JOURNERA

Integrating Elasticsearch with Analytics Workflows

ODSC West
November 1, 2019

Stephanie Kirmer
@data_stephanie
github.com/skirmer/elastic_analytics

AGENDA

If you plan to follow along, get your downloads and installation done now! bit.ly/2LEEz8f

Introducing Elasticsearch

Overview

- Part of a family of data storage options called **NoSQL**
    - Not the same as tabular or SQL style data storage
    - Allows ingestion of masses of unstructured data quickly/flexibly
- Optimized for fast and **powerful searching**
- **Scales to "big data"**– but usable for small projects
- **Open source tool**

*Sometimes abbreviated "ES"

A Sidebar About “Search”

Searching	Not Searching (Querying, for example)
Accommodates uncertainty, ambiguity	Requires precise, specific, clear requests
Tries to help you figure out what you need	Extremely literal
Example: Googling “data storage ideas”	Example: Typing https://www.elastic.co/ in browser

Elasticsearch is designed to be great for searching

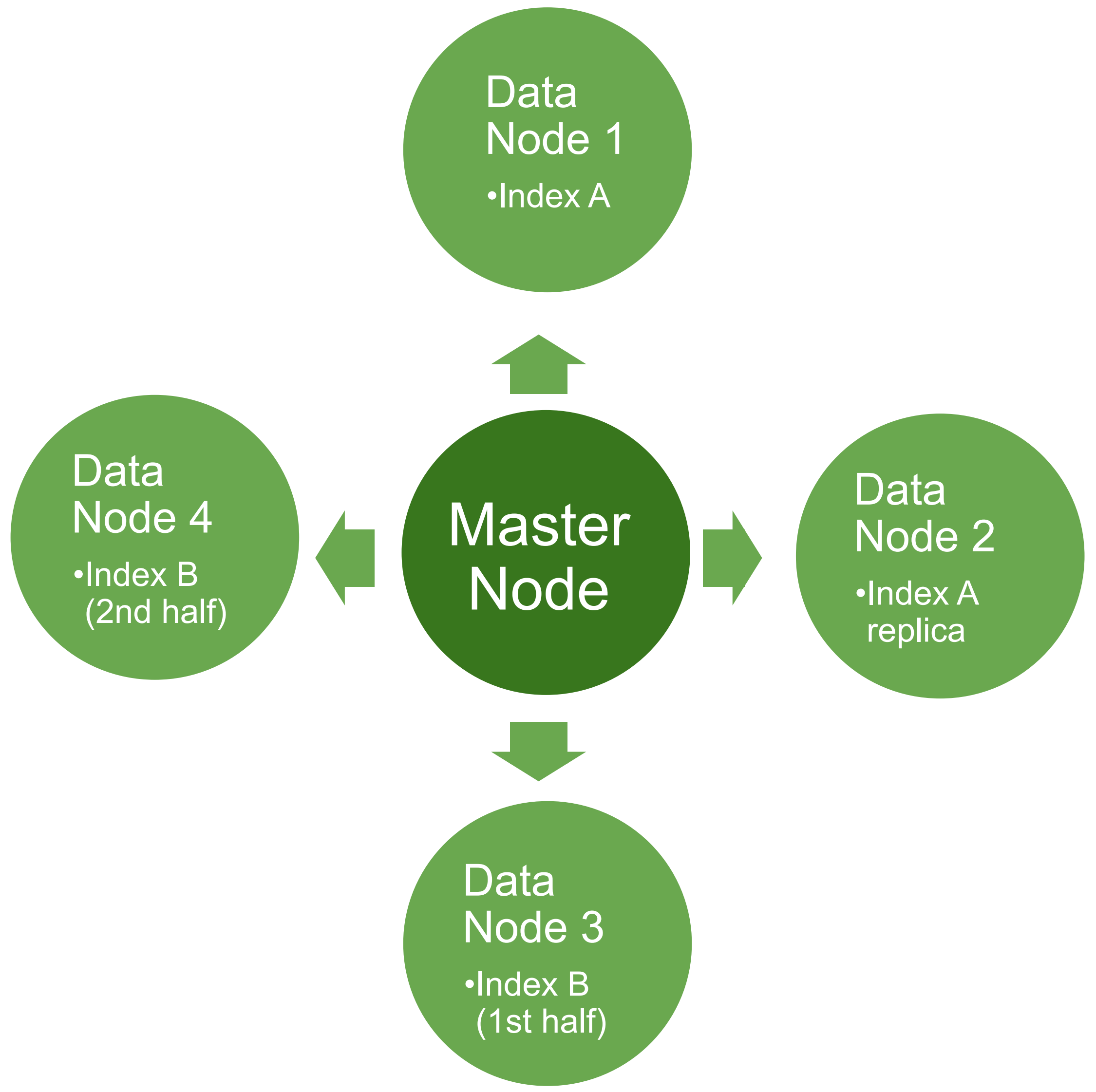
- Built on top of a technology called Lucene from Apache – Java only
- Allows easy API access to Lucene without Java

Elasticsearch (thanks to Lucene) can handle:

