Requirements & Configuration

In [1]:
```python
import urllib, urllib.request
import xmltodict
import json
import pymongo
import pandas as pd
import os
import matplotlib.pyplot as plt
import seaborn as sns
```

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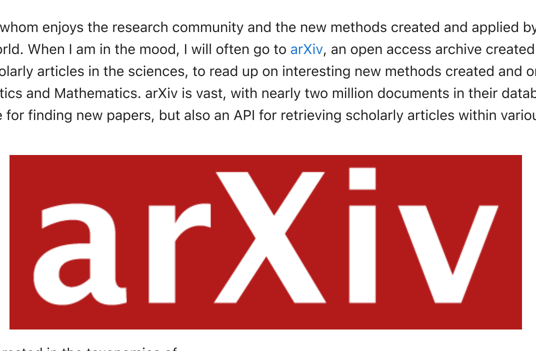
Overview

Personally, I am a person whom enjoys the research community and the new methods created and applied by researchers and developers around the world. When I am in the mood, I will often go to arXiv, an open access archive created and maintained by Cornell University for scholarly articles in the sciences, to read up on interesting new methods created and or applied within Computer Science, Statistics and Mathematics. arXiv is vast, with nearly two million documents in their database. Thankfully they not only have a search engine for finding new papers, but also an API for retrieving scholarly articles within various categories according to their taxonomy.



As stated above, I am interested in the taxonomies of:

Computer Science

- cs.AI = Artificial Intelligence
- cs.CE = Computational Engineering
- cs.DB = Databases
- cs.ET = Emerging Technologies
- cs.DC = Distributed Computing
- cs.LG = Machine Learning
- cs.IT = Information Theory

Statistics

- stat.AP = Statistical Applications
- stat.ML = Machine Learning
- stat.TH = Theory
- stat.ME = Methodology

Mathematics

- math.PR = Probability Theory
- math.ST = Mathematical Statistics

The goal of this project is to not only learn about MongoDB, but to also inform myself of relevant research articles and researchers in the areas I am interested in. However, due to the limiting factor of storage constraints on the free tier of MongoDB Atlas, only the top 1000 documents, **by relevance**, for each category were retrieved.

ETL

In the ETL phase, data is extracted from the arXiv database using their API. Then, the data is transformed into a JSON format and is then loaded into our MongoDB arXiv database. This is all done in one fell swoop with the *for loop* within the **get_arxiv()** function.

In [46]:
```python
# Database Information
cnx = 'mongodb+srv://gabe:gabe_mongo@arxiv.xawxi.mongodb.net/test'
# Connection to MongoDB
client = pymongo.MongoClient(cnx)
```

In [43]:
```python
# Access 'arXiv' database
db = client['arxiv']
```

In [47]:
```python
# Dropping all exisiting documents in the collections
db.Math.drop(), db.Statistics.drop(), db.ComputerScience.drop()
```

Out[47]:
```
(None, None, None)
```

Fetch and Insertion of Data

In [36]:
```python
# arXiv category taxonomy for the "for loop"
csCats = ['cs.AI', 'cs.CE', 'cs.DB', 'cs.ET', 'cs.DC', 'cs.LG', 'cs.IT']
statCats = ['stat.AP', 'stat.ML', 'stat.TH', 'stat.ME']
mathCats = ['math.PR', 'math.ST']
```

