Powerful, Accurate and Efficient Search Algorithms

- ranked searching -- best results returned first
- many powerful query types: phrase queries, wildcard queries, proximity queries, range queries and more
- fielded searching (e.g. title, author, contents)
- sorting by any field
- multiple-index searching with merged results
- allows simultaneous update and searching
- flexible faceting, highlighting, joins and result grouping
- fast, memory-efficient and typo-tolerant suggesters
- pluggable ranking models, including the Vector Space Model and Okapi BM25
- configurable storage engine (codecs)

## Cross-Platform Solution

- Available as Open Source software under the Apache License which lets you use Lucene in both commercial and Open Source programs
- 100%-pure Java
- Implementations in other programming languages available that are index-compatible

**Apache Lucene is a DNA of most of the search technologies in today's market. Even the machine learning languages like Mahout, Famous web crawler like Nutch, etc are using Lucene.**

# Elasticsearch and Apache Lucene

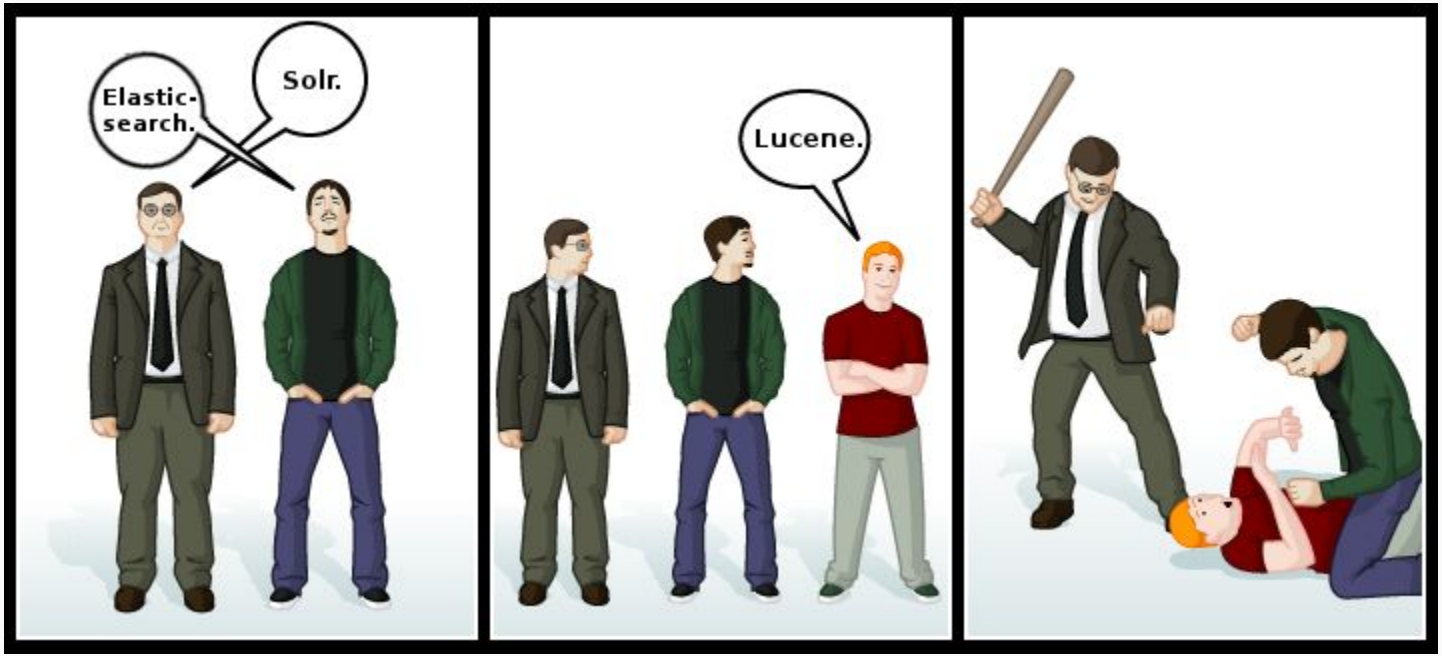
*Apache Lucene is doing the heavy lifting for Elasticsearch*. But...

**Lucene** is a java library. You can include it in your project and refer to its functions using function calls.

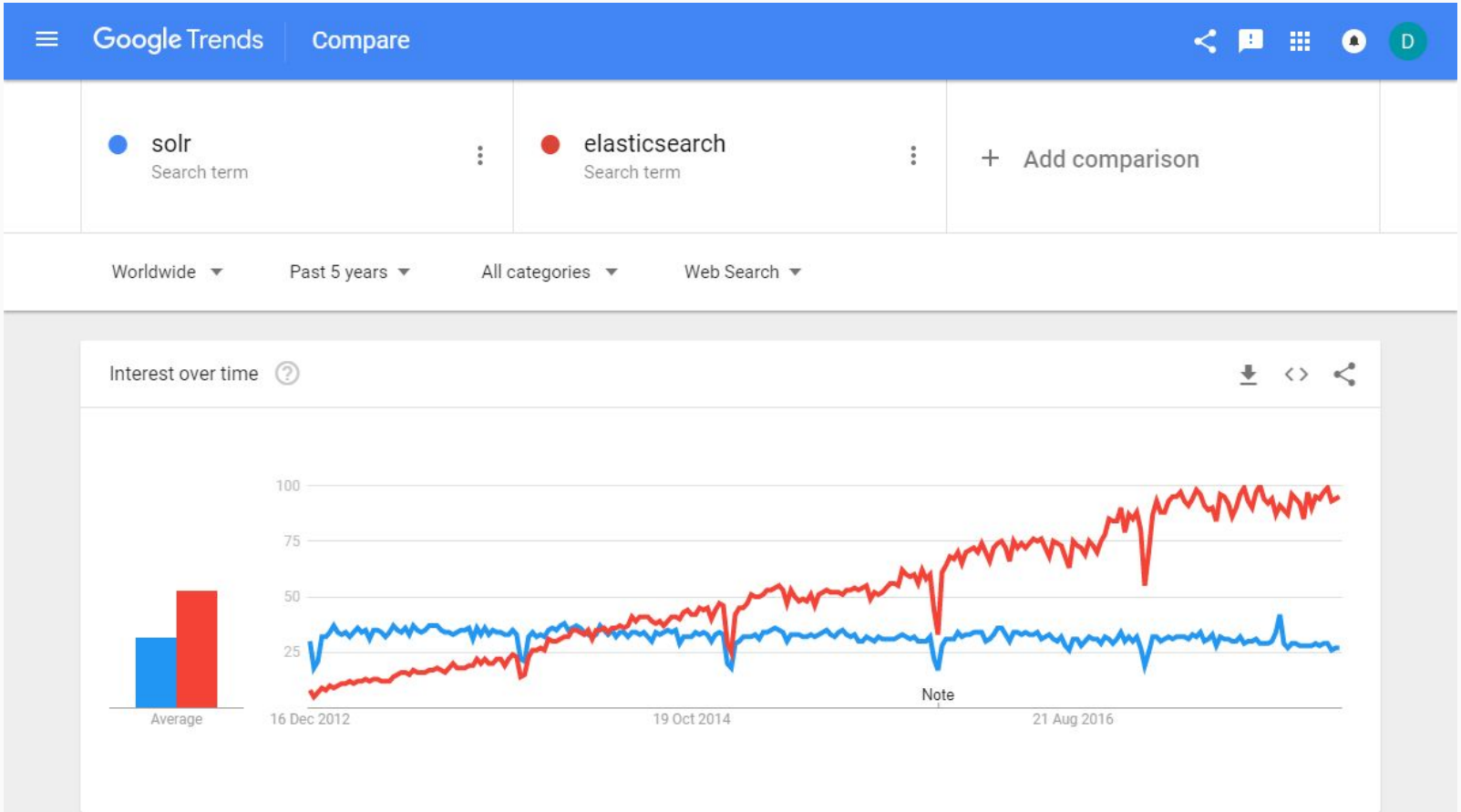
**Elasticsearch** is built on top of Lucene and provides:

- *a JSON based REST API* to refer to Lucene features
- *a distributed system* on top of Lucene (abstraction of distributed structure)
- *other supporting features* like thread-pool, queues, node/cluster monitoring API, data monitoring API, Cluster management, etc.

