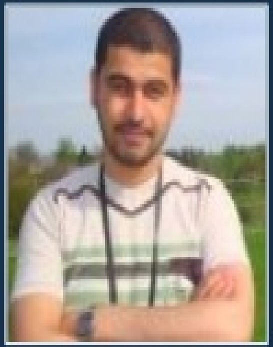
Fully Automated QA System for Large Scale Search and Recommendation Engines Using Spark

Khalifeh AlJadda
www.aljadda.com
Twitter: @aljadda

Mohammed Korayem
www.cs.indiana.edu/~mkorayem/

Search Data Science

About Me



Khalifeh AlJadda

Lead Data Scientist, Search Data Science

CAREERBUILDER

- Joined CareerBuilder in 2013
- **PhD, Computer Science – University of Georgia (2014)**
- **BSc, MSc, Computer Science, Jordan University of Science and Technology**

Activities:

- Founder and Chairman of CB Data Science Council
- Frequent public speaker in the field of data science
- Creator of GELATO (Glycomic Elucidation and Annotation Tool)

CAREERBUILDER Search by the Numbers

100 million +
Searches per day

1,5 billion +
Documents indexed and searchable

500+
Search Servers

30+
Software Developers, Data Scientists + Analysts

1
Global Search Technology platform

Powering 50+ Search Experiences Including:

Search Pro
(Search-CareerBuilder RDB, Recruitment Edge, Supply & Demand)

Small Business Resume Database
(Search Basic, RDB Basic)

Talentstream Engage
(Talent Network)

Talentstream Recruit

Talentstream Supply & Demand
(Supply & Demand Portal)

Candidate Sourcing Platform

Broadbean Resume Search
(Multi-vendor Resume Search)

Talentstream Gather

CAREERBUILDER

workinretail.com
Retail jobs. Retail talent.

StaffNurse.com
Nursing & Healthcare Jobs
A CareerBuilder Company

Lesjeudis.com

JOBSCENTRAL

OILANDGAS JOBSEARCH

WorkInNursingJobs.com

phonemploi.com

RecruLex.com

erecrut.com
Emploi Commerce · Vente

MiracleWorkers.com

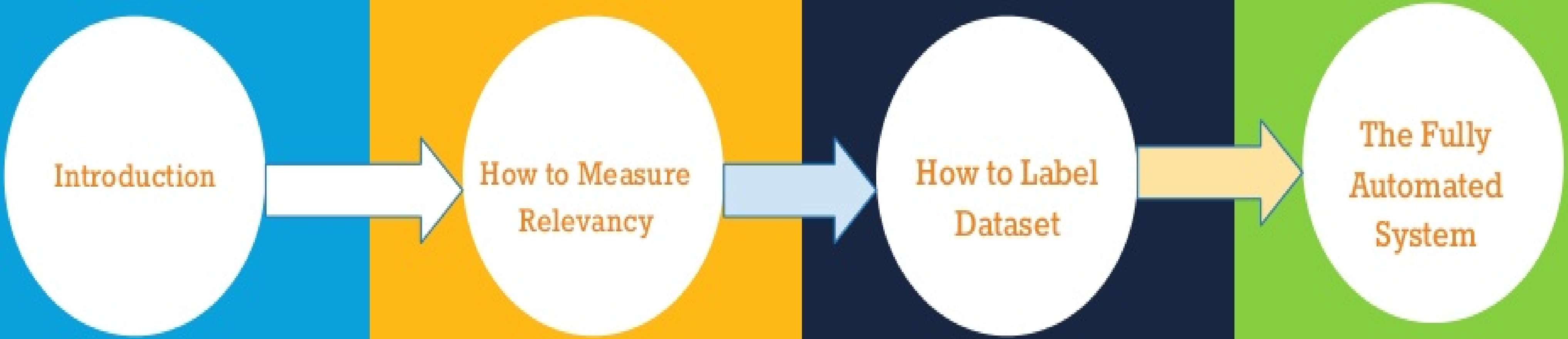
sologig.com

HEADHUNTER.com

MoneyJobs

CAO emplois.com

Talk Flow


Introduction

How to Measure Relevancy

How to Label Dataset

The Fully Automated System

Introduction

CAREER BUILDER™

What is Information Retrieval (IR)?

Information retrieval (IR) is finding material (usually documents) of an unstructured nature (usually text) that satisfies an information need from within large collections (usually stored on computers).*

*introduction to information retrieval: http://nlp.stanford.edu/IR-book/pdf/irbookprint.pdf

Information Retrieval (IR) vs Relational Database (RDB)

	RDB	IR
Objects	Records	Unstructured Documents
Model	Relational	Vector Space
Main Data Structure	Table	Inverted Index
Queries	SQL	Free text

The inverted index

What RDB would store:

Document ID	Content Field
doc1	once upon a time, in a land far, far away
doc2	the cow jumped over the moon.
doc3	the quick brown fox jumped over the lazy dog.
doc4	the cat in the hat
doc5	The brown cow said “moo” once.
…	…

How the content is INDEXED into Inverted Index:

Term	Documents
a	doc1 $_{[2x]}$
brown	doc3 $_{[1x]}$, doc5 $_{[1x]}$
cat	doc4 $_{[1x]}$
cow	doc2 $_{[1x]}$, doc5 $_{[1x]}$
…	…
once	doc1 $_{[1x]}$, doc5 $_{[1x]}$
over	doc2 $_{[1x]}$, doc3 $_{[1x]}$
the	doc2 $_{[2x]}$, doc3 $_{[2x]}$, doc4 $_{[2x]}$, doc5 $_{[1x]}$
…	…

Vocabulary

Relevancy: Information need satisfaction

Precision: Accuracy

Recall: Coverage

Search: Find documents that match a user’s query

Recommendation: Leveraging context to automatically suggest relevant results

How to Measure Relevancy

Motivation

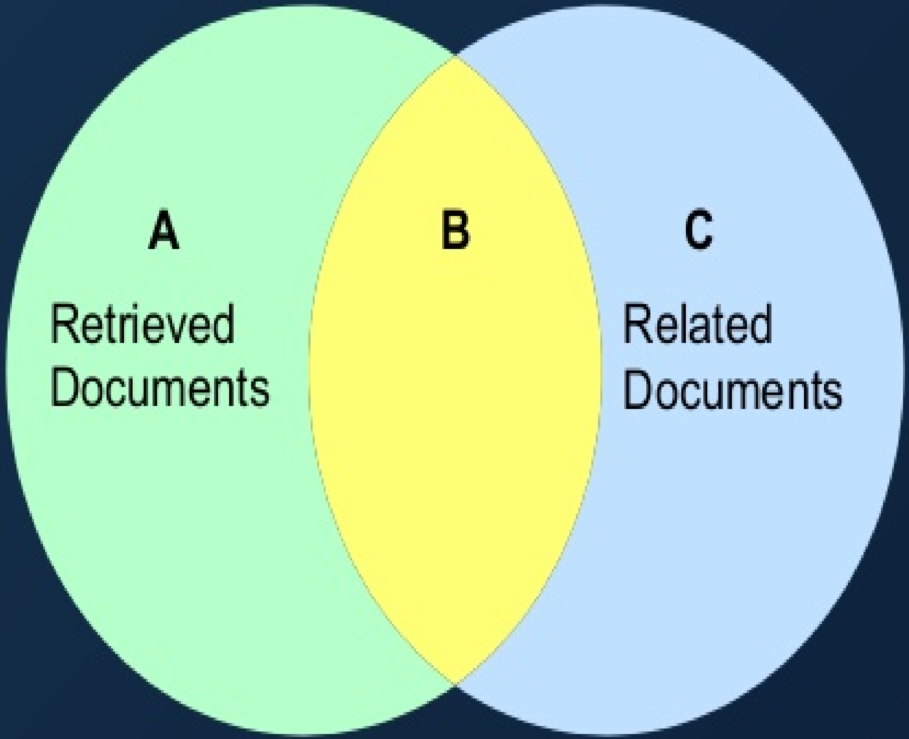
Users will turn away if they get irrelevant results

New algorithms and features need test

A/B test is expensive since it has impact on the end users

A/B test requires days before a conclusion can be made

How to Measure Relevancy?