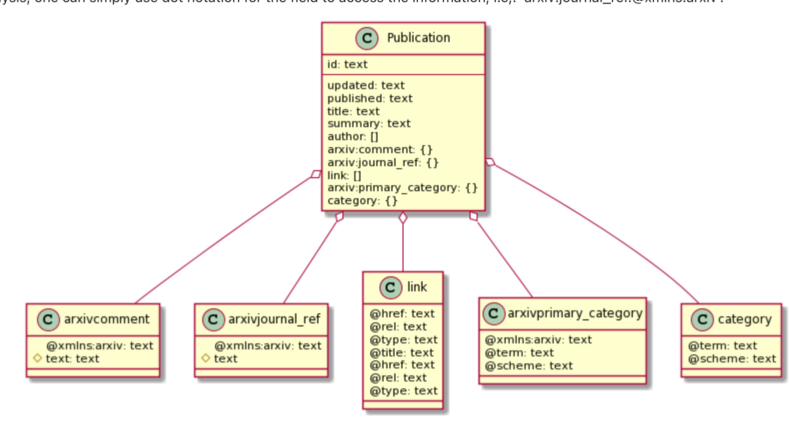
In [38]:
```python
def get_arxiv(db, collection, category=list, file=bool):

    if collection == 'Math':
        col = db.Math
    elif collection == 'ComputerScience':
        col = db.ComputerScience
    elif collection == 'Statistics':
        col = db.Statistics
    else:
        raise ValueError('Collection not in MongoDB')

    if type(category) != list:
        raise TypeError('Category is not in list format')
    else:
        for cat in category:
            url = 'http://export.arxiv.org/api/query?search_query=cat:{}&start=0&max_results=1000&sortBy=releva
            data = urllib.request.urlopen(url)
            arxiv_data = data.read().decode('utf-8')

            # Returned data is an "Atom Document" - convert to ordered dictionary
            arxiv_dict = xmltodict.parse(arxiv_data)

            # Converting to JSON
            arxivJSON = json.dumps(arxiv_dict, indent=4)

            # Decoding JSON
            arxiv_final = json.loads(arxivJSON)

            # Insert document into collection
            try:
                col.insert_many(arxiv_final['feed']['entry'])
                print('Document {} inserted into {} collection'.format(cat, collection))
            except:
                print('An error has occured')

            # Optional - write and save to file
            if file == True:
                with open('{}.json'.format(cat.replace('.', '_')), 'w') as write_file:
                    json.dump(arxiv_dict, write_file, indent=4)


    return arxiv_final
```

In [50]:
```python
math = get_arxiv(db, 'Math', mathCats, False)
cs = get_arxiv(db, 'ComputerScience', csCats, False)
stat = get_arxiv(db, 'Statistics', statCats, False)
```

```
Document math.PR inserted into Math collection
Document math.ST inserted into Math collection
Document cs.AI inserted into ComputerScience collection
Document cs.CE inserted into ComputerScience collection
Document cs.DB inserted into ComputerScience collection
Document cs.ET inserted into ComputerScience collection
Document cs.DC inserted into ComputerScience collection
Document cs.LG inserted into ComputerScience collection
Document cs.IT inserted into ComputerScience collection
Document stat.AP inserted into Statistics collection
Document stat.ML inserted into Statistics collection
Document stat.TH inserted into Statistics collection
Document stat.ME inserted into Statistics collection
```

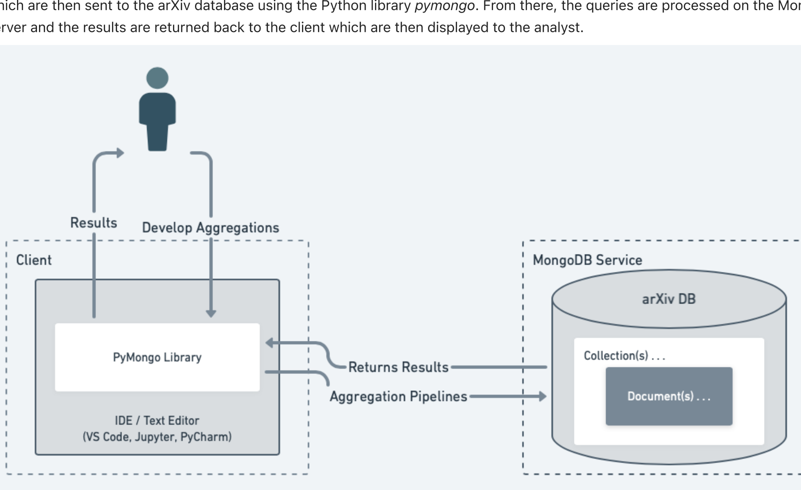
Document Structure

The documents returned by the arXiv API were converted to JSON format and straight away imported into their respective collection in the arXiv database. The class diagram below represents what a *single collection* looks like. However, all collections have the same structure. The '{}' indicates a nested substructure where the additional data is found linked below the main document (publication). A particularity worth noting is that the '@' in the nested substructure is a formatting design by arXiv where, as will be seen below in the analysis, one can simply use dot notation for the field to access the information, i.e,. 'arxiv:journal_ref.@xmlns:arxiv'.



Analysis

In performing analysis, the following system architecture was developed to gain a more intuitive understanding of how the Mongo aggregation pipelines were utilized. Starting with the analyst, they develop aggregation queries in their IDE or text editor of choice which are then sent to the arXiv database using the Python library *pymongo*. From there, the queries are processed on the MongoDB server and the results are returned back to the client which are then displayed to the analyst.