- Typos
- Wildcards
- Fuzzy matching
- Updating and searching simultaneously

Visualizing Elasticsearch Storage

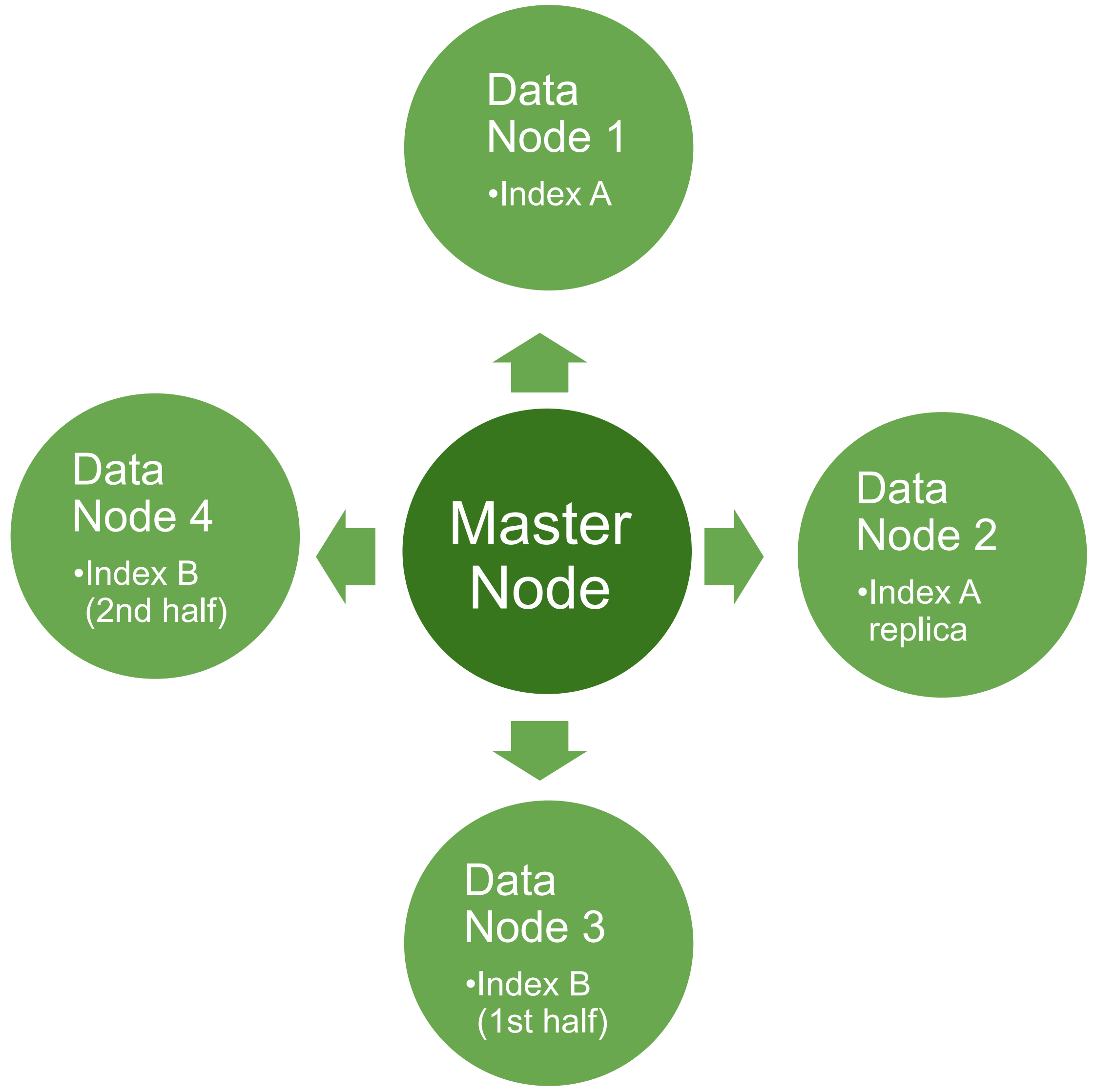
- **Cluster** = group of nodes
- **Master Node** = central manager
  - Manages indices
  - Tracks and organizes nodes
  - Decides which shards to allocate to nodes
- **Data Node** = where data is kept/handled
  - Search, aggregation functions



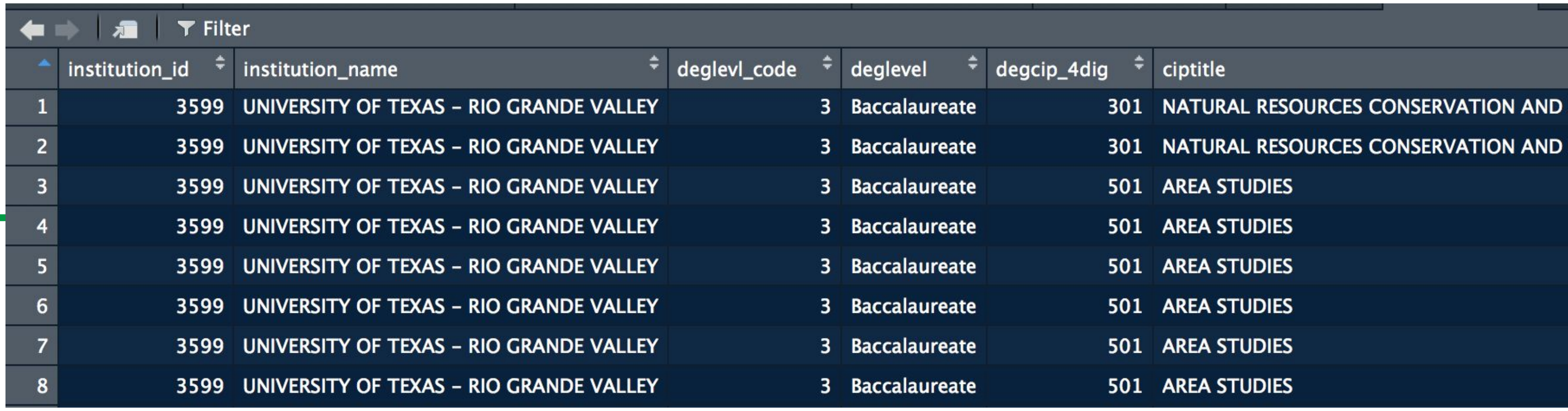
Visualizing Elasticsearch Storage

Data Architecture

- Data is divided into **indices**
- **Indices:**
  - Are user-defined groupings of data with some commonality
  - can live on one node, or
  - can be "sharded" and broken across nodes
  - can be duplicated on different nodes