Precision = B/A

Recall = B/C

F1 = 2 * (Prec * Rec) / (Prec+Rec)

Assumption:

We have only 3 jobs for aquatic director in our Solr index

Precision = 2/4 = 0.5

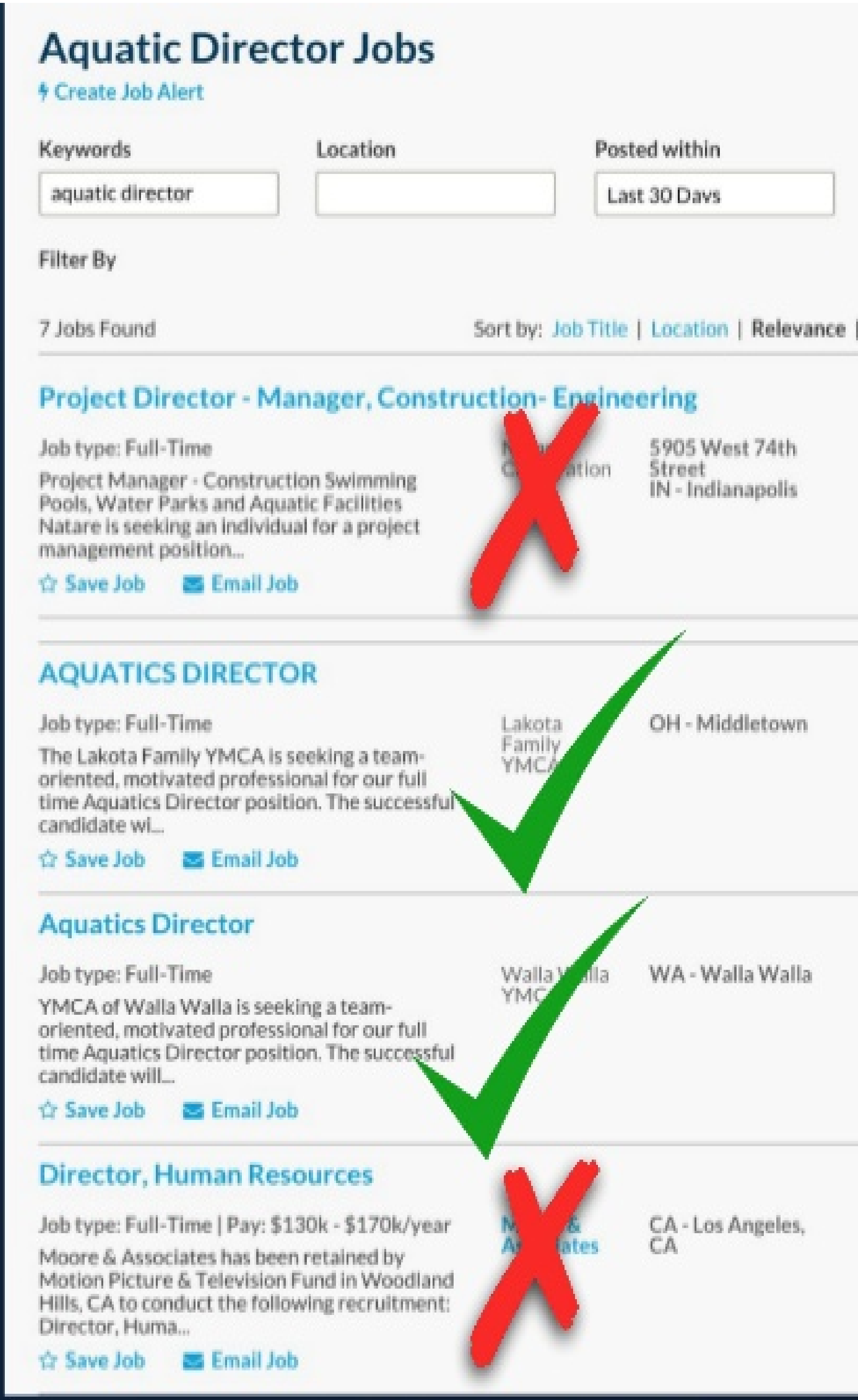
Recall = 2/3 = 0.66

F1 = 2 * (0.5 * 0.66) / (0.5 + 0.66) = 0.56

Problem:

Assume Prec = 90% and Rec = 100% but assume the 10% irrelevant documents were ranked at the top of the results

is that OK?



Aquatic Director Jobs

Create Job Alert

Keywords: aquatic director

Location:

Posted within: Last 30 Days

Filter By

7 Jobs Found

Sort by: Job Title | Location | Relevance |

Project Director - Manager, Construction- Engineering ✗

Job type: Full-Time

Natare Corporation

5905 West 74th Street
IN - Indianapolis

Project Manager - Construction Swimming Pools, Water Parks and Aquatic Facilities Natare is seeking an individual for a project management position...

Save Job Email Job

AQUATICS DIRECTOR ✓

Job type: Full-Time

Lakota Family YMCA

OH - Middletown

The Lakota Family YMCA is seeking a team-oriented, motivated professional for our full time Aquatics Director position. The successful candidate wi...

Save Job Email Job

Aquatics Director ✓

Job type: Full-Time

Walla Walla YMCA

WA - Walla Walla

YMCA of Walla Walla is seeking a team-oriented, motivated professional for our full time Aquatics Director position. The successful candidate will...

Save Job Email Job

Director, Human Resources ✗

Job type: Full-Time | Pay: $130k - $170k/year

Moore & Associates

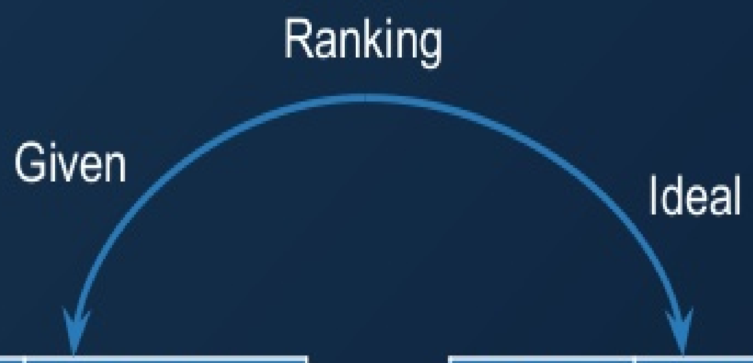
CA - Los Angeles, CA

Moore & Associates has been retained by Motion Picture & Television Fund in Woodland Hills, CA to conduct the following recruitment: Director, Huma...

Save Job Email Job

Discount Cumulative Gain (DCG)

- Position is considered in quantifying relevancy.
- Labeled dataset is required.