# Hipster in the Hood



# SOLR vs Elasticsearch



# Introduction

## *Installation*

# Installation Options

- Download binaries
- Docker images
- Cloud options (AWS, GCP)

# DEMO

## Elasticsearch - The First Bite

Installing Elasticsearch

Execute some commands and queries against running Elasticsearch instance

# Elastic Stack

**Kibana** gives shape to your data and is the extensible user interface for configuring and managing all aspects of the Elastic Stack

**Beats** is a platform for lightweight shippers that send data from edge machines to Logstash and Elasticsearch

**Logstash** is a dynamic data collection pipeline with an extensible plugin ecosystem and strong Elasticsearch synergy

Duration: 15 min
01-installation

# Assignment 1 - Installation

Install **Elasticsearch** and **Kibana** on a local machine.

The most optimum way is to install the environment on the local machine using **docker-compose**.

Alternatively ,follow the next guides to install from binaries:

- https://www.elastic.co/downloads/elasticsearch
- https://www.elastic.co/downloads/kibana

You will also need a **Java 8+** installed on your machine. If needed, go to http://www.oracle.com/technetwork/java/javase/downloads/index.html and install it

# What is a Document?

# JSON

Most entities in most applications can be serialized into a **JSON object**

A **key** is the name of a field or property

A **value** can be a string, a number, a Boolean, another object, an array of values, or some other specialized type such as a string representing a date or an object representing a geolocation

*Note: Field names can be any valid string, but* may not *include periods*

# JSON Document with Objects

```
{
    "name":          "John Smith",
    "age":           42,
    "confirmed":     true,
    "join_date":     "2014-06-01",
    "home": {
        "lat":       51.5,
        "lon":       0.1
    },
    "accounts": [
        {
            "type": "facebook",
            "id":   "johnsmith"
        },
        {
            "type": "twitter",
            "id":   "johnsmith"
        }
    ]
}
```

## Object

Object is just a JSON object
Objects may contain other objects

## Document

In Elasticsearch, *document* has a specific meaning - it refers to the top-level or *root objects* that is *serialized into JSON* and stored under a *unique ID*

# Document Metadata

Document also has **metadata** - information *about* the document.

The three required metadata elements are as follows:

| | |
|---|---|
| `_index` | Where the document lives |
| `_id` | The unique identifier for the document |

*Note:* `_index` *and* `_id` *uniquely identify the document*

# Index API - PUT

Documents are *indexed* — stored and made searchable — by using the **`index` API:**

```
PUT /{index}/_doc/{id}
{
  "field": "value",
  ...
}
```

Example:

```
PUT /website/_doc/123
{
  "title": "My first blog entry",
  "text":  "Just trying this out...",
  "date":  "2014/01/01"
}
```

# Index API - POST

If our data doesn't have a natural ID, Elasticsearch autogenerate one for us:

```
POST /{index}/_doc/
{
   "field": "value",
   ...
}
```

Example:

```
POST /website/_doc/
{
  "title": "My first blog entry",
  "text":  "Just trying this out...",
  "date":  "2014/01/01"
}
```

-> generates:

```
"_id":       "AVFgSgVHUP18jI2wRx0w"
```

# Index API - GET (Retrieving a Document)

To get the document, use the same approach but with HTTP verb **GET:**

```
GET /website/_doc/123
```

Result:

```
{
  "_index" :    "website",
  "_id" :       "123",
  "_version" :  1,
  "found" :     true,
  "_source" :   {
      "title":  "My first blog entry",
      "text":   "Just trying this out...",
      "date":   "2014/01/01"
  }
}
```

# Index API - HEAD

Instead of GET you can use **HEAD** to check whether a document exists:

```
HEAD /website/_doc/123
```

```
HEAD /website/_doc/999
```

Result (if exists):

```
HTTP/1.1 200 OK
Content-Type: text/plain; charset=UTF-8
Content-Length: 0
```

Result (if does not exists):

```
HTTP/1.1 404 Not Found
Content-Type: text/plain; charset=UTF-8
Content-Length: 0
```

# DEMO

## Indices, Documents and Types

Creating an Index

Indexing some data

Retrieving data

# Updating a Document

Documents in Elasticsearch are *immutable*; we cannot change them

We can **reindex** or replace the document with all its data
1. delete the old document
2. index a new document

*Partial updates* are also supported:
1. Retrieve the JSON from the old document
2. Change it
3. Delete the old document
4. Index a new document

# Deleting a Document

Similarly, to delete a document use HTTP verb **DELETE**:

```
DELETE /website/_doc/123
```

*Note: Deleting a document doesn't immediately remove the document from disk; it just marks it as deleted*

# Optimistic Concurrency Control

Elasticsearch is *distributed* and also *asynchronous* and *concurrent*

When documents are created, updated, or deleted, the new version of the document has to be replicated to other nodes in the cluster. Updates may arrive *out of sequence*.

`_version` metadata is incremented whenever a document is changed

When updating a document `_version` can be used to prevent conflicting changes

# Other APIs for Document Manipulations

| | |
|---|---|
| `_update` | Partial updates (even using scripts) |
| `_mget` | Retrieving Multiple Documents |
| `_bulk` | Allows making multiple *create*, *index*, *update* or *delete* requests in a single step |

# Break

15 minutes

# Basic Searching

# Elasticsearch Power

We saw how Elasticsearch can be used as a simple NoSQL-style distributed document store.

We can throw JSON documents at Elasticsearch and retrieve each one by ID

But the real power of Elasticsearch lies in its ability to make sense out of chaos

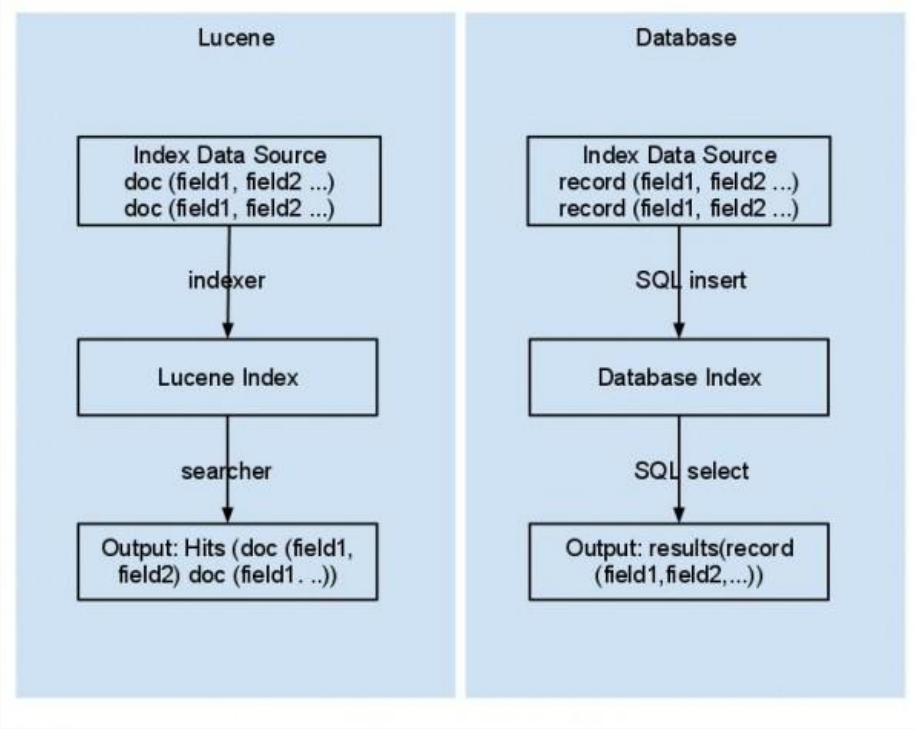
Elasticsearch not only *stores* the document, but also *indexes* the content of the document in order to make it searchable.