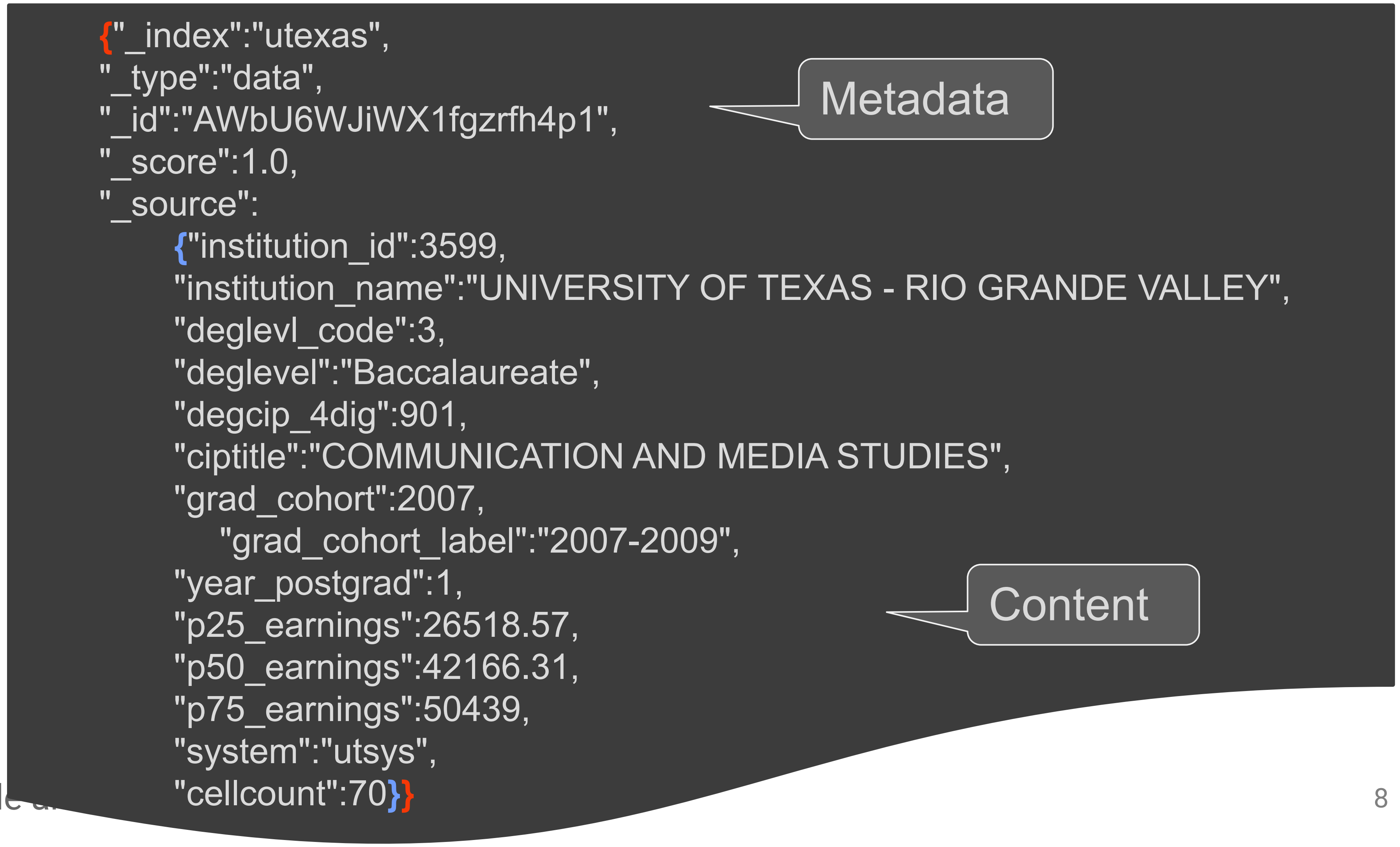
Tabular Data vs Document-Based Data



	institution_id	institution_name	deglevl_code	deglevel	degcip_4dig	ciptitle
1	3599	UNIVERSITY OF TEXAS – RIO GRANDE VALLEY	3	Baccalaureate	301	NATURAL RESOURCES CONSERVATION AND
2	3599	UNIVERSITY OF TEXAS – RIO GRANDE VALLEY	3	Baccalaureate	301	NATURAL RESOURCES CONSERVATION AND
3	3599	UNIVERSITY OF TEXAS – RIO GRANDE VALLEY	3	Baccalaureate	501	AREA STUDIES
4	3599	UNIVERSITY OF TEXAS – RIO GRANDE VALLEY	3	Baccalaureate	501	AREA STUDIES
5	3599	UNIVERSITY OF TEXAS – RIO GRANDE VALLEY	3	Baccalaureate	501	AREA STUDIES
6	3599	UNIVERSITY OF TEXAS – RIO GRANDE VALLEY	3	Baccalaureate	501	AREA STUDIES
7	3599	UNIVERSITY OF TEXAS – RIO GRANDE VALLEY	3	Baccalaureate	501	AREA STUDIES
8	3599	UNIVERSITY OF TEXAS – RIO GRANDE VALLEY	3	Baccalaureate	501	AREA STUDIES

Nested data

- metadata on outer layer (red braces)
- content on inner layer (blue braces)


Metadata
Content

```
{"_index":"utexas",
"_type":"data",
"_id":"AWbU6WJiWX1fgzrfh4p1",
"_score":1.0,
"_source":
        {"institution_id":3599,
        "institution_name":"UNIVERSITY OF TEXAS - RIO GRANDE VALLEY",
        "deglevl_code":3,
        "deglevel":"Baccalaureate",
        "degcip_4dig":901,
        "ciptitle":"COMMUNICATION AND MEDIA STUDIES",
        "grad_cohort":2007,
            "grad_cohort_label":"2007-2009",
        "year_postgrad":1,
        "p25_earnings":26518.57,
        "p50_earnings":42166.31,
        "p75_earnings":50439,
        "system":"utsys",
        "cellcount":70}}
```

Data courtesy of Annie Millerbernd of the San Antonio Express-News. You can learn more about it and see the original dataset here: https://data.world/amillerbernd/ut-system-post-grad-earnings

Code a

Why Use Elasticsearch?

Safe	Fast	Scalable	Flexible	Open Source
• Copying your data easily and conveniently (via replicas) = if a node fails, your data is safe	• ES can search in parallel on multiple nodes and replicas, and find your data faster	• Once you establish your ES database, you can add nodes and allow your database to grow	• Robust search helps you by discerning typos, ranking results, parsing text, and more	• Free to use at small scale, substantial documentation, community support

Among other reasons!

Code and Data: https://bit.ly/2LEEz8F

Query Language Crash Course

Elastic Query DSL (domain specific language): a JSON-style syntax built to interact with ES databases.

Why use query language?

Consistency across interfaces and media

Versatility and power in search, filtering, and aggregating – ES was built to work with this.

Downsides?

It’s sometimes hard to work with – idiosyncratic rules of syntax.

Changes happen – new version releases mean new rules

Follow Along!

When you see a slide with this gray header, try running the code yourself!

JOURNERA

System Requirements:

Docker installed and running

Repository ready: `git clone https://github.com/skirmer/elastic_analytics.git`

Setup Steps (see the README for commands to copy/paste)

Get into the top level of the cloned repo

At Terminal:

1. `./supporting_materials/setup_texas.sh 5.5`
2. `curl -X POST 'http://localhost:9200/utexas/_bulk' -H 'Content-Type: application/json' --data-binary @supporting_materials/ut_data.json`

Handy docker tips
`docker ps` to check your containers
`docker kill [name]` to hard shutdown your containers

Start up R/RStudio or your favorite Python IDE, and run further commands from there.

Libraries for R and Python

Choosing the right tool for your needs

Library Characteristics

Library	Returns	Query Language	Supports Authentication	R	Python
uptasticsearch	Tabular	Required	✗	●	●
elastic	JSON	Supported, not required	●	●	✗
elasticsearch-py	JSON	Supported, not required	●	✗	●

For python: `pip install [library name]` (use python3)
For R: `install.packages("[library_name]")`
uptasticsearch python: `https://github.com/uptake/uptasticsearch.git`

uptasticsearch welcomes public PRs!

KEY CONSIDERATIONS

Secure Authentication
Do you need to securely log in?

Output Format
Do you mind handling JSON output?

Query Construction
Is writing query language a barrier?