The queries designed here sometimes reflect my personal interests. For example, in regard to statistics, I classify myself as a Bayesian and thus, I have constructured a regex pipeline for finding any document containing Bayes, Bayesian or Bayesianism. Main aggregations are indicated by a numbered header and subsequent summary / objective of that aggregation pipeline.

In [51]:
```python
# View all of the collections in the MongoDB
db = client['arxiv']
collections = db.list_collection_names()
collections
```

Out[51]:
```
['Math', 'Statistics', 'ComputerScience']
```

In [52]:
```python
# Number of documents in each collection
db.Math.count_documents({}), db.ComputerScience.count_documents({}), db.Statistics.count_documents({})
```

Out[52]:
```
(2000, 7000, 4000)
```

1.) Author Occurences

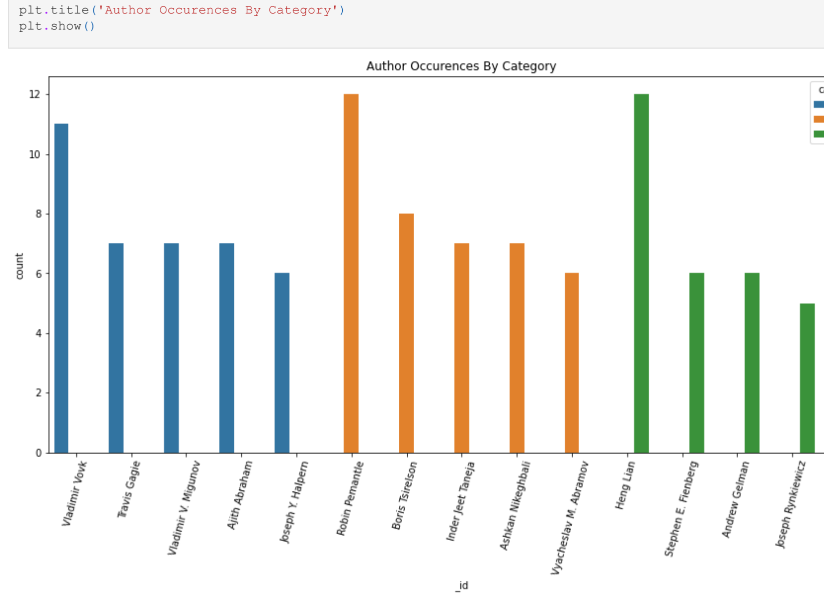
It is quite possible an author may appear more than once, i.e., more than one article posted on arXiv, so lets investigate this and visualize the top five authors from each category.

In [90]:
```python
def author_count(col, cat):
    project = {'$project': {'_id': 0, 'author.name':1}}
    unwind = {'$unwind': '$author.name'}
    groupby = {'$group': {'_id': '$author.name', 'count': {'$sum': 1}}}

    pipeline = [project, unwind, groupby]

    authors = col.aggregate(pipeline)

    authors = pd.DataFrame(authors)
    top5 = authors.nlargest(5, 'count')
    top5['category'] = cat

    return top5
```

In [91]:
```python
csAuthors = author_count(db.ComputerScience, 'CS')
mathAuthors = author_count(db.Math, 'Math')
statAuthors = author_count(db.Statistics, 'Stat')
```

In [93]:
```python
topAuthors = csAuthors.append([mathAuthors, statAuthors])
```

In [109…
```python
plt.figure(figsize=(15, 7))
sns.barplot(x='_id', y='count', data=topAuthors, hue='category')
plt.xticks(rotation=75)
plt.title('Author Occurences By Category')
plt.show()
```



2.) Kilian Q. Weinberger

Kilian is one of my favorite professors and machine learning researchers due to his ability to explain technical concepts in a simplified manner. In regard to the most relevant articles, does he show up here?

In [12]:
```python
# One of my favorite machine learning researchers at the moment - Does he have any relevant papers?
match = {'$match': {'author.name': 'Kilian Q. Weinberger'}}

project = {'$project': {'title': 1, 'published': 1, 'author.name': 1, '_id': 0}}

pipeline = [match, project]

# Support Vector Machines is actually a proprietary name owned by Oracle
for doc in db.ComputerScience.aggregate(pipeline):
    print(doc)
```

```
{'published': '2015-01-26T16:51:34Z', 'title': 'Compressed Support Vector Machines', 'author': [{'name': 'Zhixi
ang Xu'}, {'name': 'Jacob R. Gardner'}, {'name': 'Stephen Tyree'}, {'name': 'Kilian Q. Weinberger'}]}
```

3.) Bayes, Bayesian, Bayesianism

I really enjoy the Bayesian school of though when it comes to statistics and therefore I would like to query for articles in statistics that contain ^Bayes in the title. This regex command allows for any character after "Bayes" and I have a hunch that most of the articles will have "Bayesian" in the title.