Ranking

Given

Ideal

Rank	Relevancy
1	0.95
2	0.65
3	0.80
4	0.85

Rank	Relevancy
1	0.95
2	0.85
3	0.80
4	0.65

$$DCG_k = \sum_{i=1}^{k} \frac{2^{rel_i} - 1}{log_2(i+1)}$$

$$NDCG_k = \frac{DCG_k}{IDCG_k}$$

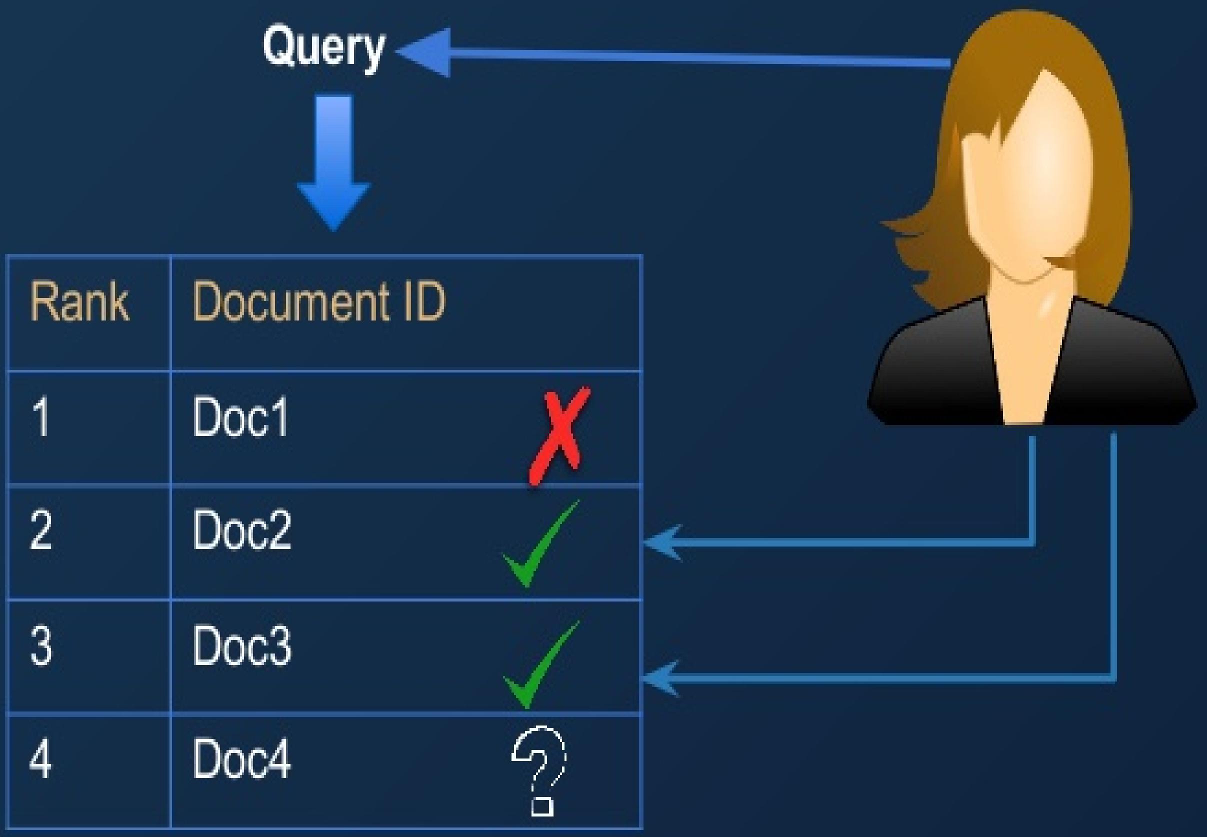
How to Label Data Set?

How to get labeled data?

- Manually
  - Pros:
    - Accuracy
  - Cons:
    - Not scalable
    - Expensive
  - How:
    - Hire employees, contractors, or interns
    - Crowd-sourcing
      - Less cost
      - Less accuracy

- Infer relevancy utilizing implicit user feedback

How to infer relevancy?

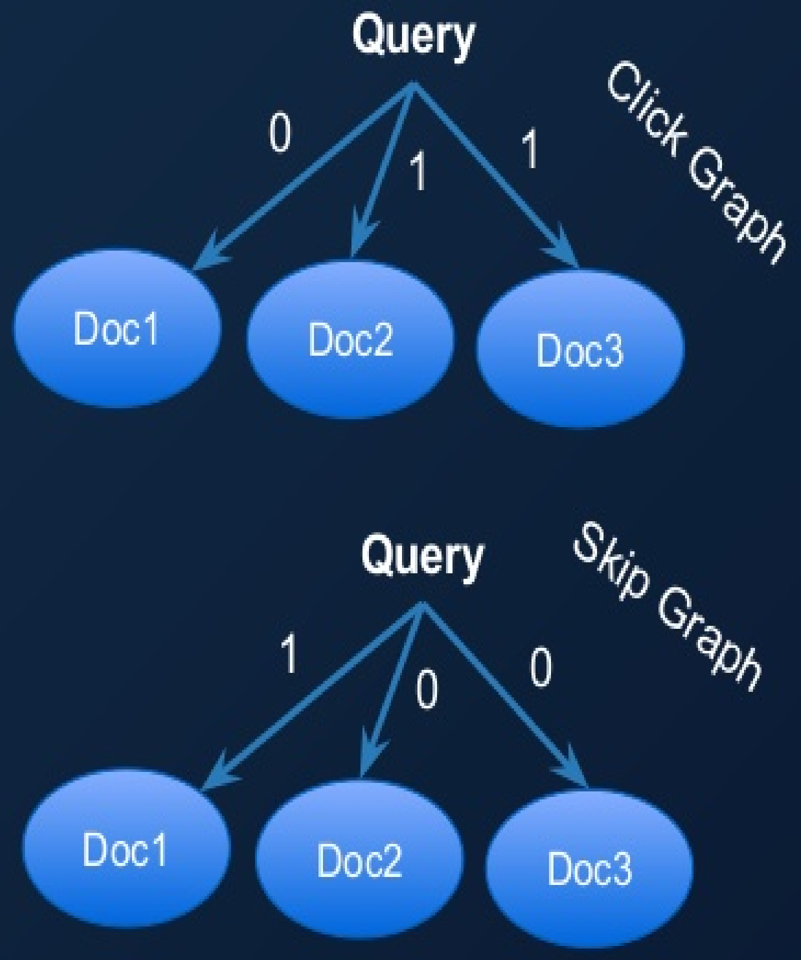


Rank	Document ID
1	Doc1 ✗
2	Doc2 ✓
3	Doc3 ✓
4	Doc4 ?

$$C_{Doc_i} = \sum_{Doc_i} click$$

$$S_{Doc_i} = \sum_{Doc_i} skip$$

$$rel_{Doc_i} = \frac{C_{Doc_i}}{S_{Doc_i} + C_{Doc_i}}$$



Query Log

Field	Example
Query ID	Q1234567890
browser ID	B12345ABCD789
Session ID	S123456ABCD7890
Raw Query	Spark or hadoop and Scala or java
Host Site	US
Language	EN
Ranked Results	D1, D2, D3, D4, .. , Dn