R Options

JOURNERA

Uptasticsearch (R)

```
test_up <- uptasticsearch::es_search(
   es_host = "http://localhost:9200"
   , es_index = "utexas"
   , query_body = query_string
   , size = 10)
```

```
query_string <- '{"query": {"match_all":{}}}'
```

Elastic (R)

```
conn = elastic::connect(es_host =
"http://localhost:9200")

test_e <- elastic::Search(index = "utexas"
   , body = query_string
   , size = 10
   , raw = TRUE
   , conn = conn)

test_e2 <-
jsonlite::fromJSON(test_e)$hits$hits
```

Non-Query Language Option:

```
test_e <- elastic::Search(
   index = "utexas"
   , q = "grad_cohort:*"
   , size = 10
   , conn = conn
   , raw = TRUE)
```

Python Options

JOURNERA

Uptasticsearch (Py)

Note: uptasticsearch is not on PYPI so you need to get it from github.

```
import json
import uptasticsearch

uptasticsearch.es_search(
   es_host="http://localhost:9200",
   query_body=query_string,
   es_index="utexas"
)
```

```
query_dict = {"query": {"match_all": {}}}
query_string = '{"query": {"match_all": {}}}'
```

Elasticsearch-py (Py)

```
from elasticsearch import Elasticsearch

es = Elasticsearch(['http://localhost:9200'])
res = es.search(
   index="utexas",
   body= query_dict
)

res['hits']['hits']
```

Tip! quickly format using
`from pandas.io.json import json_normalize`

Non-Query Language Option (Elasticsearch_dsl)

```
from elasticsearch_dsl import Search

res2 = Search(using = es).query("match", _index
= 'utexas').execute()
res2.to_dict()['hits']['hits']
```

Querying and Filtering

Identifying Available Fields

R:

```
uptasticsearch::get_fields(es_host = "http://localhost:9200",
es_indices = "utexas")
```

At Command Line:

```
curl http://localhost:9200/utexas/_mapping > fields.json
```

Constructing a Basic Query

Return all records :

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

```
query_dict = {"query": {"match_all": {}}}
query_string = '{"query": {"match_all": {}}}'
```

Constructing a Basic Query

Return all records :

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

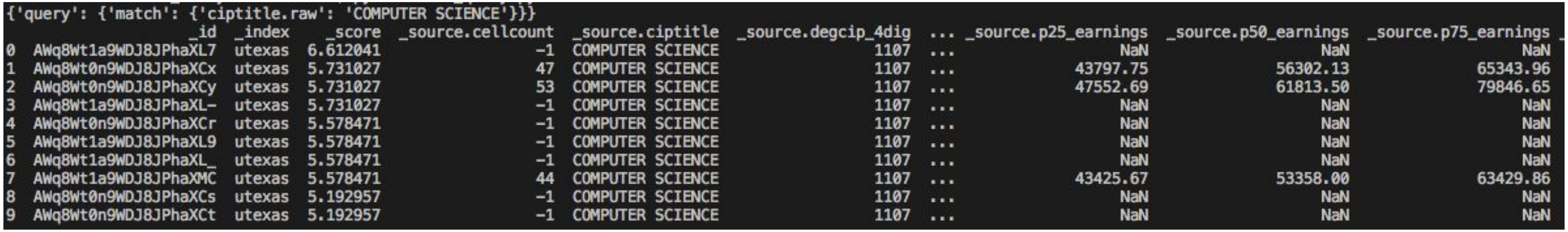
Constructing a Basic Query

Match one field :

```
{
"query": { "match": { "ciptitle.raw": "COMPUTER SCIENCE"} }
}
```

Tip: green text means something new has been added to the query

Result Sample



```
{'query': {'match': {'ciptitle.raw': 'COMPUTER SCIENCE'}}}
                  _id  _index    _score  _source.cellcount  _source.ciptitle  _source.degcip_4dig  ... _source.p25_earnings  _source.p50_earnings  _source.p75_earnings _
0  AWq8Wt1a9WDJ8JPhaXL7  utexas  6.612041                 -1  COMPUTER SCIENCE                 1107  ...                  NaN                   NaN                   NaN
1  AWq8Wt0n9WDJ8JPhaXCx  utexas  5.731027                 47  COMPUTER SCIENCE                 1107  ...             43797.75              56302.13              65343.96
2  AWq8Wt0n9WDJ8JPhaXCy  utexas  5.731027                 53  COMPUTER SCIENCE                 1107  ...             47552.69              61813.50              79846.65
3  AWq8Wt1a9WDJ8JPhaXL-  utexas  5.731027                 -1  COMPUTER SCIENCE                 1107  ...                  NaN                   NaN                   NaN
4  AWq8Wt0n9WDJ8JPhaXCr  utexas  5.578471                 -1  COMPUTER SCIENCE                 1107  ...                  NaN                   NaN                   NaN
5  AWq8Wt1a9WDJ8JPhaXL9  utexas  5.578471                 -1  COMPUTER SCIENCE                 1107  ...                  NaN                   NaN                   NaN
6  AWq8Wt1a9WDJ8JPhaXL_  utexas  5.578471                 -1  COMPUTER SCIENCE                 1107  ...                  NaN                   NaN                   NaN
7  AWq8Wt1a9WDJ8JPhaXMC  utexas  5.578471                 44  COMPUTER SCIENCE                 1107  ...             43425.67              53358.00              63429.86
8  AWq8Wt0n9WDJ8JPhaXCs  utexas  5.192957                 -1  COMPUTER SCIENCE                 1107  ...                  NaN                   NaN                   NaN
9  AWq8Wt0n9WDJ8JPhaXCt  utexas  5.192957                 -1  COMPUTER SCIENCE                 1107  ...                  NaN                   NaN                   NaN
```

Things to notice:

- Only Computer Science is shown
- NaNs are present in earnings, cellcount sometimes is -1

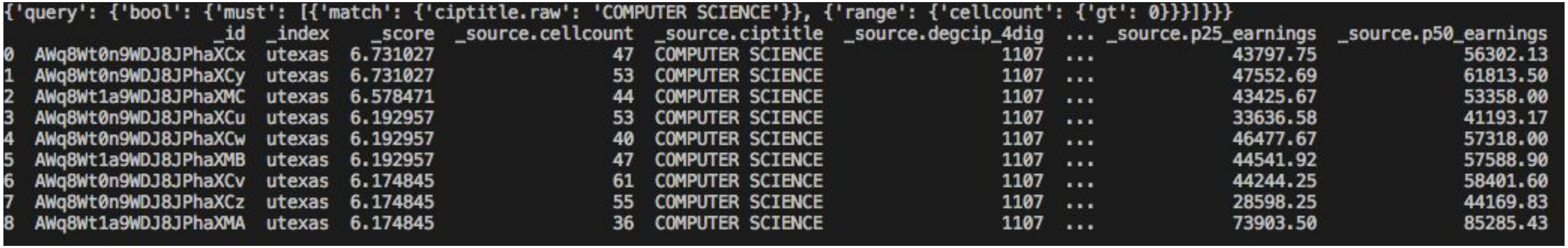
(this means redacted due to small group size)

Constructing a Basic Query

Match one field AND Greater Than one field :

```
{
"query":
   { "bool" : {
      "must" : [ { "match": { "ciptitle.raw": "COMPUTER SCIENCE" } }
             , { "range" : { "cellcount" : { "gt" : 0 } } } ]
   } }
}
```