# Apache Lucene vs RDBMS: Full-Text Search Mechanism

The RDBMS database index is not designed for the full-text index

The database query with fuzzy terms, `LIKE`, can harm performance

If you need more than one fuzzy matching words: `like "% keyword1%" and like "% keyword2%"` ... the efficiency also will be damaged more



# Search Queries

- *A structured query* on concrete fields like `gender` or `age`, sorted by a field like `join_date`, similar to SQL query
- *A full-text query*, which finds all documents matching the search keywords, and returns them sorted by *relevance*
- A combination of the two

# The Empty Search

**GET /_search**


```
{
"hits" : {
  "total" : 14,
  "hits" : [
    {
    "_index":   "us",
    "_type":    "tweet",
    "_id":      "7",
    "_score":   1,
    "_source": {
      "date": "2014-09-17",
      "name":    "John Smith",
      "tweet":   "The Query DSL...",
      "user_id": 2
     }
  },
                    ... 9 RESULTS REMOVED ...
  ],
  "max_score" :   1
},
"took" :           4,
"_shards" : {
  "failed" :      0,
  "successful" :  10,
  "total" :       10
},
"timed_out" :      false
}
```

# The Empty Search

`hits` - contains the `total` number of documents matched the query

`hits[]` - array contains matched documents - the result, where each contains:

`_index` and `_id` of the document, plus the `_source` field

`_score` is a relevance score,
measure of how well the document matches the query
(default sorting: by *score descending*
meaning most relevant documents first)

`max_score` - the highest `_score` of any document that matches the query

`took` - how many milliseconds the entire search request took to execute

`_shards` - the `total` number of shards that were involved in the query

# DEMO

## Basic Searching

Index some test data

Search the data in various ways

# Multi-index, Multi-type Searches

`/gb/_search`

Search all document in the gb index

`/gb,us/_search`

Search all documents in the gb and us indices

`/g*,u*/_search`

Search all document in any indices beginning with g or beginning with u

# Search *Lite*

Looks for *john* in the `name` field and *mary* in the `tweet` field

Actual query is:

```
+name:john +tweet:mary
```

Search query specified as url-query parameter (URL encoded):

```
GET /_search?q=%2Bname%3Ajohn%2Btweet%3Amary
```

More complicated query:

```
+name:(mary john) +date:>2014-09-10 +(aggregations geo)
```

```
?q=%2Bname%3A(mary+john)+%2Bdate%3A%3E2014-09-10+%2B(aggregations+geo)
```

# Query String Syntax

The query string “mini-language” is used by the Query String Query and by the `q` query string parameter in the `search API`

Parsed into a series of **terms** and **operators**

*Terms* can be:

*single word* - `quick` or `brown`

*phrase* - `"quick brown"`

*Operators* customizes the search

# Operators

## Field Names

```
status:active

title:(quick OR brown)
title:(quick brown)

author:"John Smith"

book.\*:(quick brown)

_missing_:title

_exists_:title
```

# Operators

## Wildcards

```
qu?ck bro*
```

## Regular expressions

```
name:/joh?n(ath[oa]n)/
```

## Fuzzines

Uses the *Damerau-Levenshtein distance*

```
quikc~ brwn~ foks~
quikc~1
```

## Proximity

```
"fox quick"~5
```

## Ranges

For date, numeric or string fields

```
date:[2012-01-01 TO 2012-12-31]
count:[1 TO 5]
tag:{alpha TO omega}
count:[10 TO *]
date:{* TO 2012-01-01}
count:[1 TO 5}

age:>10
age:>=10

age:(>=10 AND <20)
age:(+>=10 +<20)
```

# Operators

## Boosting

```
quick^2 fox
"john smith"^2 (foo bar)^4
```

## Grouping

```
(quick OR brown) AND fox

status:(active OR pending)
title:(full text search)^2
```

## Reserved Characters

```
+ - = && || > < ! ( ) { } [ ]
^ " ~ * ? : \ /
```

## Boolean Operators

By default, all terms are optional,
as long as one term matches

\+ operator - *must* be present

\- operator - *must not* be present

```
quick brown +fox -news
```

```
{
  "bool": {
    "must": {"match": "fox"},
    "should": { "match":
                    "quick brown" },
    "must_not": {"match":"news"}
  }
}
```

# Recommendation

*Lite* query-string search is very powerful

Great for throwaway queries from the command line or during development

On the other hand:

- Queries can look cryptic and difficult to debug
- Allows any user to run potentially slow, heavy requests on any field, possibly exposing sensitive data or killing your cluster nodes

It is *not recommended* to expose query-string searches directly to your users

Duration: 30 min
02-search-lite

# Assignment 2 - Querying using Search Lite

You are a bartender, who is happy to suggest cocktail ideas to guests in the bar

# Mapping and Analysis

# Exact Values Versus Full Text

Two types of data:

- Exact values (e.g. *user ID*, *email*, *age* etc.)
- Full text (textual data e.g. *tweet text*, *blog text* etc.)

Exact values are easy to query

Querying full-text data is much more subtle

# Querying full-text

Not just: *“Does this document match the query”*

but also: *“How **well** does this document match the query?”*

In other words: **How relevant is this document to the given query?**

# Querying full-text

We have no intention to match the whole full-text field exactly
Instead, we want to search *within* text fields

… and not only that…

- A search for `UK` should also return documents mentioning the `United Kingdom`.
- A search for `jump` should also match `jumped`, `jumps`, `jumping`, and perhaps even `leap`.
- `johnny walker` should match `Johnnie Walker`, and `johnnie depp` should match `Johnny Depp`.
- `fox news hunting` should return stories about hunting on Fox News, while `fox hunting news` should return news stories about fox hunting.

# Inverted Index

To support full-text search:

- text is first Analyzed
- results are used to build an Inverted Index

*Inverted Index* is a structure, designed to allow very fast full-text searches

# Tokenization

Example documents:

1. *The quick brown fox jumped over the lazy dog*
2. *Quick brown foxes leap over lazy dogs in summer*

| Term | Doc_1 | Doc_2 |
|---|---|---|
| Quick | | X |
| The | X | |
| brown | X | X |
| dog | X | |
| dogs | | X |
| fox | X | |
| foxes | | X |
| in | | X |
| jumped | X | |
| lazy | X | X |
| leap | | X |
| over | X | X |
| quick | X | |
| summer | | X |
| the | X | |

Search for: `quick brown`

| Term | Doc_1 | Doc_2 |
|---|---|---|
| brown | X | X |
| quick | X | |
| Total | 2 | 1 |

# Normalizing Terms

Example documents:

1. *The quick brown fox jumped over the lazy dog*
2. *Quick brown foxes leap over lazy dogs in summer*

| Term | Doc_1 | Doc_2 |
|---|---|---|
| brown | X | X |
| dog | X | X |
| fox | X | X |
| in | | X |
| jump | X | X |
| lazy | X | X |
| over | X | X |
| quick | X | X |
| summer | | X |
| the | X | X |

`Quick` can be lowercased to become `quick`.

`foxes` can be stemmed--reduced to its root form—to become `fox`. Similarly, `dogs` could be stemmed to `dog`.

`jumped` and `leap` are synonyms and can be indexed as just the single term `jump`.