In [9]:
```python
# Statistics papers with "Baye" in the title
project = {'$project': {'_id': 0,
                        'title': 1,
                        'author.name': 1}}

match = {'$match': {'title': {'$regex': '^Bayes'}}}

limit = {'$limit': 15}

pipeline = [project, match, limit]

# This is interesting; I may have to look into some of these papers
for doc in db.Statistics.aggregate(pipeline):
    print(doc)
```

```
{'title': 'Bayesball: A Bayesian hierarchical model for evaluating fielding in\n  major league baseball', 'auth
or': [{'name': 'Shane T. Jensen'}, {'name': 'Kenneth E. Shirley'}, {'name': 'Abraham J. Wyner'}]}
{'title': 'Bayesian multinomial regression with class-specific predictor selection', 'author': [{'name': 'Paul
Gustafson'}, {'name': 'Geneviève Lefebvre'}]}
{'title': 'Bayesian Classification and Regression with High Dimensional Features', 'author': {'name': 'Longhai
Li'}}
{'title': 'Bayesian Online Changepoint Detection', 'author': [{'name': 'Ryan Prescott Adams'}, {'name': 'David
J. C. MacKay'}]}
{'title': 'Bayesian Group Factor Analysis', 'author': [{'name': 'Seppo Virtanen'}, {'name': 'Arto Klami'}, {'na
me': 'Suleiman A. Khan'}, {'name': 'Samuel Kaski'}]}
{'title': 'Bayesian methods for low-rank matrix estimation: short survey and\n  theoretical study', 'author':
{'name': 'Pierre Alquier'}}
{'title': 'Bayesian estimation of possible causal direction in the presence of\n  latent confounders using a li
near non-Gaussian acyclic structural equation\n  model with individual-specific effects', 'author': [{'name':
'Shohei Shimizu'}, {'name': 'Kenneth Bollen'}]}
{'title': 'Bayesian Probabilistic Matrix Factorization: A User Frequency Analysis', 'author': [{'name': 'Cody S
everinski'}, {'name': 'Ruslan Salakhutdinov'}]}
{'title': 'Bayesian Poisson process partition calculus with an application to\n  Bayesian Lévy moving average
s', 'author': {'name': 'Lancelot F. James'}}
{'title': 'Bayesian-motivated tests of function fit and their asymptotic\n  frequentist properties', 'author':
[{'name': 'Marc Aerts'}, {'name': 'Gerda Claeskens'}, {'name': 'Jeffrey D. Hart'}]}
{'title': 'Bayesian analysis for reversible Markov chains', 'author': [{'name': 'Persi Diaconis'}, {'name': 'Si
lke W. W. Rolles'}]}
{'title': 'Bayesian Nonparametric Estimation of a Unimodal Density via two\n  $\\mathbf{S}$-paths', 'author':
{'name': 'Man-Wai Ho'}}
{'title': 'Bayesian transformation hazard models', 'author': [{'name': 'Gousheng Yin'}, {'name': 'Joseph G. Ibr
ahim'}]}
{'title': 'Bayesian shrinkage prediction for the regression problem', 'author': [{'name': 'Kei Kobayashi'}, {'n
ame': 'Fumiyasu Komaki'}]}
{'title': 'Bayesian Inference for Linear Dynamic Models with Dirichlet Process\n  Mixtures', 'author': [{'nam
e': 'François Caron'}, {'name': 'Manuel Davy'}, {'name': 'Arnaud Doucet'}, {'name': 'Emmanuel Duflos'}, {'nam
e': 'Philippe Vanheeghe'}]}
```

In [10]:
```python
# How many total articles have this feature?
bayes = [doc for doc in db.Statistics.aggregate(pipeline)]
print('The number of articles in Statistics with ^Bayes in the title is', len(bayes))
```

```
The number of articles in Statistics with ^Bayes in the title is 15
```

4.) Authors with articles in computer science and math

Mathematics and Computer Science complement each other and I was curious to if any authors have articles in both the relevant section computer science and mathematics? The desired output is the top three authors with the total occurences.