Action Log

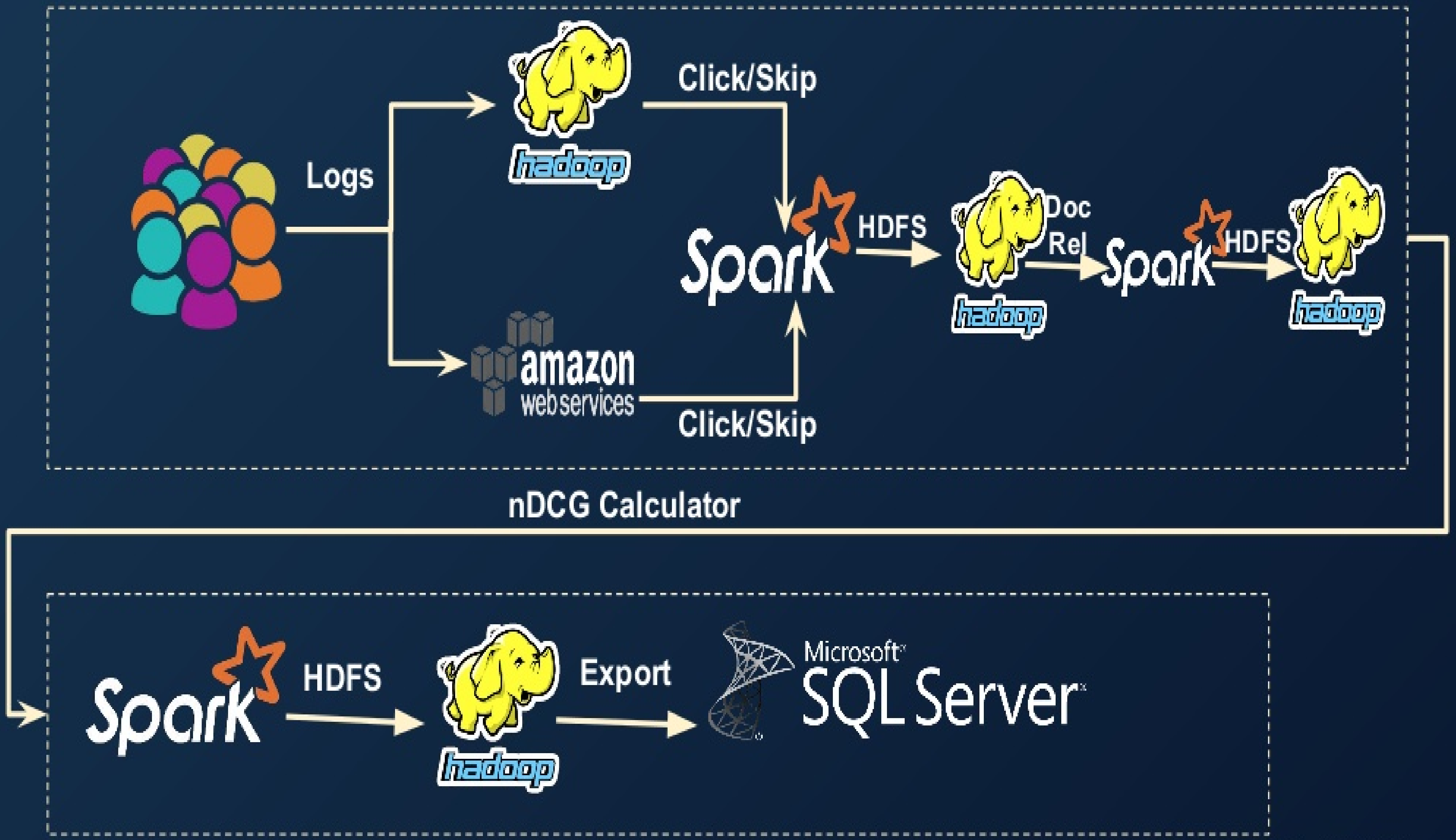
Field	Example
Query ID	Q1234567890
Action Type*	Click
Document ID	D1
Document Location	1

*Possible Action Types: Click, Download, Print, Block, Unblock, Save, Apply, Dwell time, Post-click path

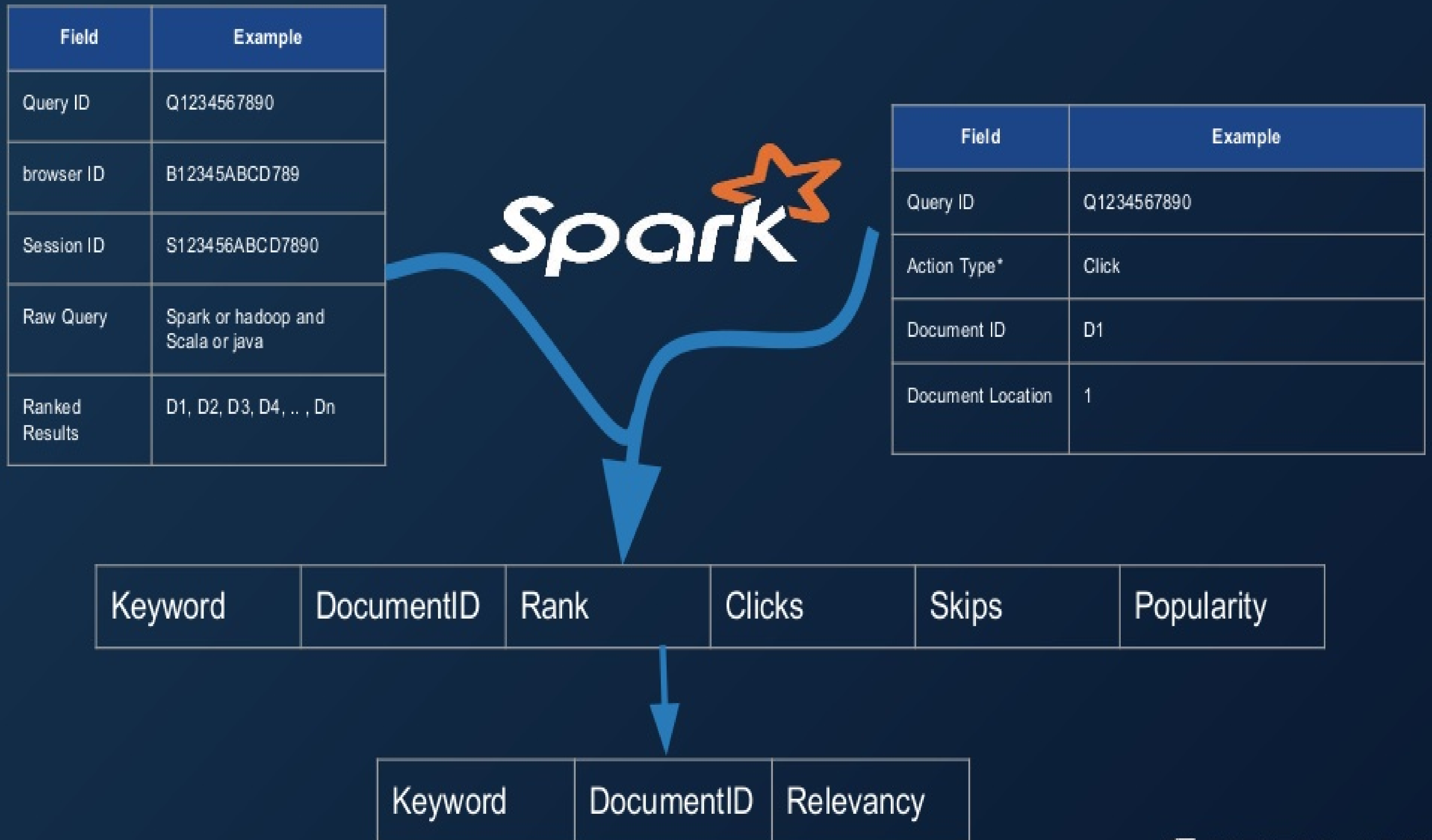
The Fully Automated System

CAREER BUILDER™

System Architecture



ETL



Field	Example
Query ID	Q1234567890
browser ID	B12345ABCD789
Session ID	S123456ABCD7890
Raw Query	Spark or hadoop and Scala or java
Ranked Results	D1, D2, D3, D4, .. , Dn

Field	Example
Query ID	Q1234567890
Action Type*	Click
Document ID	D1
Document Location	1

Keyword	DocumentID	Rank	Clicks	Skips	Popularity

Keyword	DocumentID	Relevancy

Noise Challenge

At least 10 distinct users need to take an action on a document to consider it in the nDCG calculation.