# Analysis

You can find only term that exists in your inverted index

So, both *indexed text* and the *query string*
***must be normalized into the same form***

The process of tokenization and normalization is called:

**Analysis**

# Analyzer

*Analysis* is a process consists of:

- First, **tokenizing** a block of text into individual terms
- Then **normalizing** these terms into a standard form
  (to improve their “searchability”)

**Analyzer** is a wrapper of:

- Character filters (tidy up the text before tokenization)
- Tokenizer (e.g. splitting the text when whitespace is encountered)
- Token filters
  - change terms by e.g. lowercasing,
  - removing terms by e.g. stopwords such *a*, *and*, *the*
  - adding terms by e.g. synonyms like *jump* and *leap*

# Build-in Analyzers

**Test String:**

*"Set the shape to semi-transparent by calling set_trans(5)"*

**Standard Analyzer** (default analyzer)

`set, the, shape, to, semi, transparent, by, calling, set_trans, 5`

**Simple Analyzer**

`set, the, shape, to, semi, transparent, by, calling, set, trans`

**Whitespace Analyzer**

`Set, the, shape, to, semi-transparent, by, calling, set_trans(5)`

**Language Analyzers** (e.g. English analyzer)

`set, shape, semi, transpar, call, set_tran, 5`

# When Analyzers are Used?

Analyzers are used for:

- **Indexing** - full-text fields are analyzed into terms that are used to create the inverted index
- **Query** - when we search on a full-text field, we need to pass the query string through the same analysis process

Full-text queries understand how each field is defined, so they can:

- When you query a *full-text* field, the query will apply the same analyzer to the query string to produce the correct list of terms to search for
- When you query an *exact-value* field, the query will not analyze the query string, but instead search for the exact value that you have specified

# Testing Analyzers

```
GET /_analyze
{
  "analyzer": "standard",
  "text": "Text to analyze"
}
```

`token` - term stored in index

`position` - term order in text

`start_offset, end_offset` - character position of the word in original text

```
{ "tokens": [ {
          "token":          "text",
          "start_offset":   0,
          "end_offset":     4,
          "type":           "<ALPHANUM>",
          "position":       1
      }, {
          "token":          "to",
          "start_offset":   5,
          "end_offset":     7,
          "type":           "<ALPHANUM>",
          "position":       2
      }, {
          "token":          "analyze",
          "start_offset":   8,
          "end_offset":     15,
          "type":           "<ALPHANUM>",
          "position":       3
      }
    ] }
```

# DEMO

## Analyzers

Analyzing text with different analyzers

Defining custom analyzers

# Mapping

When Elasticsearch detects a new string field in your documents, it automatically configures it as a full-text `text` field and analyzes it with the `standard` analyzer

You don’t always want this

You can configure these fields manually by specifying the **mapping**

# Mapping

Elasticsearch needs to know what type of data each field contains
This information is contained in the *mapping*

Each document in an index has a *type*
Every *type* has its own **mapping**, or **schema definition**

Mapping defines:

- fields within a type
- how the field should be handled by Elasticsearch
- metadata associated with a type


Indices created in Elasticsearch 6.0.0 or later may only contain a single mapping type
Mapping types will be completely removed in Elasticsearch 7.0.0

# Dynamic Mapping

When you index a document that contains a new field—one previously not seen—Elasticsearch will use **dynamic mapping** to try to guess the field type from the basic data types available in JSON

| JSON Type | Field Type |
|---|---|
| Boolean: `true` or `false` | `boolean` |
| Whole number: `123` | `long` |
| Floating point: `123.45` | `double` |
| String, valid date: `2014-09-15` | `date` |
| String: `foo bar` | `text` |

# Customizing Field Mappings

Basic field datatypes are sufficient for many cases

Yet you will often need to customize the mapping for individual fields, especially text fields, in order to:

- Distinguish between full-text string fields and exact value string fields
- Use language-specific analyzers
- Optimize a field for partial matching
- Specify custom date formats
- And much more

```
{
  "number_of_clicks": {
    "type": "integer"
  }
}
```

# Field Datatypes

Each field has a data type which can be:

- a simple type like `text`, `keyword`, `date`, `long`, `double`, `boolean` or `ip`.
- a type which supports the hierarchical nature of JSON such as `object` or `nested`.
- or a specialised type like `geo_point`, `geo_shape`, or `completion`.

Often is useful to index the same field in different ways for different purposes

E.g. string field can be indexed as `text` for full-text search and as a `keyword` field for sorting or aggregations.

This is the purpose of *multi-fields*

# Example Mapping

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


**Existing field mappings cannot be updated.**
You should create a new index with correct mapping and reindex your data into that index.

# DEMO

## Mapping

Viewing the type mapping

Testing the mapping

Multi-field

# Empty Fields

There is no way of storing a `null` value in Lucene

These three fields would all be considered to be empty, and would not be indexed

```
"null_value":                null,
"empty_array":               [],
"array_with_null_value":     [ null ]
```

# Inner Objects

**Inner objects** are often used to embed one entity or object inside another. For instance, instead of having fields called `user_name` and `user_id` inside our `tweet` document, we could write:

```
{
    "tweet":            "Elasticsearch is very flexible",
    "user": {
        "id":           "@johnsmith",
        "gender":       "male",
        "age":          26,
        "name": {
            "full":     "John Smith",
            "first":    "John",
            "last":     "Smith"
        }
    }
}
```

# Inner Objects

```
PUT my_index/my_type/1
{
  "region": "US",
  "manager": {
    "age":     30,
    "name": {
      "first": "John",
      "last":  "Smith"
    }
  }
}
```

```
{
  "region":                "US",
  "manager.age":           30,
  "manager.name.first":    "John",
  "manager.name.last":     "Smith"
}
```

# Inner Objects

```
PUT my_index
{
  "mappings": {
    "my_type": {
      "properties": {
        "region": {
          "type": "keyword"
        },
        "manager": {
          "properties": {
            "age":  { "type": "integer" },
            "name": {
              "properties": {
                "first": { "type": "text" },
                "last":  { "type": "text" }
              }
            } ...
```

Duration: 30 min
03-indexing-data

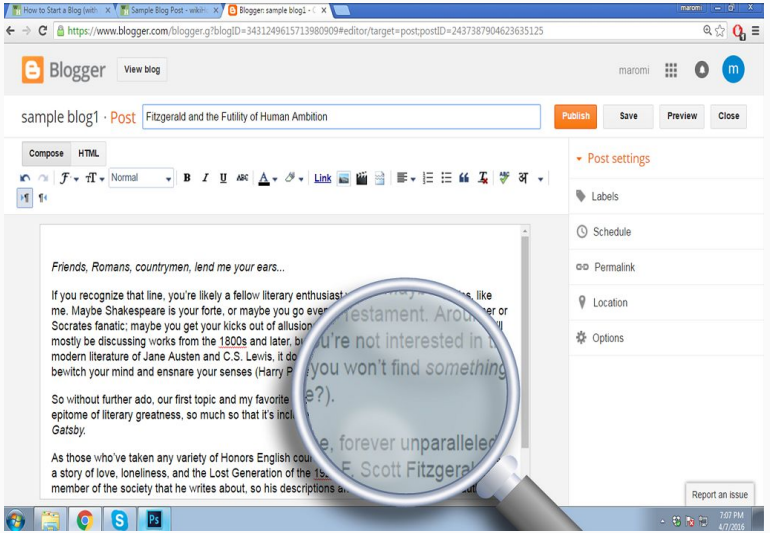
# Assignment 3 - Analyzers and Mappings

**Add search capabilities to a blog website**

Use appropriate datatypes for the index fields

Use appropriate Analyzers for the fields

Run defined queries to validate mapping definitions



# Elasticsearch Workshop

Afternoon

# Query DSL

# Full-Body Search

Search *lite*—a query-string search—is useful for ad hoc queries

To harness the full power of search, use the request body *search* API
Parameters are passed in the HTTP request body instead of in the query string

Request body search handles:

- the query itself, but also...
- return highlighted snippets from your results
- aggregate analytics across all results or subsets of results
- return did-you-mean suggestions, etc.