In [67]:
```python
stage_lookup = {
    '$lookup': {
        'from': 'Math',
        'localField': 'author.name',
        'foreignField': 'author.name',
        'as': 'same_author'
    }
}

match = {'$match': {'same_author.0': {'$exists': True}}}

project = {'$project': {'_id': 0, 'author.name':1}}

unwind = {'$unwind': '$author.name'}

group_by = {'$group': {'_id': '$author.name', 'count': {'$sum': 1}}}

limit = {'$limit': 3}

sort = {'$sort': {'count': -1}}

pipeline = [stage_lookup, match, project, unwind, group_by, sort, limit]

for doc in db.ComputerScience.aggregate(pipeline):
    print(doc)
```

```
{'_id': 'Vladimir Vovk', 'count': 11}
{'_id': 'Florentin Smarandache', 'count': 5}
{'_id': 'Pavel Chigansky', 'count': 1}
```

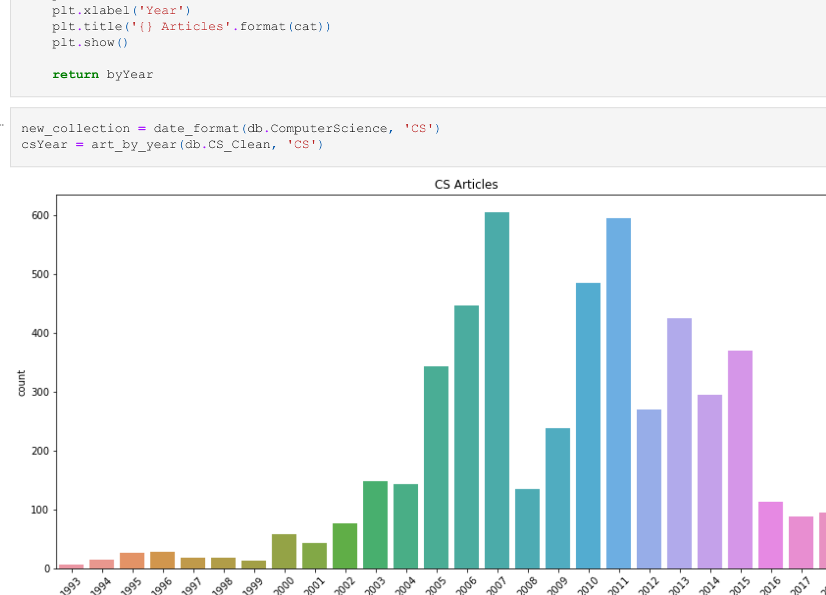
5.) Number of articles by year and by category

The goal is to count the number of documents by year in each category and to visualize the results. This will be an interesting aggregation since the API endpoint is by "relevance". Therefore, it may be that the most relevant articles are not the most recent ones.

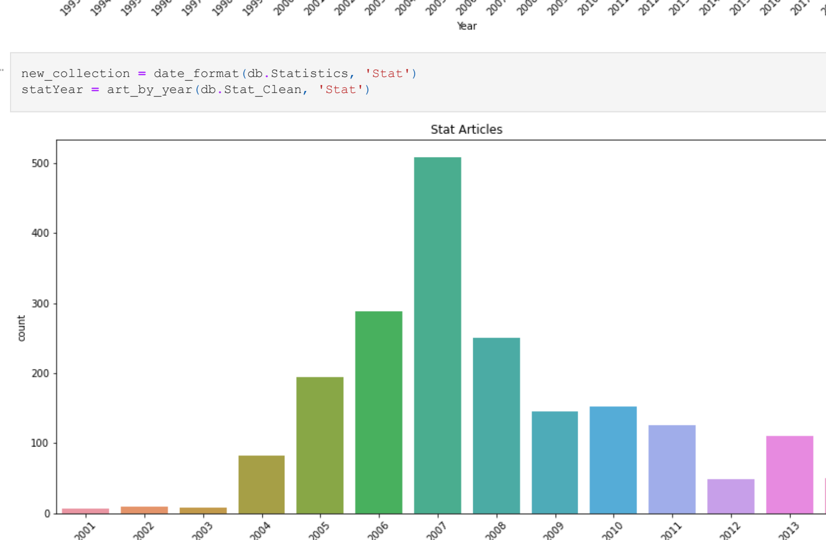
In [11]:
```python
def date_format(col, cat):
    """
    First the published field needs to be converted from a string to a date time data type

    return: new collection name resulting from new date type conversion
    """
    add_fields = {'$addFields': {
        'formatted_date': {
            '$dateFromString': {'dateString': '$published'}
        }}}

    out = {'$out': '{}_Clean'.format(cat)}

    date_format = [add_fields, out]

    for doc in col.aggregate(date_format):
        print(doc)

    return out['$out']
```