Result Sample



```
{'query': {'bool': {'must': [{'match': {'ciptitle.raw': 'COMPUTER SCIENCE'}}, {'range': {'cellcount': {'gt': 0}}}]}}}
                    _id  _index     _score  _source.cellcount  _source.ciptitle  _source.degcip_4dig  ... _source.p25_earnings  _source.p50_earnings
0  AWq8Wt0n9WDJ8JPhaXCx  utexas  6.731027                 47  COMPUTER SCIENCE                 1107  ...              43797.75              56302.13
1  AWq8Wt0n9WDJ8JPhaXCy  utexas  6.731027                 53  COMPUTER SCIENCE                 1107  ...              47552.69              61813.50
2  AWq8Wt1a9WDJ8JPhaXMC  utexas  6.578471                 44  COMPUTER SCIENCE                 1107  ...              43425.67              53358.00
3  AWq8Wt0n9WDJ8JPhaXCu  utexas  6.192957                 53  COMPUTER SCIENCE                 1107  ...              33636.58              41193.17
4  AWq8Wt0n9WDJ8JPhaXCw  utexas  6.192957                 40  COMPUTER SCIENCE                 1107  ...              46477.67              57318.00
5  AWq8Wt1a9WDJ8JPhaXMB  utexas  6.192957                 47  COMPUTER SCIENCE                 1107  ...              44541.92              57588.90
6  AWq8Wt0n9WDJ8JPhaXCv  utexas  6.174845                 61  COMPUTER SCIENCE                 1107  ...              44244.25              58401.60
7  AWq8Wt0n9WDJ8JPhaXCz  utexas  6.174845                 55  COMPUTER SCIENCE                 1107  ...              28598.25              44169.83
8  AWq8Wt1a9WDJ8JPhaXMA  utexas  6.174845                 36  COMPUTER SCIENCE                 1107  ...              73903.50              85285.43
```

Things to notice:

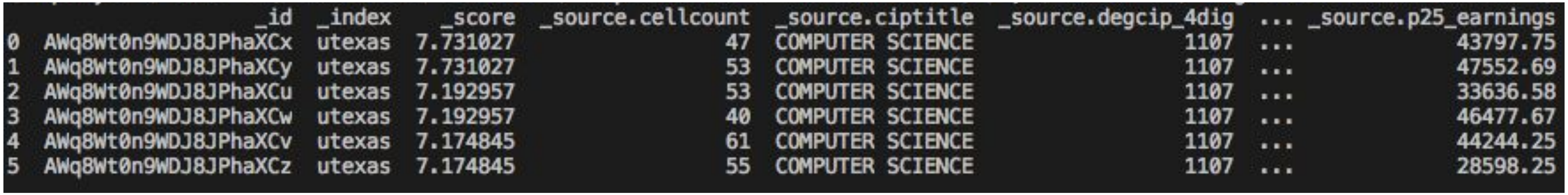
- Only Computer Science is shown
- Cellcount values are all above 0 - no more NaNs or -1

Constructing a Basic Query

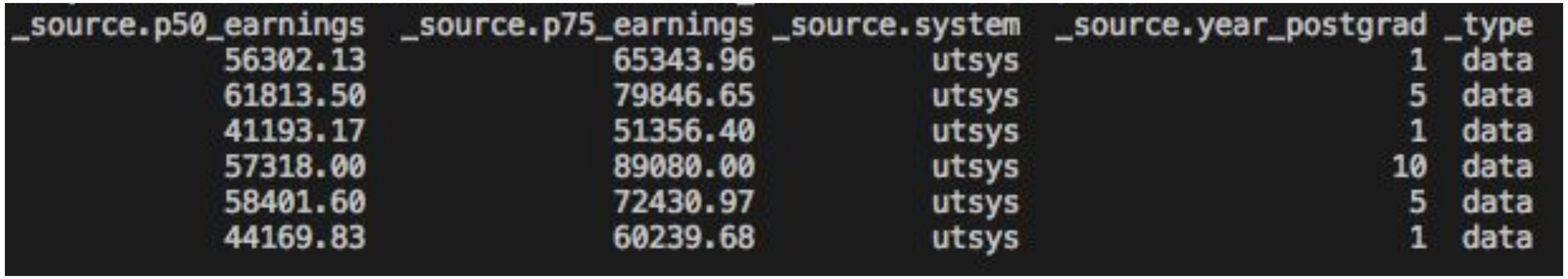
Match two fields AND Greater Than one field :

```
{
"query":
   { "bool" : {
      "must" : [ { "match": { "ciptitle.raw": "COMPUTER SCIENCE" } }
               , { "match": { "institution_id": "3599" } }
              , { "range" : { "cellcount" : { "gt" : 0 } } } ]
   } }
}
```

Result Sample



```
                    _id  _index     _score  _source.cellcount  _source.ciptitle  _source.degcip_4dig  ...  _source.p25_earnings
0  AWq8Wt0n9WDJ8JPhaXCx  utexas  7.731027                  47  COMPUTER SCIENCE                 1107  ...              43797.75
1  AWq8Wt0n9WDJ8JPhaXCy  utexas  7.731027                  53  COMPUTER SCIENCE                 1107  ...              47552.69
2  AWq8Wt0n9WDJ8JPhaXCu  utexas  7.192957                  53  COMPUTER SCIENCE                 1107  ...              33636.58
3  AWq8Wt0n9WDJ8JPhaXCw  utexas  7.192957                  40  COMPUTER SCIENCE                 1107  ...              46477.67
4  AWq8Wt0n9WDJ8JPhaXCv  utexas  7.174845                  61  COMPUTER SCIENCE                 1107  ...              44244.25
5  AWq8Wt0n9WDJ8JPhaXCz  utexas  7.174845                  55  COMPUTER SCIENCE                 1107  ...              28598.25
```



```
_source.p50_earnings  _source.p75_earnings _source.system  _source.year_postgrad _type
            56302.13              65343.96          utsys                      1  data
            61813.50              79846.65          utsys                      5  data
            41193.17              51356.40          utsys                      1  data
            57318.00              89080.00          utsys                     10  data
            58401.60              72430.97          utsys                      5  data
            44169.83              60239.68          utsys                      1  data
```

Things to notice:

- Only Computer Science is shown
- Cellcount values are all above 0
- Only UT-Rio Grande Valley is shown

Some Other Querying Options

match_phrase

Match a set of words all together.

exists

Supply a field, returns documents that have at least one non-null value in the original field.

wildcard

Pass a string with a wildcard anywhere – but be careful, it can be a slow search!

filter

Just like "must" except without scoring – we'll talk about this in a moment.

must_not

Instead of "must" – use to omit records with a word or phrase.