Any skip followed clicks on different sessions from the same browser ID is ignored.

Actions beyond Clicks weight more than Clicks. For example, we count Download as 20 clicks, and Print as 100 clicks

Accuracy

500 resumes had been manually reviewed by our data analyst. The accuracy of the relevancy scores calculated by our system is

96%

Dataset by the Numbers

19 million +
Search logs

250,000+
Tagged resumes

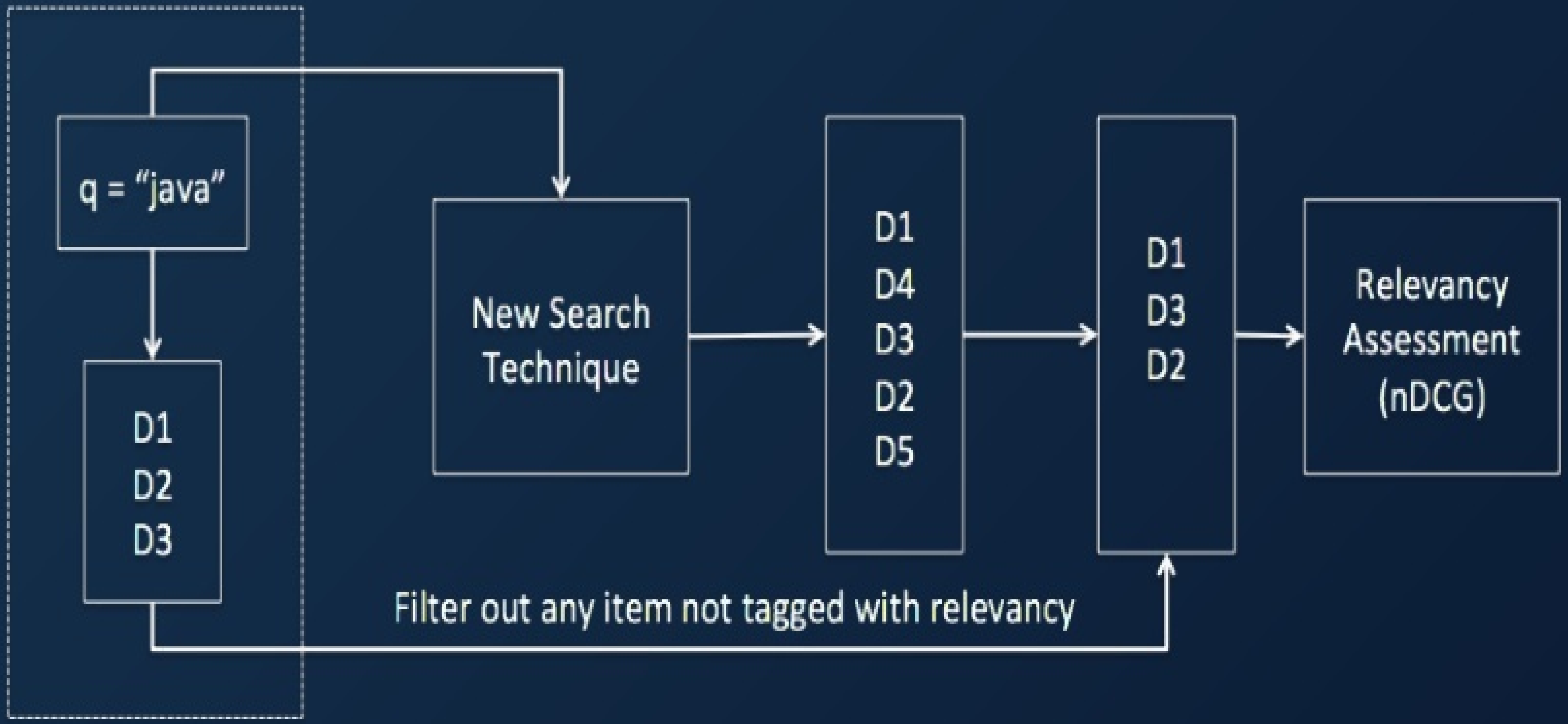
100,000+
Distinct Queries

10+
Distinct users per query

7
Times a week

Spark
Solr
OOZiE
sqoop
HIVE
HDFS
Microsoft SQL Server

Query Synthesizer



q = "java"