# Empty Search

```
GET /_search
{}
```

```
GET blog/_search
{
  "from": 30,
  "size": 10
}
```

```
POST blog/_search
{
  "from": 30,
  "size": 10
}
```

*Note: The HTTP libraries of certain languages don't allow `GET` requests to have a request body. The truth is that RFC 7231 does not define what should happen to a GET request with a body.*

Instead of the cryptic query-string approach, request body search allows writing queries by using the **query domain-specific language** - query DSL

# Query DSL

- The query DSL is a flexible
- expressive search language
- expose most of the power of Lucene through a simple JSON interface.
- you should be using it to write your queries in production
- makes your queries more flexible, more precise, easier to read, and easier to debug.

```
GET /_search
{
    "query": YOUR_QUERY_HERE
}
```

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

# Structure of a Query Clause

```
{
  QUERY_NAME: {
    ARGUMENT: VALUE,
    ARGUMENT: VALUE,...
  }
}
```

```
{
  "match": {
    "tweet": "elasticsearch"
  }
}
```

```
{
  QUERY_NAME: {
    FIELD_NAME: {
      ARGUMENT: VALUE,
      ARGUMENT: VALUE,...
    }
  }
}
```

```
GET /_search
{
  "query": {
    "match": {
      "tweet": "elasticsearch"
    }
  }
}
```

# Combining Multiple Clauses

*Query clauses* are simple building blocks to create complex queries:

- *Leaf* clauses (like the `match` clause)
- *Compound* clauses (combine other query clauses, like `bool`, `must` etc. or other compound clauses)

```
{
    "bool": {
        "must":     { "match": { "tweet": "elasticsearch" }},
        "must_not": { "match": { "name":  "mary" }},
        "should":   { "match": { "tweet": "full text" }},
        "filter":   { "range": { "age" : { "gt" : 30 }} }
    }
}
```

# Combining Multiple Clauses

The following query looks for emails that contain `business opportunity` and should either be starred, or be both in the Inbox and not marked as spam:

```
{
    "bool": {
        "must": { "match":    { "email": "business opportunity" }},
        "should": [
            { "match":        { "starred": true }},
            { "bool": {
                "must":       { "match": { "folder": "inbox" }},
                "must_not":   { "match": { "spam": true }}
            }}
        ],
        "minimum_should_match": 1
    }
}
```

# Most Important Queries

**match_all** Query:

```
{ "match_all": {}}
```

**match** Query:

```
{ "match": { "tweet": "About Search" }}

{ "match": { "age":    26           }}
{ "match": { "date":   "2014-09-01" }}
{ "match": { "public": true         }}
{ "match": { "tag":    "full_text"  }}
```

**multi_match** Query:

```
{
    "multi_match": {
      "query":    "full text search",
      "fields":   [ "title", "body" ]
    }
}
```

# Most Important Queries

**range** Query:

```
{ "range": {
    "age": {
      "gte":  20,
      "lt":   30
    }
  }
}
```

| | |
|---|---|
| `gt` | Greater than |
| `gte` | Greater than or equal to |
| `lt` | Less than |
| `lte` | Less than or equal to |

**term** Query:

```
{ "term": { "age":    26           }}
{ "term": { "date":   "2014-09-01" }}
{ "term": { "public": true         }}
{ "term": { "tag":    "full_text"  }}
```

**terms** Query:

```
{ "terms": { "tag": [ "search", "full_text", "nosql" ] }}
```

**exists** and **missing** Queries:

```
{ "exists": { "field": "title"} }
{ "missing": { "field": "title"} }
```

# Combining Queries Together - `bool` query

`bool` query combines multiple queries together in user-defined boolean combinations

```
{
    "bool": {
        "must":     { "match": { "title": "how to make millions" }},
        "must_not": { "match": { "tag":   "spam" }},
        "should": [
            { "match": { "tag": "starred" }},
            { "range": { "date": { "gte": "2014-01-01" }}}
        ]
    }
}
```

The relevance score is calculated for each sub-query and then merged together

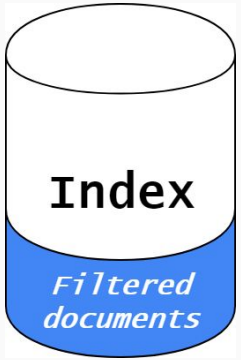
TIP

*If there are no `must` clauses, at least one `should` clause has to match. However, if there is at least one `must` clause, no `should` clauses are required to match.*

# Filtering Query

If we want that some sub-query does not affect total relevance score - **filtering query**

```
{
    "bool": {
        "must":     { "match": { "title": "how to make millions" }},
        "must_not": { "match": { "tag":   "spam" }},
        "should": [
            { "match": { "tag": "starred" }}
        ],
        "filter": {
          "range": { "date": { "gte": "2014-01-01" }}
        }
    }
}
```




Another benefit is increased performance by not calculating score and by caching

Use query clauses for *full-text* search or for any condition that should affect the *relevance score*, and use filters for everything else

# Query Context vs Filter Context

| query | filter |
| --- | --- |
| relevance | boolean yes/no |
| full text | exact values |
| not cached | cached |
| slower | faster |

*Filter first, then query remaining docs*

# Validating Queries

```
GET /gb/_validate/query
{
  "query": {
    "tweet" : {
      "match" : "really powerful"
    }
  }
}
```

```
{
  "valid" :          false,
  "_shards" : {
    "total" :        1,
    "successful" :   1,
    "failed" :       0
  }
}
```

```
GET /_validate/query?explain
{
  "query": {
    "match" : {
      "tweet" : "really powerful"
    }
  }
}
```

```
{
  "valid" :          true,
  "_shards" :        { ... },
  "explanations" : [ {
    "index" :        "us",
    "valid" :        true,
    "explanation" : "tweet:really tweet:powerful"
  }, {
    "index" :        "gb",
    "valid" :        true,
    "explanation" : "tweet:realli tweet:power"
  } ]
}
```

# Explain why a document (doesn't) match the given query

```
GET /us/_doc/1/_explain
{
   "query" : {
      "bool" : {
         "filter" : { "term" :  { "user_id" : 2           }},
         "must" :  { "match" : { "tweet" :   "honeymoon" }}
      }
   }
}
```

```
"failure to match filter: cache(user_id:[2 TO 2])"
```

# DEMO

## Query DSL

Trying out various queries using Query DSL

Duration: 30 min
04-query-dsl

# Assignment 4 - Query Data using Query DSL

Practice Elasticsearch Query DSL by Searching tweet messages.

# Sorting & Relevance

# Sorting

Default sorting in Elasticsearch (Lucene) is `_score` descending - the most relevant docs first

But you can also sort by any field value, use different sort options, use a script to calculate sort value, sort by geo coordinates etc.


**Memory Considerations**
When sorting, the relevant sorted field values are loaded into memory. This means that per shard, there should be enough memory to contain them. For string based types, the field sorted on should not be analyzed / tokenized. For numeric types, if possible, set the type to narrower types.

# Sorting Example

```
GET /my_index/_search
{
    "sort" : [
        { "post_date" : {"order" : "asc"}},
        "user",
        { "name" : "desc" },
        { "age" : "desc" },
        "_score"
    ],
    "query" : {
        "term" : { "user" : "kimchy" }
    }
}
```

| | |
|---|---|
| `asc` | Sort in ascending order |
| `desc` | Sort in descending order |

# Sorting Multi-Valued Fields (Sort Mode)

```
PUT /my_index/_doc/1?refresh
{
   "product": "chocolate",
   "price": [20, 4]
}

POST /_search
{
   "query" : {
      "term" : { "product" : "chocolate" }
   },
   "sort" : [
      {"price" : {"order" : "asc", "mode" : "avg"}}
   ]
}
```

| | |
|---|---|
| `min` | Pick the lowest value. |
| `max` | Pick the highest value. |
| `sum` | Use the sum of all values as sort value (num only). |
| `avg` | Use the average of all values as sort value (num only). |
| `median` | Use the median of all values as sort value (num only). |

# Script Based Sorting

https://qbox.io/blog/elasticsearch-scripting-sorting

```
GET /_search
{
    "query" : {
        "term" : { "user" : "kimchy" }
    },
    "sort" : {
        "_script" : {
            "type" : "number",
            "script" : {
                "lang": "painless",
                "source": "doc['field_name'].value * params.factor",
                "params" : {
                    "factor" : 1.1
                }
            },
            "order" : "asc"
        } } }
```

# Document Relevance

In order to sort by *relevance*, we need to represent relevance as a *value*

The higher the value - the more the document is relevant to the search

`_score` - *relevance score* is represented by the floating-point number

Default sorting in Elasticsearch (Lucene) is `_score` descending

# Calculating Document Relevance

How common is the term in this doc (term frequency)