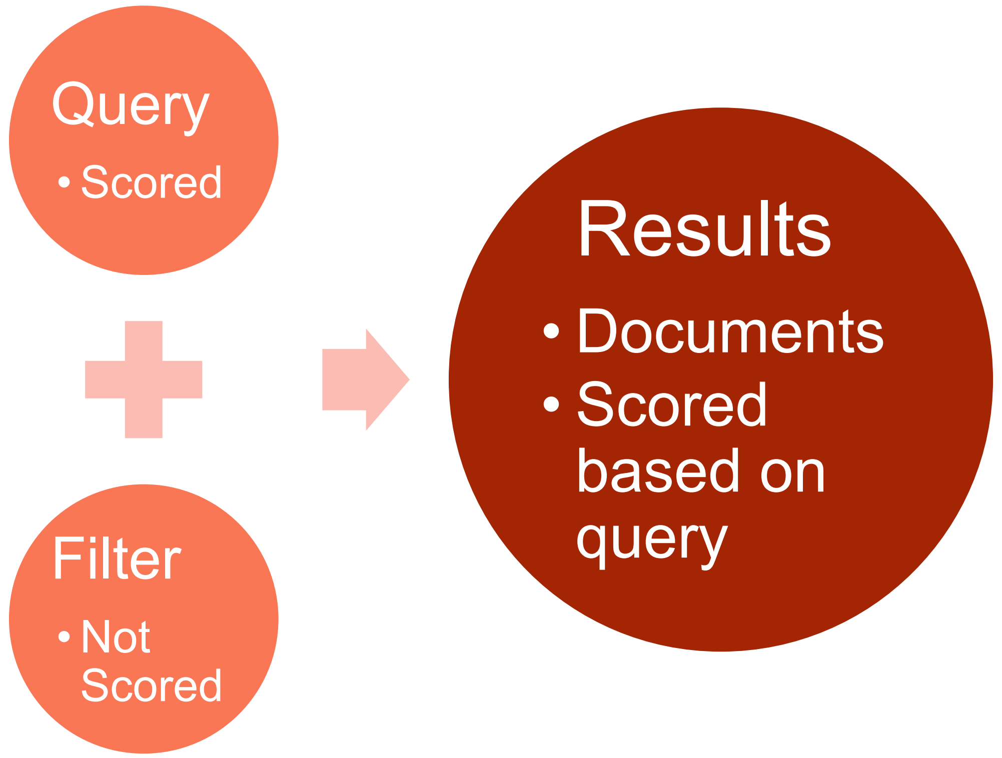
This is just a small sample- ES query language offers many very powerful search options!

Query vs Filter: Scoring Results

ES queries can provide a **numeric score** indicating how well the document meets the criteria given.

When you use **"query"** at the beginning of the query, you get a score returned alongside your results.

When you use **"filter",** Elasticsearch does not score the results on the given criteria.

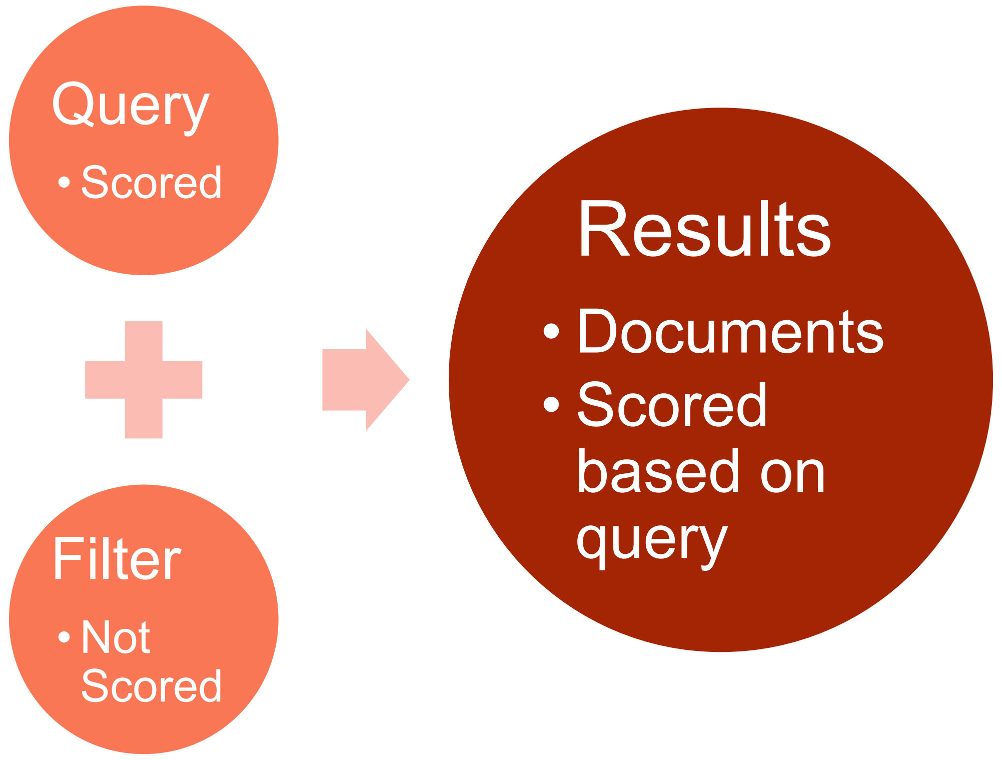


Query vs Filter: Example

Do we want scores returned for this search? Yes.

```
{ "query":
    { "bool": {
      "must":  [
          { "match": { "ciptitle.raw": "AREA STUDIES" } }
          , { "match": { "deglevel": "Baccalaureate" } }
      ]
      "filter": [
          { "match": {"institution_id": "3599" } }
      ]
    } }
}
```

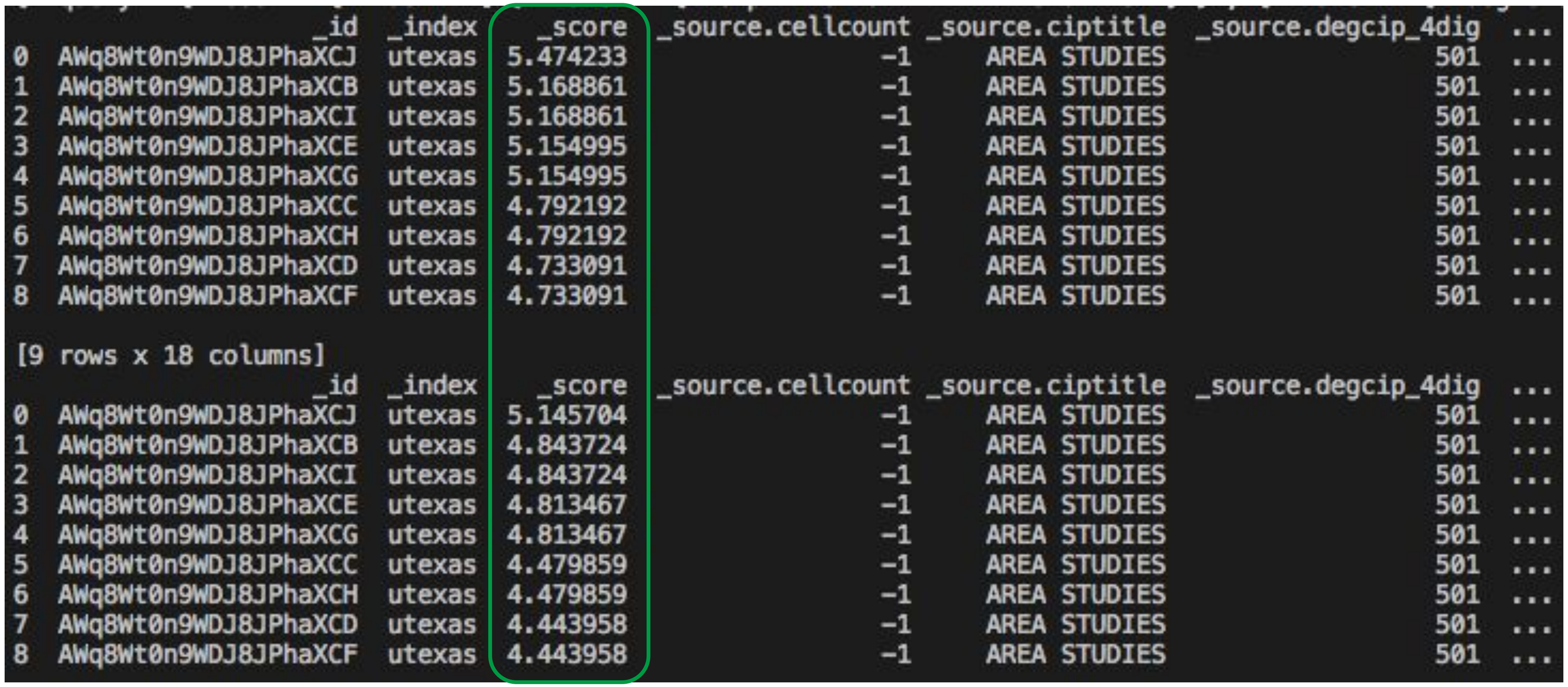
Do we want the scores to include this criterion? NO.