D1
D2
D3

New Search Technique

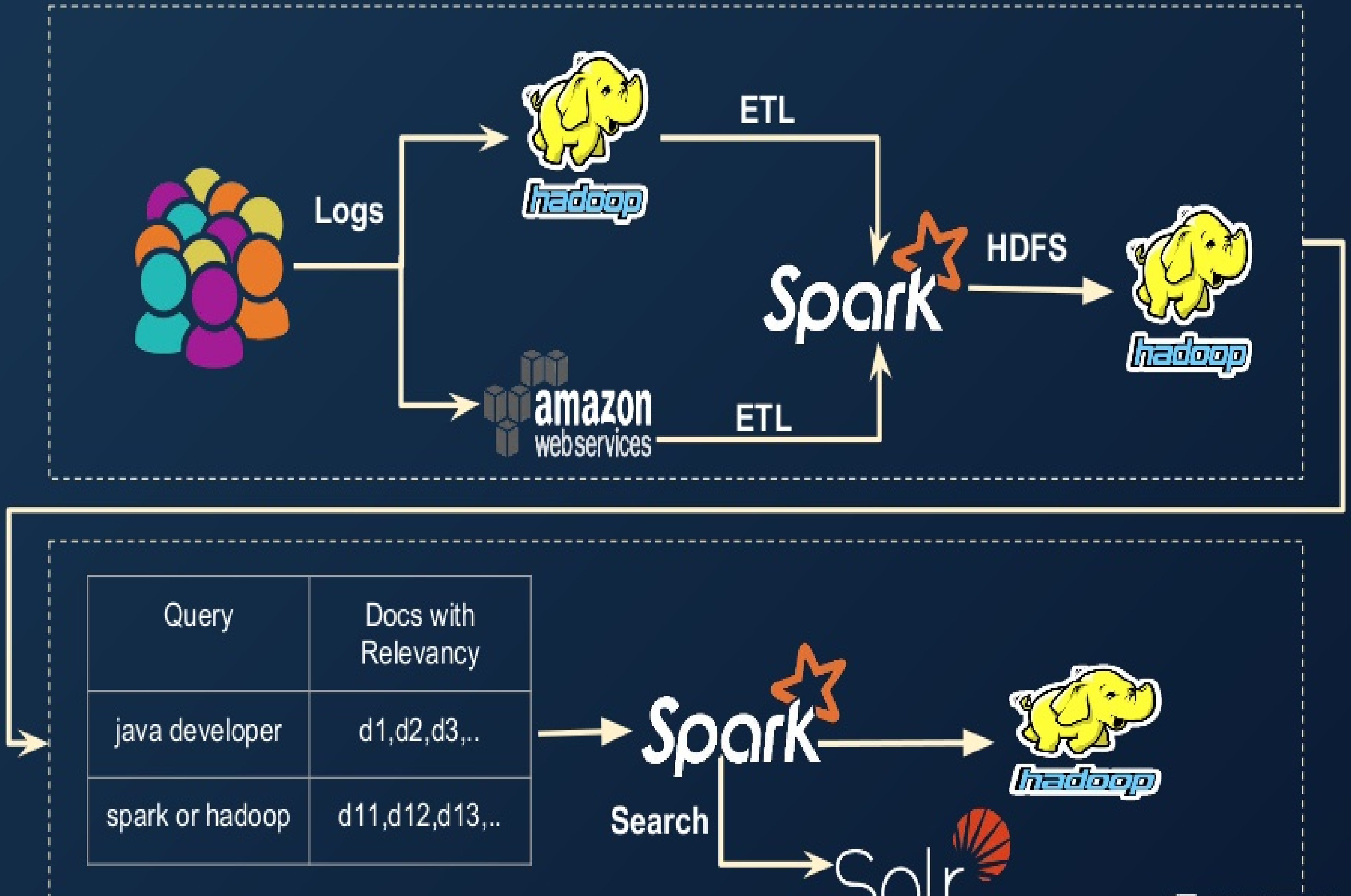
D1
D4
D3
D2
D5

D1
D3
D2

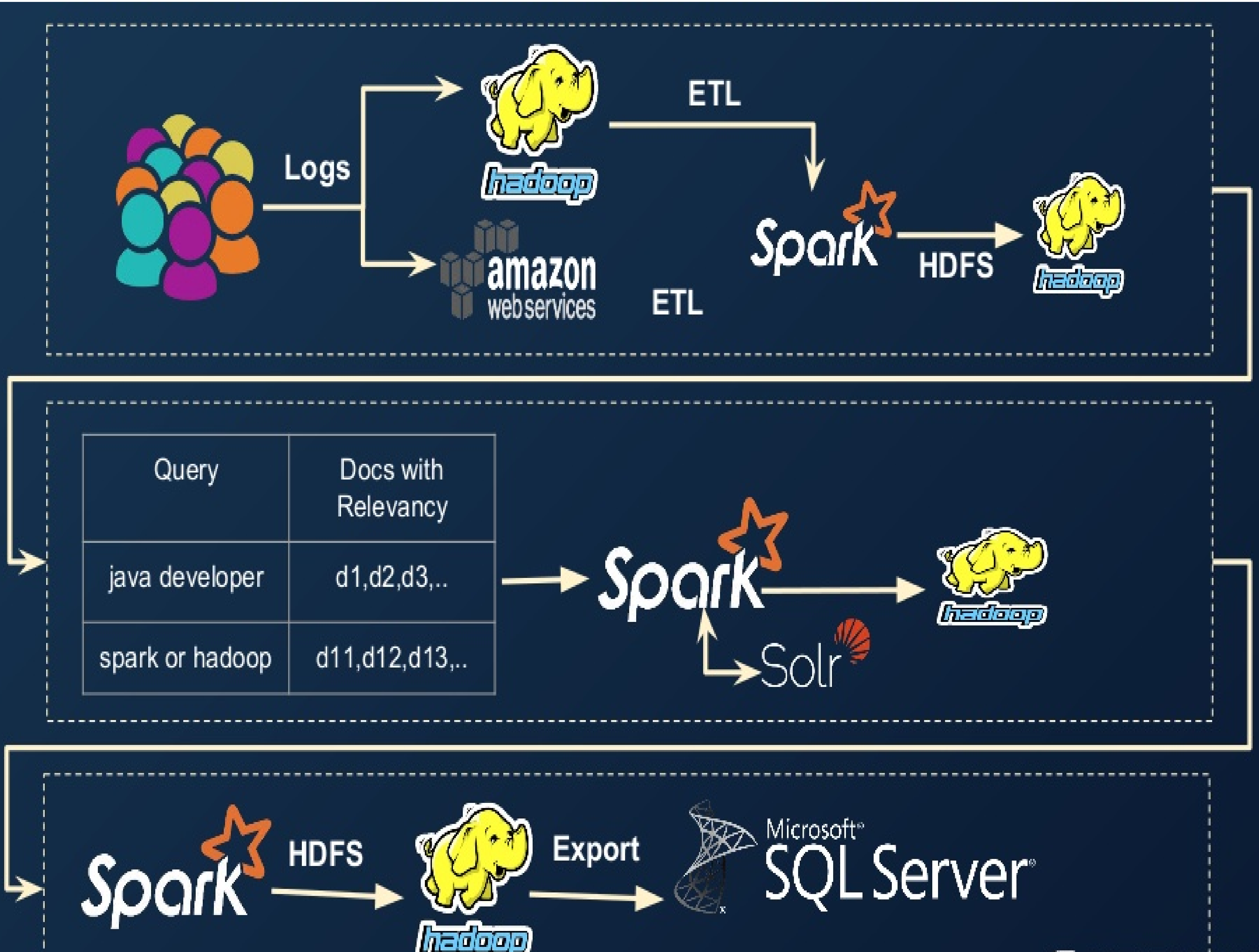
Relevancy Assessment (nDCG)