-> more is better

How common is the term in ALL docs (Inverse document frequency)

-> less is better

How long is the doc?  (Length norm)

-> shorter is better

# Calculating Relevance in Bool Query

```
{
    "bool": {
        "must":     { "match": { "title": "how to make millions" }},
        "must_not": { "match": { "tag":   "spam" }},
        "should": [
            { "match": { "tag": "starred" }},
            { "range": { "date": { "gte": "2014-01-01" }}}
        ]
    }
}
```

`_score` of bool query = sum ( `_score` of each query)
* num of matching queries
/ num of queries

**more matching “should” queries == better relevance score**

# Boosting

We can control the relative weight of a query clause by specifying a **boost** value

A boost value greater than 1 increases the relative weight of that clause

Note that the increase or decrease is not linear
(`boost` of 2 does not double the `_score`)

The new `_score` is *normalized* after the boost is applied (complex algorithm)

Suffice to say that a higher `boost` value results in a higher `_score`

# Boosting

```
GET /_search
{
  "query": {
    "bool": {
      "should": [
        {
          "match": {
            "title": {
              "query": "quick brown fox",
              "boost": 2
            }
          }
        },
        {
          "match": {
            "content": "quick brown fox"
          }
        } ...
```

`title` query clause is twice as important as the `content` query clause, since it's boosted by factor 2

A query clause without a *boost* value has a neutral boos factor of 1

*Query-time boosting* is the main tool that you can use to tune relevance

Practically, there is no simple formula for deciding on the "correct" boost value for a particular query clause. It's a matter of try-it-and-see

# constant_score Query

Sometimes we just don't care about relevance the documents have for a query

We just want to know is that a certain word appears in a field

```
GET vacation_homes/_search
{
  "query": {
    "bool": {
      "should": [
        { "constant_score": {
          "query": { "match": { "description": "wifi" }}
        }},
        { "constant_score": {
          "query": { "match": { "description": "garden" }}
        }},
        { "constant_score": {
          "query": { "match": { "description": "pool" }}
        }}
      ] ...
```

# Relevance Tuning is the Last 10%

Understanding the score-generation process is critical to manipulate the score for your particular business domain

In practice, simple combinations of queries will get you good search results

To get *great* search results you'll need to play with different tuning methods

The best approach is to put instrumentation code in place and monitor what happens when you change some parameter

# DEMO

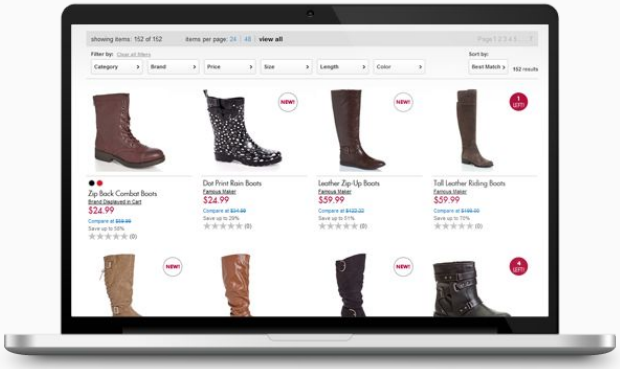
## Sorting & Relevance

Checking how relevance is calculated in different queries

Duration: 15 min
05-boosting

# Assignment 5 - Tweaking Relevance

As an e-commerce shop manager, tweak search queries to promote products which are on sale or are high in inventory



# Break

15 minutes

# Dealing with Human Languages

# Dealing with Human Languages

Full-text search is a battle between:

- *precision* — returning as few irrelevant documents as possible and
- *recall* — returning as many relevant documents as possible

By matching only the exact words user has queried, we would miss out many document the user would consider to be relevant

E.g. search for “quick brown fox” should match a document containing “fast brown foxes”, “Johnny Walker” to match “Johnnie Walker” etc.

# Dealing with Human Languages

If documents exist that *do* contain exactly what the user has queried, those documents should appear at the top of the result set

… but weaker matches can be included further down the list.

If no documents match exactly, at least we can show the user potential matches; they may even be what the user originally intended!

There are several lines of attack to this problem

# Dealing with Human Languages

- **Normalizing tokens**
  Remove diacritics like ´, ^, and ¨
- **Reducing words to their root form**
  Remove the distinction between singular and plural or between tenses
- **Stopwords**
  Remove commonly used words like `the`, `and`, `or` to improve search performance
- **Synonyms**
  Including synonyms so that a query for `quick` could also match `fast`
- **Typos and misspellings**
  Check for misspellings or alternate spellings, or match on homophones

# Language Analyzers

Elasticsearch ships with a collection of language analyzers

Out-of-the-box support for many of the world's most common languages

Arabic, Armenian, Basque, Brazilian, Bulgarian, Catalan, Chinese, Czech, Danish, Dutch, English, Finnish, French, Galician, German, Greek, Hindi, Hungarian, Indonesian, Irish, Italian, Japanese, Korean, Kurdish, Norwegian, Persian, Portuguese, Romanian, Russian, Spanish, Swedish, Turkish, and Thai

You can also customize existing or create your own language analyzers

# Language Analyzer

These analyzers typically perform four roles:

- Tokenize text into individual words

  `The quick brown foxes → [The, quick, brown, foxes]`

- Lowercase tokens

  `The → the`

- Remove common *stopwords*

  `[The, quick, brown, foxes] → [quick, brown, foxes]`

- Stem tokens to their root form

  `foxes → fox`

# Language Analyzer

Additional transformations may be executed, too:

- The `english` analyzer removes the possessive `'s`
  `John's → john`
- The `french` analyzer removes elisions `l'` and `qu'` and diacritics like ¨
  `l'église → eglis`
- The german analyzer normalizes terms, replacing ä and ae with a, or ß with ss, among others
  `äußerst → ausserst`

# Multi-language Case

The goal, although not always possible, should be to keep languages separate
Mixing languages in the same inverted index can be problematic

Approaches are (at indexing time):

- One predominant language per *document*
- One predominant language per *field*
- A mixture of languages per field

At query time:
Try detecting user language and search and return results in that language only

# Aggregations

# Aggregations

With aggregations, we zoom out to get an overview of our data.

Instead of looking for individual documents, we want to analyze and summarize our complete set of data

While the functionality is completely different from search, it leverages the same data-structures

Aggregations execute quickly and are *near real-time*, just like search

This is extremely powerful for reporting and dashboards

Aggregations are so powerful that many companies have built large Elasticsearch clusters solely for analytics

# High Level Concepts

Like the query DSL, aggregations have a composable syntax

There are only a few basic concepts to learn, but nearly limitless combinations of those basic components

Two main concepts are:

- **Buckets** - Collections of documents that meet a criterion
- **Metrics** - Statistics calculated on the documents in a bucket

Every **aggregation** is simply a combination of one or more buckets and zero or more metrics

Buckets are conceptually similar to grouping in SQL, while metrics are similar to `COUNT()`, `SUM()`, `MAX()`, and so forth

# Buckets

Because buckets can be nested, we can derive a much more complex aggregation:

1. Partition documents by country (bucket).
2. Then partition each country bucket by gender (bucket).
3. Then partition each gender bucket by age ranges (bucket).
4. Finally, calculate the average salary for each age range (metric)

This will give you the average salary per `<country, gender, age>` combination.

All in one request and with one pass over the data!

# DEMO

## Aggregations

Applying various metrics to buckets (grouped data)

Duration: 15 min
06-aggregating-data

# Assignment 6 - Aggregating Data

**Bank Accounts Balance Statistic Reporting**

Help Bank management to sell more credit loans

# Geo-spatial Searching

# Geolocation

Gone are the days when we wander around a city with paper map

I'm not interested in restaurants in London—I want to know about restaurants *within a 5-minute walk* of my *current location*.