In [12]:
```python
def art_by_year(col, cat):
    project = {'$project': {'_id': 0}}
    group_by = {'$group': {'_id': {'year': {'$year': '$formatted_date'}},
                'count': {'$sum': 1}}}

    group_by_date = col.aggregate([project, group_by])
    byYear = pd.DataFrame(group_by_date)
    byYear['_id'] = pd.json_normalize(byYear['_id'])

    plt.figure(figsize=(15, 7))
    sns.barplot(x='_id', y='count', data=byYear)
    plt.xticks(rotation=45)
    plt.xlabel('Year')
    plt.title('{} Articles'.format(cat))
    plt.show()

    return byYear
```

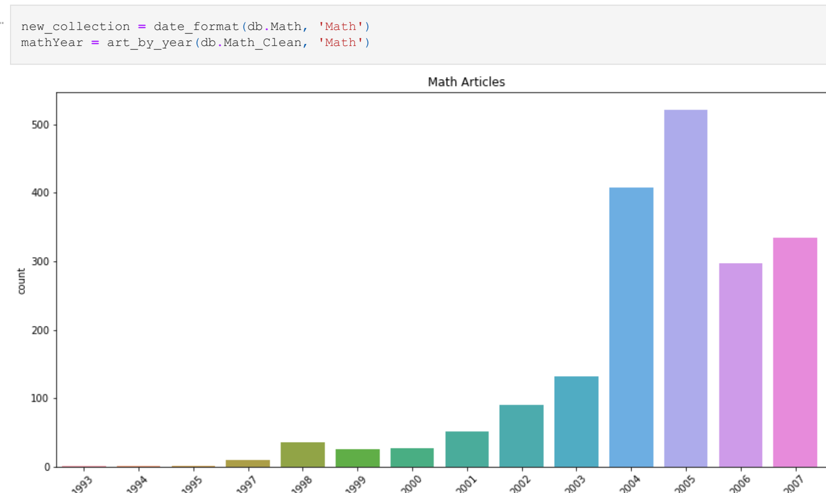
In [106…
```python
new_collection = date_format(db.ComputerScience, 'CS')
csYear = art_by_year(db.CS_Clean, 'CS')
```



In [107…
```python
new_collection = date_format(db.Statistics, 'Stat')
statYear = art_by_year(db.Stat_Clean, 'Stat')
```



In [108…
```python
new_collection = date_format(db.Math, 'Math')
mathYear = art_by_year(db.Math_Clean, 'Math')
```



Conclusion

In this project, I have learned, in more depth, about MongoDB and its document based schema, querying syntax, importing data and aggregation pipelines. Furthermore, the benefits of MongoDB are not limited to its schema, but also to its ability to scale horizontally, also known as "scale-out", which is primarily achieved through sharding - something that is not possible with traditinal relational database management systems (RDBMS).

In regard to my arXiv analysis, I came away with insights such as the most relevant articles in mathmematics and statistics were uploaded in the mid-2000's. Likewise, computer science wasn't far behind with the most publications in that category coming at the tail end of the 2000's until about 2014. This is maybe due to a couple factors; 1.) It may have to do with the way arXiv ranks the articles in their database, 2.) In research, their is something called the lindy effect which says the life span of an intangible "thing" is proportional to its current life.

The "join" statement in aggregation #4 informed us of the top 3 (well really top 2) authors with the most amount of total articles published in the category of mathematics and computer science. These two authors were Vladimir Vovk with 11 total counts and Florentin Smarandache with 5 total counts.

The aggregation pipeline involving regex allowed me to search for any paper with "Bayes" in the title. There were a lot of interesting papers in this query and one of those I downloaded - "Bayes, Jeffreys, Prior Distributions and the Philosophy of Statistics" by Andrew Gelman whom is a prominent statistician at Columbia University. My second favorite paper was "Bayesball: A Bayesian hierarchical model for evaluating fielding in major league baseball". Mainly because I wouldn't have thought to see a paper with "Bayes Ball" in the title.

A short, but also interesting query was searching for one of my favorite professors, Kilian Q. Weinberger, whom is from Germany but has been living in the United States and working at Cornell University for some time now. He had one article about Compressed Support Vector Machines.

Finally, we have the top 5 authors by occurence and category. It's ironic that the each of the first place authors in each category have about 10-12 counts. Again, in the statistics bar chart you can see Andrew Gelman. The others, I do not know.