Filter out any item not tagged with relevancy

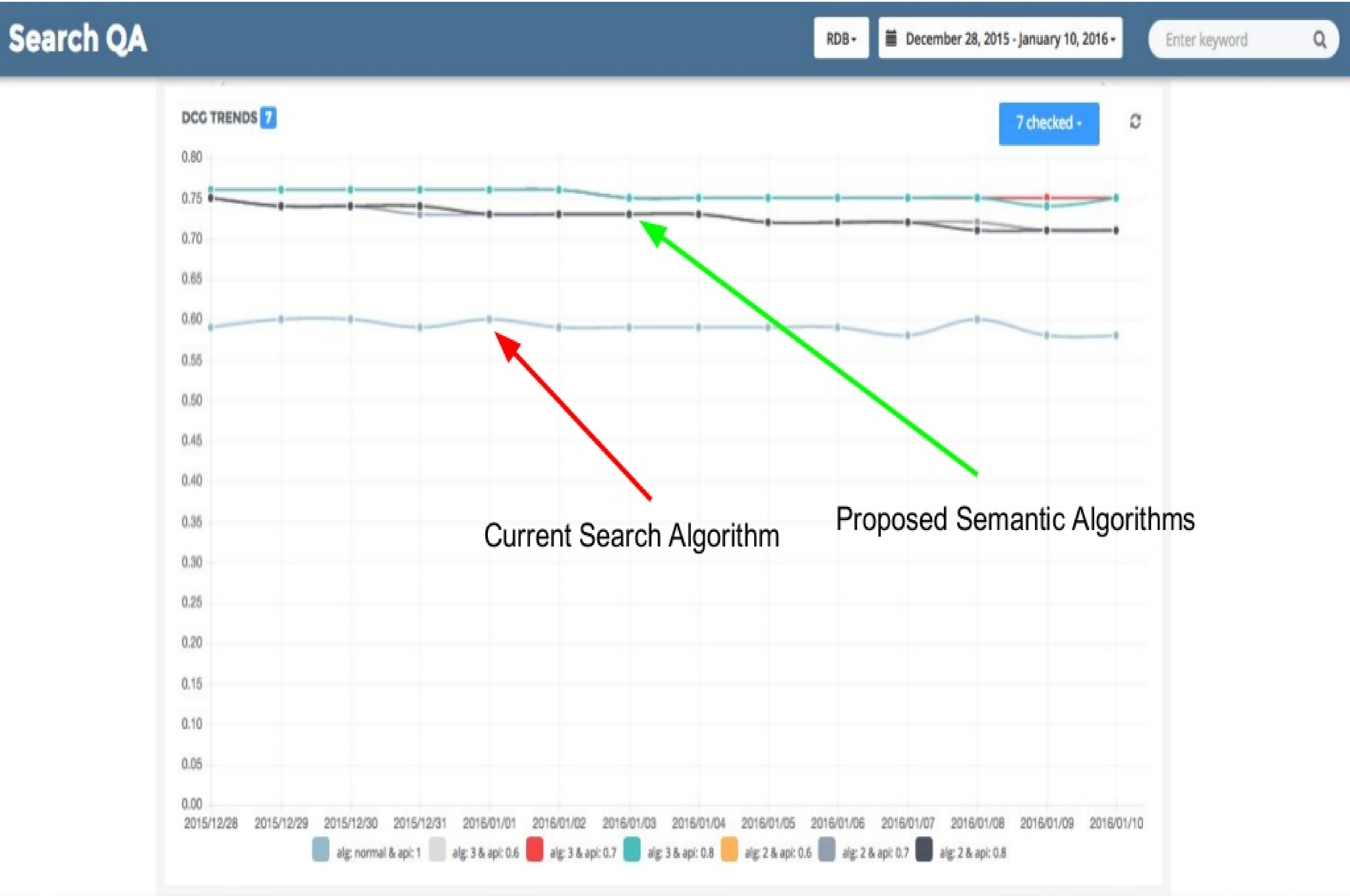
Synthesize Queries



Query	Docs with Relevancy
java developer	d1,d2,d3,..
spark or hadoop	d11,d12,d13,..



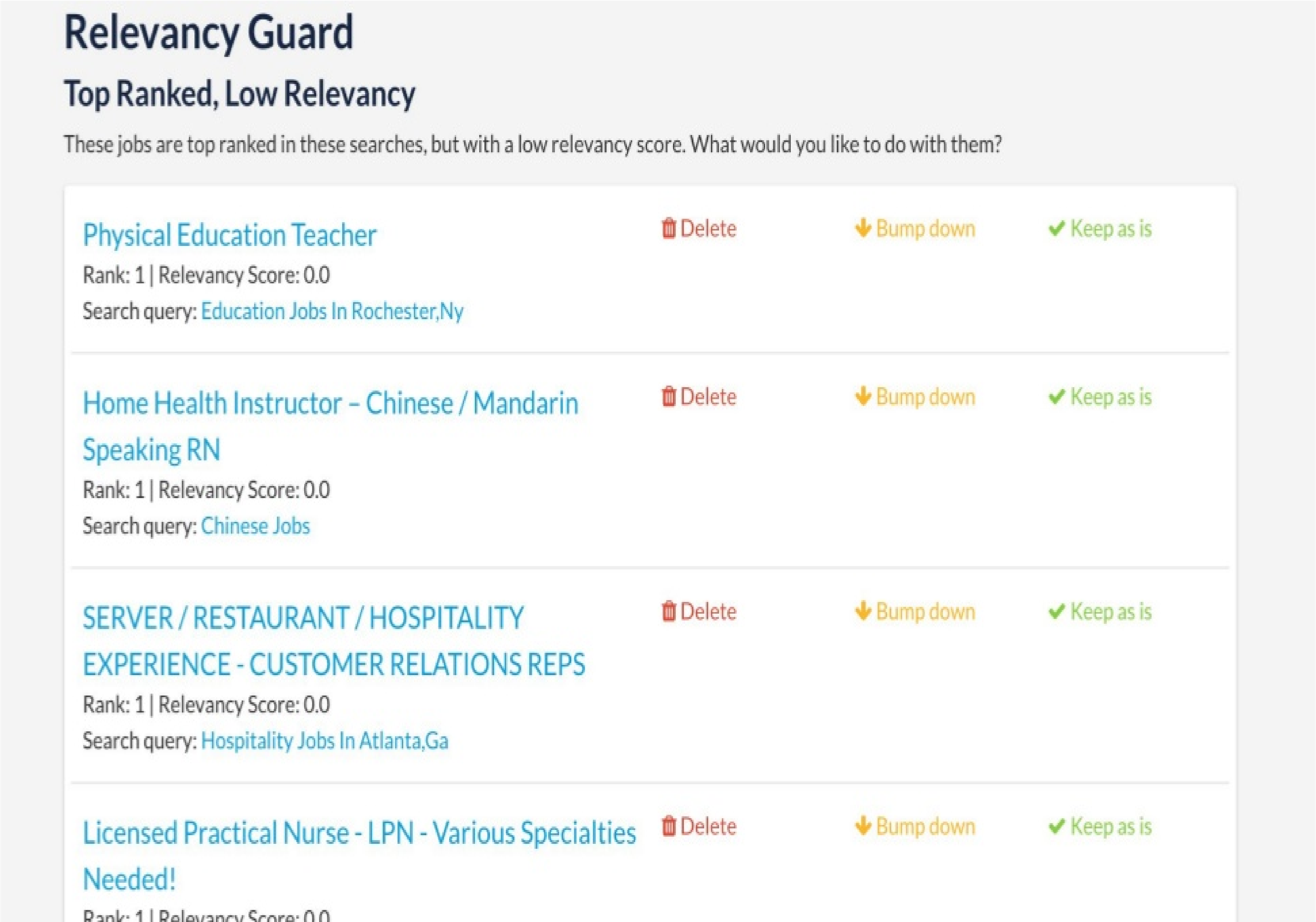
Query	Docs with Relevancy
java developer	d1,d2,d3,..
spark or hadoop	d11,d12,d13,..



Current Search Algorithm

Proposed Semantic Algorithms

Quick Win



Relevancy Guard

Top Ranked, Low Relevancy

These jobs are top ranked in these searches, but with a low relevancy score. What would you like to do with them?

Physical Education Teacher

Rank: 1 | Relevancy Score: 0.0

Search query: Education Jobs In Rochester,Ny

🗑 Delete ↓ Bump down ✓ Keep as is

Home Health Instructor – Chinese / Mandarin Speaking RN

Rank: 1 | Relevancy Score: 0.0

Search query: Chinese Jobs

🗑 Delete ↓ Bump down ✓ Keep as is

SERVER / RESTAURANT / HOSPITALITY EXPERIENCE - CUSTOMER RELATIONS REPS

Rank: 1 | Relevancy Score: 0.0

Search query: Hospitality Jobs In Atlanta,Ga

🗑 Delete ↓ Bump down ✓ Keep as is

Licensed Practical Nurse - LPN - Various Specialties Needed!