But geolocation is only one part of the puzzle

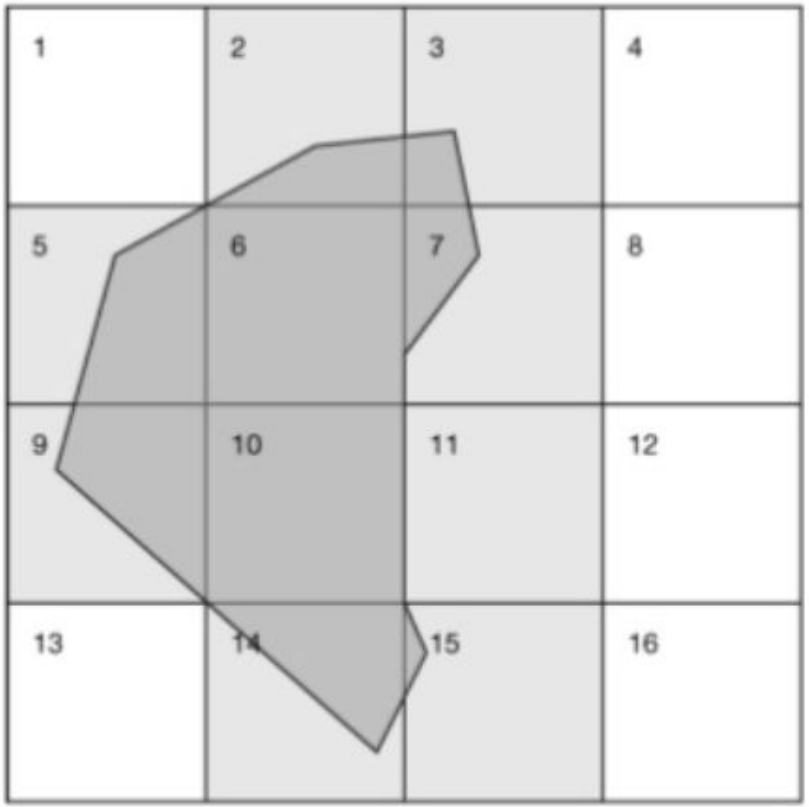
The beauty of Elasticsearch is that it allows you to combine geolocation with full-text search, structured search, and analytics

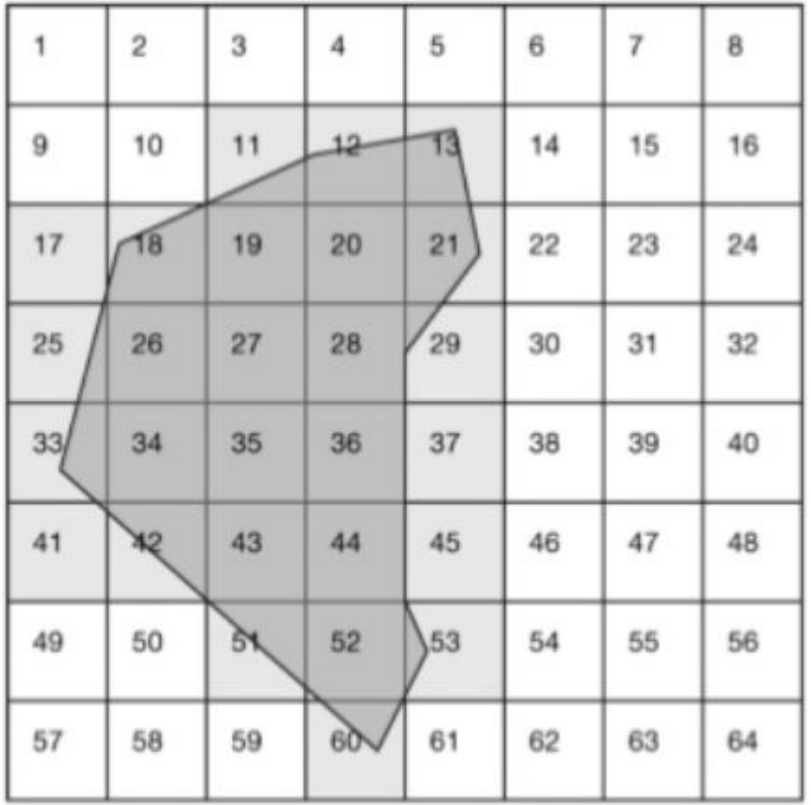
# Geolocation

Examples:

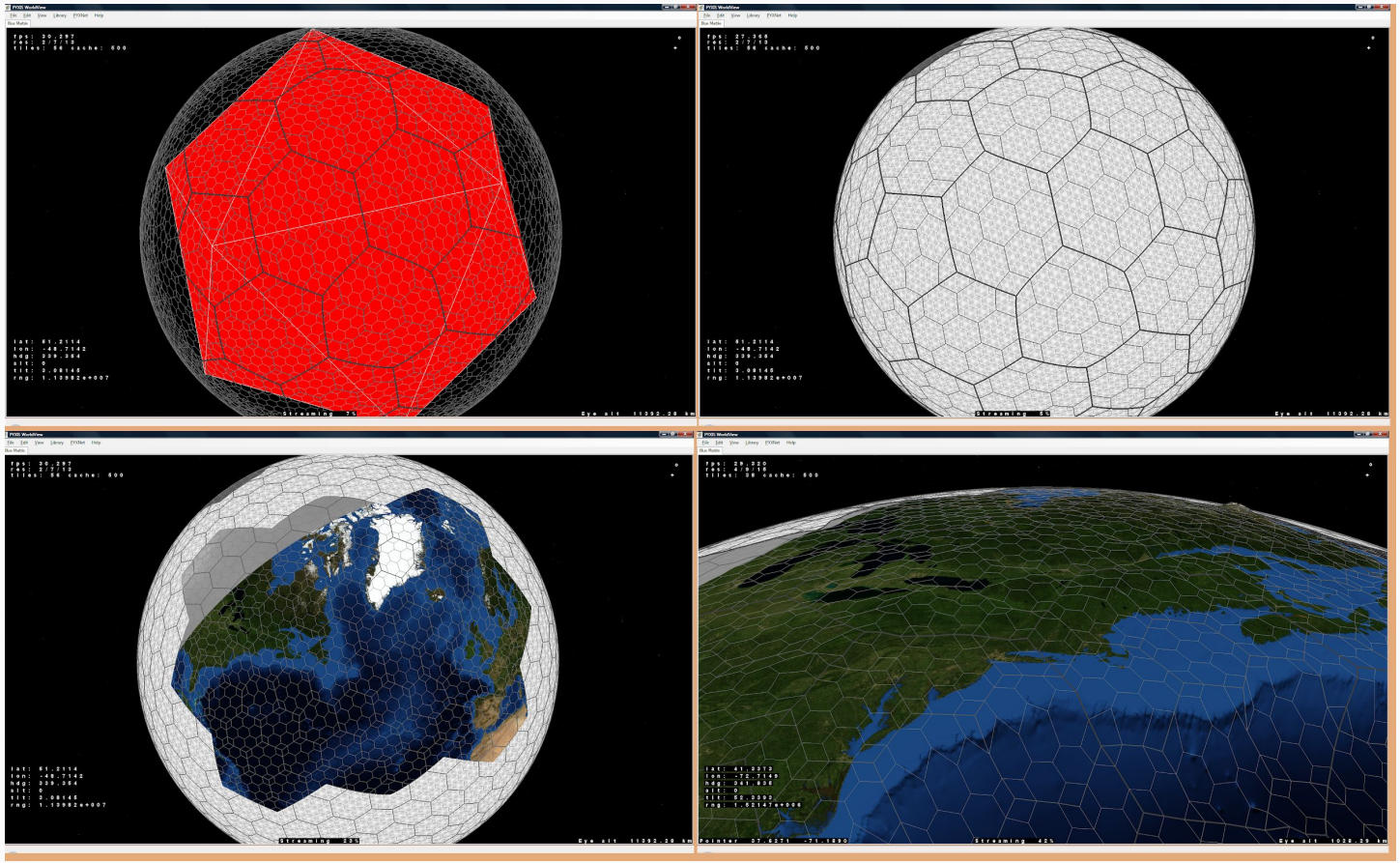
- show me restaurants that mention vitello tonnato, are within a 5-minute walk, and are open at 11 p.m., and then rank them by a combination of user rating, distance, and price
- show me a map of vacation rental properties available in August throughout the city, and calculate the average price per zone