Code and Data: https://bit.ly/2LEEz8F

Query vs Filter: Example

Same query, first with two criteria scored (1 in filter) and second with only 1 criterion scored.



```
                     _id  _index     _score  _source.cellcount  _source.ciptitle  _source.degcip_4dig  ...
0  AWq8Wt0n9WDJ8JPhaXCJ   utexas  5.474233                 -1      AREA STUDIES                  501  ...
1  AWq8Wt0n9WDJ8JPhaXCB   utexas  5.168861                 -1      AREA STUDIES                  501  ...
2  AWq8Wt0n9WDJ8JPhaXCI   utexas  5.168861                 -1      AREA STUDIES                  501  ...
3  AWq8Wt0n9WDJ8JPhaXCE   utexas  5.154995                 -1      AREA STUDIES                  501  ...
4  AWq8Wt0n9WDJ8JPhaXCG   utexas  5.154995                 -1      AREA STUDIES                  501  ...
5  AWq8Wt0n9WDJ8JPhaXCC   utexas  4.792192                 -1      AREA STUDIES                  501  ...
6  AWq8Wt0n9WDJ8JPhaXCH   utexas  4.792192                 -1      AREA STUDIES                  501  ...
7  AWq8Wt0n9WDJ8JPhaXCD   utexas  4.733091                 -1      AREA STUDIES                  501  ...
8  AWq8Wt0n9WDJ8JPhaXCF   utexas  4.733091                 -1      AREA STUDIES                  501  ...

[9 rows x 18 columns]
                     _id  _index     _score  _source.cellcount  _source.ciptitle  _source.degcip_4dig  ...
0  AWq8Wt0n9WDJ8JPhaXCJ   utexas  5.145704                 -1      AREA STUDIES                  501  ...
1  AWq8Wt0n9WDJ8JPhaXCB   utexas  4.843724                 -1      AREA STUDIES                  501  ...
2  AWq8Wt0n9WDJ8JPhaXCI   utexas  4.843724                 -1      AREA STUDIES                  501  ...
3  AWq8Wt0n9WDJ8JPhaXCE   utexas  4.813467                 -1      AREA STUDIES                  501  ...
4  AWq8Wt0n9WDJ8JPhaXCG   utexas  4.813467                 -1      AREA STUDIES                  501  ...
5  AWq8Wt0n9WDJ8JPhaXCC   utexas  4.479859                 -1      AREA STUDIES                  501  ...
6  AWq8Wt0n9WDJ8JPhaXCH   utexas  4.479859                 -1      AREA STUDIES                  501  ...
7  AWq8Wt0n9WDJ8JPhaXCD   utexas  4.443958                 -1      AREA STUDIES                  501  ...
8  AWq8Wt0n9WDJ8JPhaXCF   utexas  4.443958                 -1      AREA STUDIES                  501  ...
```

```
"match": {
"deglevel":
"Baccalaureate”
}
```
In query (scored)

```
"match": {
"deglevel":
"Baccalaureate”
}
```
In filter (not scored)

Code and Data: https://bit.ly/2LEEz8F

Summarizing and Sorting

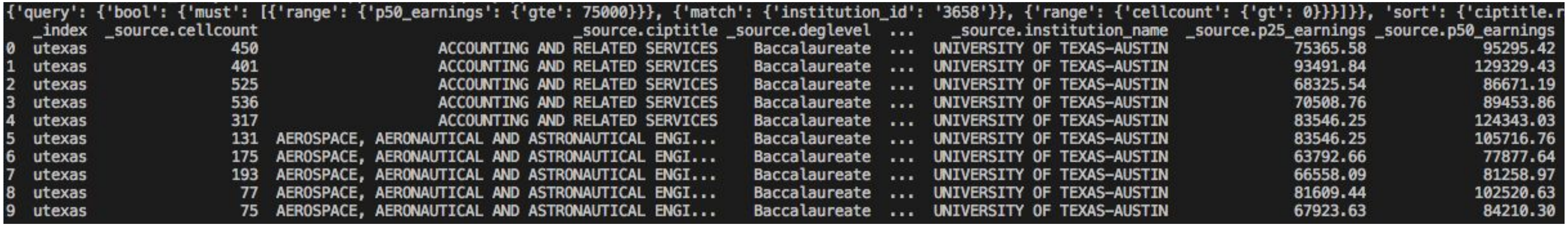
Get fancier with your searching!

Sorting in Query

Query, then sort the output

```
{ "query":
   { "bool" : {
      "must" : [ { "range": { "p50_earnings": { "gte" : 75000 } } }
               , { "match": { "institution_id": "3658" } }
                   , { "range": { "cellcount" : { "gt" : 0 } } } ]
   }
},
"sort": {
   "ciptitle.raw": "asc"
   }
}
```