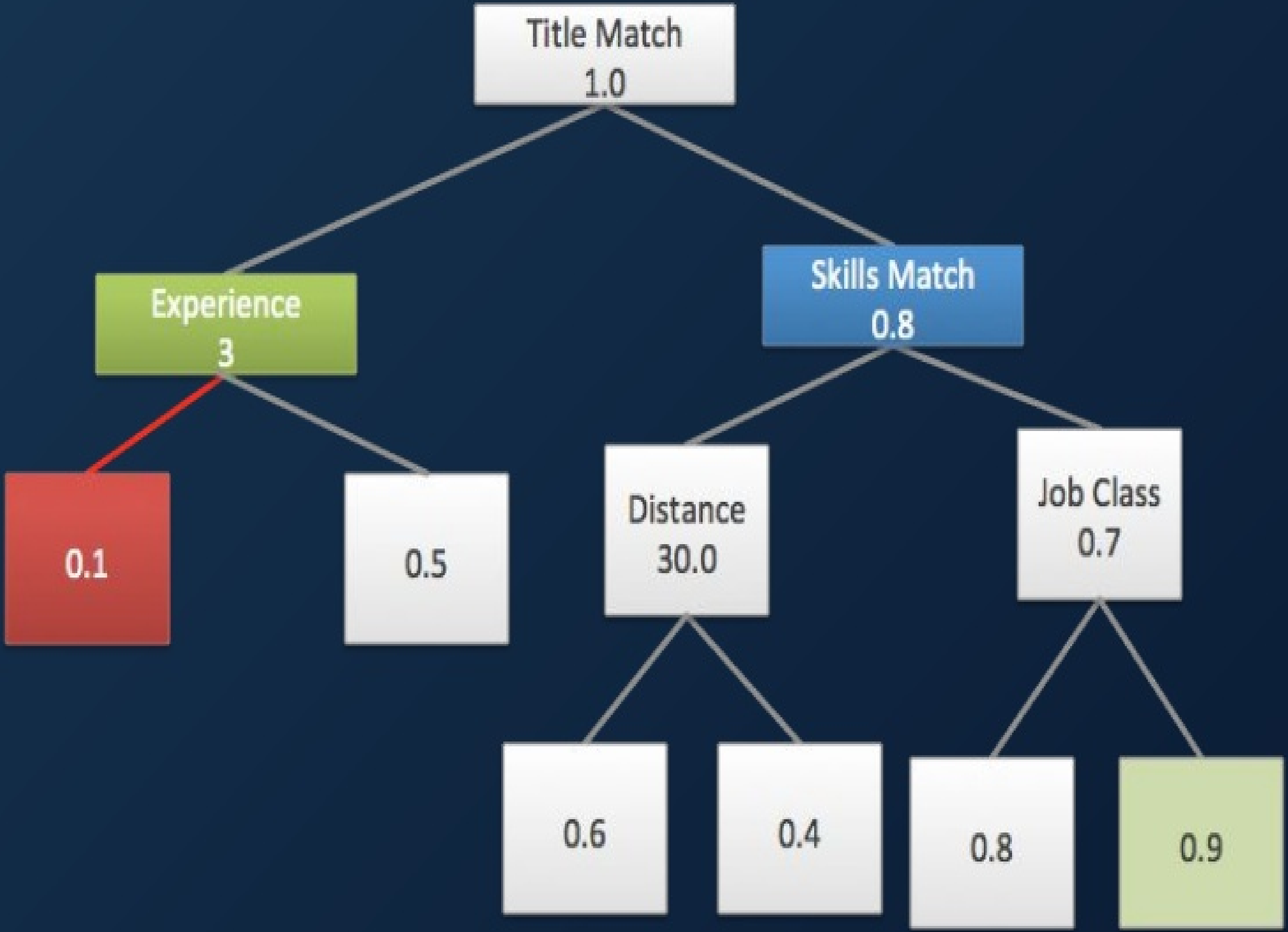
Rank: 1 | Relevancy Score: 0.0

🗑 Delete ↓ Bump down ✓ Keep as is

Learning to Rank (LTR)

- It applies machine learning techniques to discover the best combination of features that provide best ranking.
- It requires labeled set of documents with relevancy scores for given set of queries
- Features used for ranking are usually more computationally expensive than the ones used for matching
- It works on subset of the matched documents (e.g. top 100)

LambdaMart Example



Title Match 1.0

Experience 3

Skills Match 0.8

0.1

0.5

Distance 30.0

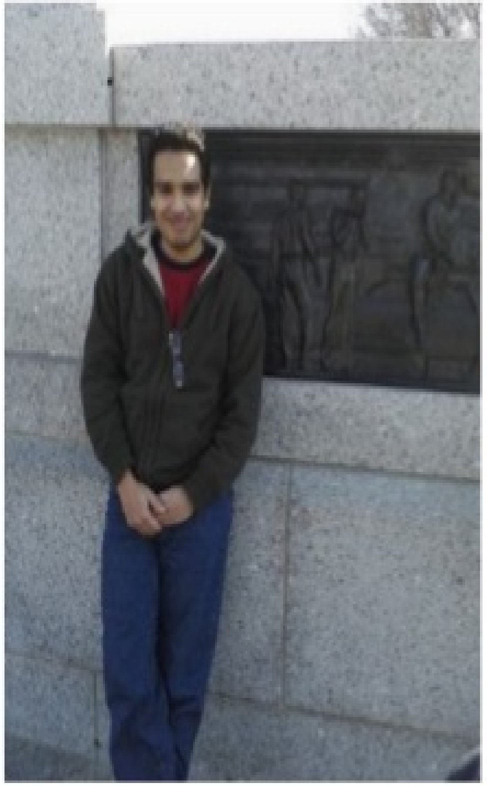
Job Class 0.7

0.6

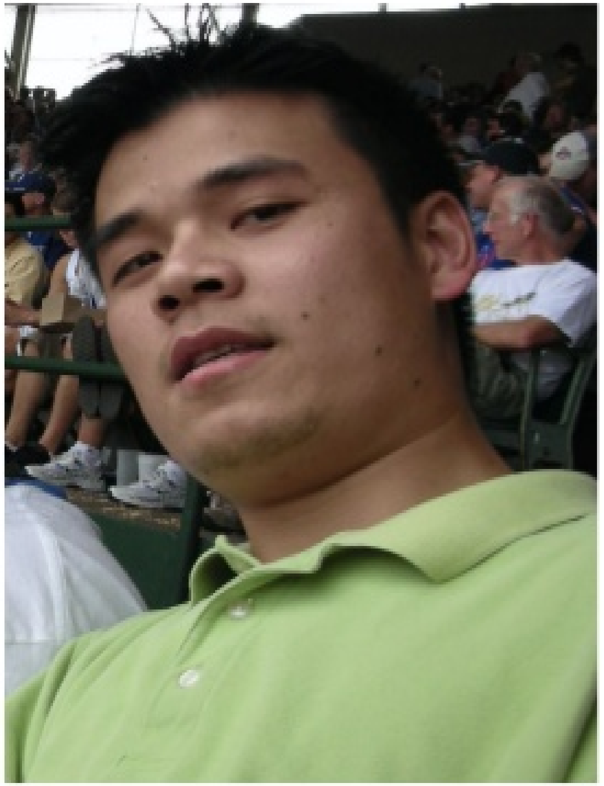
0.4

0.8

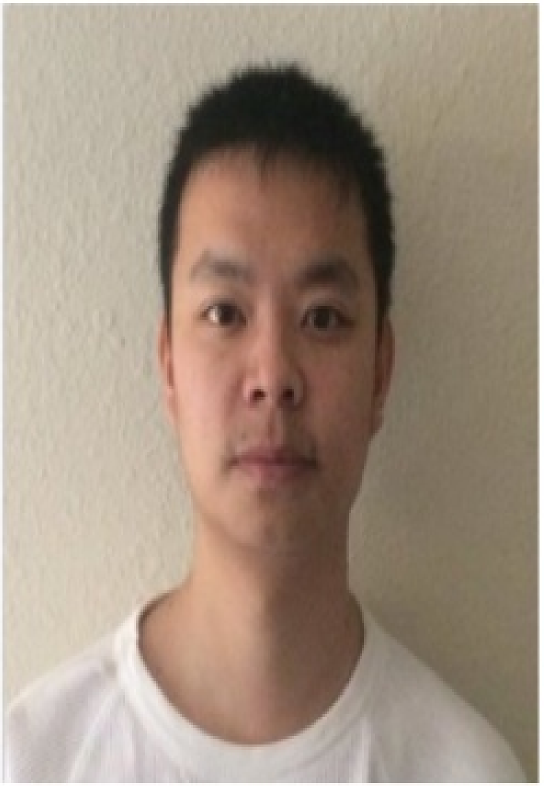
0.9



Mohammed Korayem



Hai Liu



Chengwei Li

David Lin

Credit

Thank You!

Khalifeh AlJadda
www.aljadda.com
Twitter: @aljadda

Search Data Science