# The Grid Structure of a Spatial Index



# The Grid Structure of a Spatial Index



# Geohashing

| City | Latitude, Longitude | Geohash |
|---|---|---|
| Belgrade | 44.7866, 20.4489 | srywc35hz |
| Nis | 43.3209, 21.8958 | srxw6q249 |
| Skopje | 41.9973, 21.4280 | srrnzt7kh |
| Minsk | 53.9045, 27.5615 | u9edejj8m |
| Brest | 52.0976, 23.7341 | u92bkh4ds |

http://geohash.org

# Geohashing

| geohash length | lat bits | lng bits | lat error | lng error | km error |
|---|---|---|---|---|---|
| 1 | 2 | 3 | ±23 | ±23 | ±2500 |
| 2 | 5 | 5 | ±2.8 | ±5.6 | ±630 |
| 3 | 7 | 8 | ±0.70 | ±0.70 | ±78 |
| 4 | 10 | 10 | ±0.087 | ±0.18 | ±20 |
| 5 | 12 | 13 | ±0.022 | ±0.022 | ±2.4 |
| 6 | 15 | 15 | ±0.0027 | ±0.0055 | ±0.61 |
| 7 | 17 | 18 | ±0.00068 | ±0.00068 | ±0.076 |
| 8 | 20 | 20 | ±0.000085 | ±0.00017 | ±0.019 |

| City | Latitude, Longitude | Geohash |
|---|---|---|
| Belgrade | 44.7866, 20.4489 | srywc35hz |
| Nis | 43.3209, 21.8958 | srxw6q249 |
| Skopje | 41.9973, 21.4280 | srrnzt7kh |
| Minsk | 53.9045, 27.5615 | u9edejj8m |
| Brest | 52.0976, 23.7341 | u92bkh4ds |

https://en.wikipedia.org/wiki/Geohash

# Representing Geolocations in Elasticsearch

`geo_points`

latitude-longitude points

`geo_shape`

complex shapes defined in GeoJSON

# Geo Points

```
PUT /attractions
{
  "mappings": {
      "properties": {
        "name": {
          "type": "text"
        },
        "location": {
          "type": "geo_point"
        }
      }
  }
}
```

```
PUT /attractions/_doc/1
{
  "name":     "Chipotle Mexican Grill",
  "location": "40.715, -74.011"
}

PUT /attractions/_doc/2
{
  "name":     "Pala Pizza",
  "location": {
    "lat":     40.722,
    "lon":    -73.989
  }
}

PUT /attractions/_doc/3
{
  "name":     "Mini Munchies Pizza",
  "location": [ -73.983, 40.719 ]
}
```

# Filtering by Geo Point

```
GET /attractions/_search
{
  "query": {
    "filtered": {
      "filter": {
        "geo_bounding_box": {
          "location": {
            "top_left": {
              "lat":  40.8,
              "lon": -74.0
            },
            "bottom_right": {
              "lat":  40.7,
              "lon": -73.0
            }
          }...
```

```
GET /attractions/_search
{
  "query": {
    "filtered": {
      "filter": {
        "geo_distance": {
          "distance": "1km",
          "location": {
            "lat":  40.715,
            "lon": -73.988
          }
        }
```

# Sorting by Distance

```
GET /attractions/_search
{
  "query": {
    "filtered": {
      "filter": {
        "geo_bounding_box": {
          "type":       "indexed",
          "location": {
            "top_left": {
              "lat":  40.8,
              "lon": -74.0
            },
            "bottom_right": {
              "lat":  40.4,
              "lon": -73.0
            }
          }...
```

```
...
},
  "sort": [
    {
      "_geo_distance": {
        "location": {
          "lat":  40.715,
          "lon": -73.998
        },
        "order":          "asc",
        "unit":           "km",
        "distance_type": "plane"
      }
    }
  ]
}
```

# Geo Aggregations

A search may return too many results to be able to display each geo-point

*Geo-aggregations* can be used to cluster geo-points into more manageable buckets

Three aggregations work with fields of type `geo_point`:

- `geo_distance` - Groups documents into concentric circles around a central point.
- `geohash_grid` - Groups documents by geohash cell, for display on a map.
- `geo_bounds` - Returns the lat/lon coordinates of a bounding box that would encompass all of the geo-points. This is useful for choosing the correct zoom level when displaying a map.

# Elasticsearch Java Clients

# Elasticsearch Clients

- Elasticserach Java Client
- JavaScript API
- Groovy API
- .NET API
- PHP API
- Perl API
- Python API
- Ruby API
- Community Contributed Clients

# Spring Data Elasticsearch

**Spring Data** project provides:

- Abstractions for different data stores
- Helps avoid boilerplate code
- Speciality of each store available
- Dynamic Repository implementations

  CRUD operations for the corresponding document class will be made available by default
- Popular modules
  - Spring Data JPA
  - Spring Data MongoDB

# Repository

```
public interface DishRepository
    extends ElasticsearchCrudRepository<Dish, String> { }
```

```
public interface DishRepository
  extends ElasticsearchCrudRepository<Dish, String> {

  List<Dish> findByFood(String food);

  List<Dish> findByTagsAndFavoriteLocation(String tag, String location);

  List<Dish> findByFavoritePriceLessThan(Double price);

  @Query("{"query": {"match_all": {}}}")
  List<Dish> customFindAll();
}
```

# Configuration

```
@Configuration
@EnableElasticsearchRepositories(basePackages = "com.company.spring.data.es.repository")
@ComponentScan(basePackages = {"com.company.spring.data.es.service"})
public class Config {
    @Bean
    public NodeBuilder nodeBuilder() {
        return new NodeBuilder();
    }
    @Bean
    public ElasticsearchOperations elasticsearchTemplate() {
        Settings.Builder elasticsearchSettings =
          Settings.settingsBuilder()
          .put("http.enabled", "false")
          .put("path.data", tmpDir.toAbsolutePath().toString())
          .put("path.home", "PATH_TO_YOUR_ELASTICSEARCH_DIRECTORY");
logger.debug(tmpDir.toAbsolutePath().toString());
         return new ElasticsearchTemplate(nodeBuilder()
          .local(true)
          .settings(elasticsearchSettings.build())
          .node()
          .client());
    }
}
```

# Entity

```
@Document(indexName = "blog", type = "article")
public class Article {

    @Id
    private String id;

    private String title;

    @Field(type = FieldType.Nested)
    private List<Author> authors;

    // standard getters and setters
}
```

# Indexing Documents

```
// creating an index
elasticsearchTemplate.createIndex(Article.class) ;

// indexing a document
Article article = new Article("Spring Data Elasticsearch") ;
article.setAuthors(asList(new Author("John Smith"), new Author("John
Doe")));
articleService.save(article) ;
```

# Querying

```
// method name-based query
String nameToFind = "John Smith" ;
Page<Article> articleByAuthorName
  = articleService.findByAuthorName(nameToFind, new PageRequest(0, 10)) ;

// a custom query
SearchQuery searchQuery = new NativeSearchQueryBuilder()
  .withFilter(regexpQuery("title", ".*data.*"))
  .build();
List<Article> articles = elasticsearchTemplate.queryForList(searchQuery,
Article.class);
```

# Updating and Deleting

```
String articleTitle = "Spring Data Elasticsearch";
SearchQuery searchQuery = new NativeSearchQueryBuilder()
  .withQuery(matchQuery("title", articleTitle).minimumShouldMatch("75%"))
  .build();
List<Article> articles = elasticsearchTemplate
     .queryForList(searchQuery, Article.class);

// now update the article
article.setTitle("Getting started with Search Engines");
articleService.save(article);

// delete a document
articleService.delete(articles.get(0));
```

# Thank you!