Result Sample



```
{'query': {'bool': {'must': [{'range': {'p50_earnings': {'gte': 75000}}}, {'match': {'institution_id': '3658'}}, {'range': {'cellcount': {'gt': 0}}}]}}, 'sort': {'ciptitle.r
  _index  _source.cellcount                              _source.ciptitle _source.deglevel  ...    _source.institution_name  _source.p25_earnings  _source.p50_earnings
0  utexas                450                  ACCOUNTING AND RELATED SERVICES     Baccalaureate  ...  UNIVERSITY OF TEXAS-AUSTIN              75365.58              95295.42
1  utexas                401                  ACCOUNTING AND RELATED SERVICES     Baccalaureate  ...  UNIVERSITY OF TEXAS-AUSTIN              93491.84             129329.43
2  utexas                525                  ACCOUNTING AND RELATED SERVICES     Baccalaureate  ...  UNIVERSITY OF TEXAS-AUSTIN              68325.54              86671.19
3  utexas                536                  ACCOUNTING AND RELATED SERVICES     Baccalaureate  ...  UNIVERSITY OF TEXAS-AUSTIN              70508.76              89453.86
4  utexas                317                  ACCOUNTING AND RELATED SERVICES     Baccalaureate  ...  UNIVERSITY OF TEXAS-AUSTIN              83546.25             124343.03
5  utexas                131  AEROSPACE, AERONAUTICAL AND ASTRONAUTICAL ENGI...     Baccalaureate  ...  UNIVERSITY OF TEXAS-AUSTIN              83546.25             105716.76
6  utexas                175  AEROSPACE, AERONAUTICAL AND ASTRONAUTICAL ENGI...     Baccalaureate  ...  UNIVERSITY OF TEXAS-AUSTIN              63792.66              77877.64
7  utexas                193  AEROSPACE, AERONAUTICAL AND ASTRONAUTICAL ENGI...     Baccalaureate  ...  UNIVERSITY OF TEXAS-AUSTIN              66558.09              81258.97
8  utexas                 77  AEROSPACE, AERONAUTICAL AND ASTRONAUTICAL ENGI...     Baccalaureate  ...  UNIVERSITY OF TEXAS-AUSTIN              81609.44             102520.63
9  utexas                 75  AEROSPACE, AERONAUTICAL AND ASTRONAUTICAL ENGI...     Baccalaureate  ...  UNIVERSITY OF TEXAS-AUSTIN              67923.63              84210.30
```

Things to notice:

- ciptitle field is sorted alphabetically
- Only UT-Austin is shown
- p50_earnings are all above $75,000 as requested

Summarizing in Query

Summarize one field:

```
{
   "aggs": {
      "common_majors": {
         "terms": {
            "field": "ciptitle.raw"
         }
      }
   }
}
```

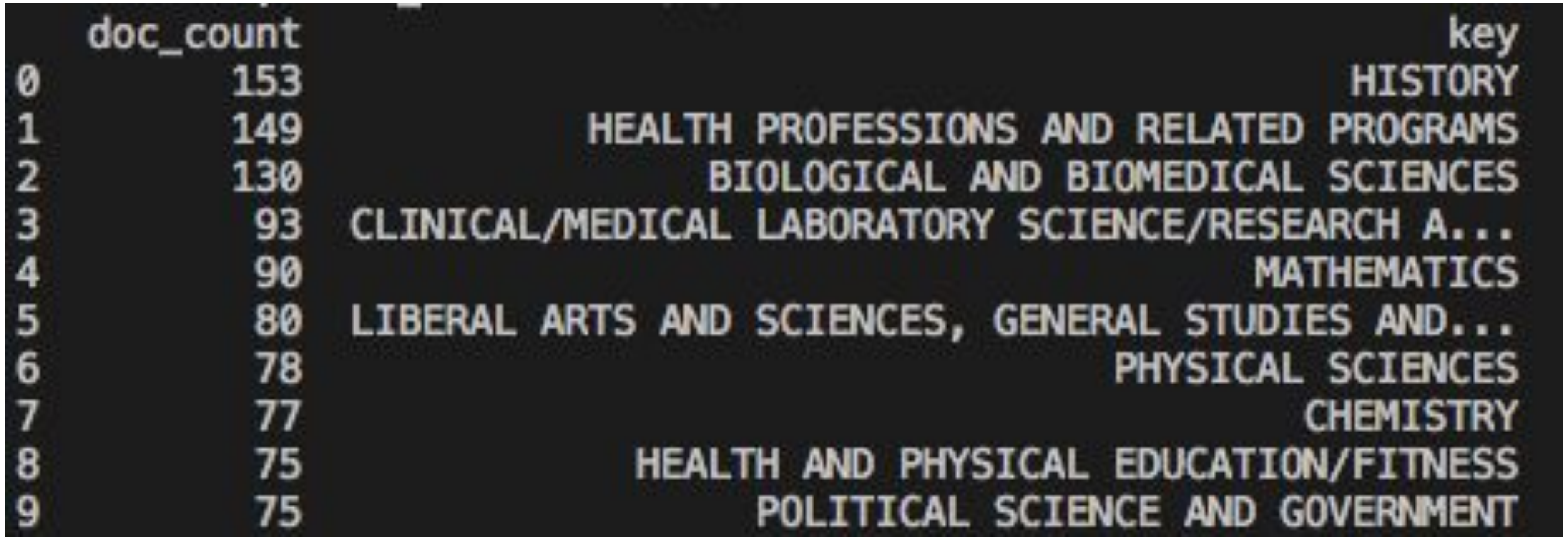
Create a new field called common_majors, which returns the number of records matching each value of ciptitle.raw.

Python Tip! Extract the correct piece of your query result:
`res['aggregations']['common_majors']['buckets']`

Code and Data: https://bit.ly/2LEEz8F

Result Sample

Produces:


```
   doc_count                                                 key
0        153                                             HISTORY
1        149            HEALTH PROFESSIONS AND RELATED PROGRAMS
2        130                BIOLOGICAL AND BIOMEDICAL SCIENCES
3         93  CLINICAL/MEDICAL LABORATORY SCIENCE/RESEARCH A...
4         90                                         MATHEMATICS
5         80  LIBERAL ARTS AND SCIENCES, GENERAL STUDIES AND...
6         78                                   PHYSICAL SCIENCES
7         77                                           CHEMISTRY
8         75              HEALTH AND PHYSICAL EDUCATION/FITNESS
9         75                     POLITICAL SCIENCE AND GOVERNMENT
```

Code and Data: https://bit.ly/2LEEz8F

Clean Up

At Terminal: `./supporting_materials/cleanup_local.sh`

This shuts down the docker container, destroying our demo database – but you can create it again just by going back to the beginning.

Further Reading

Explore More about Elasticsearch!

github.com/skirmer/elastic_analytics
www.stephaniekirmer.com
@data_stephanie

ES Query Language

- http://elasticsearch-cheatsheet.jolicode.com/
- https://elasticsearch-dsl.readthedocs.io/en/latest/search_dsl.html
- https://www.elastic.co/guide/en/elasticsearch/reference/current/_introducing_the_query_language.html
- https://www.elastic.co/guide/en/elasticsearch/reference/6.4/query-dsl-bool-query.html
- https://www.elastic.co/guide/en/elasticsearch/reference/6.4/query-filter-context.html
- https://logz.io/blog/elasticsearch-queries/

Library Docs

- https://elasticsearch-py.readthedocs.io/en/master/index.html
- https://github.com/ropensci/elastic
- https://github.com/UptakeOpenSource/uptasticsearch – Make contributions, the packages are always improving!

Data Credit:

The data being used in this tutorial is from data.world, and comes out of the hard work done by Annie Millerbernd of the San Antonio Express-News. You can learn more about it and see the original dataset here: https://data.world/amillerbernd/ut-system-post-grad-earnings

Thank You!

JOURNERA