CHENNAI MATHEMATICAL INSTITUTE

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Qualcomm
on 24th June 2021

Knowledge Graphs - Going Beyond Data!

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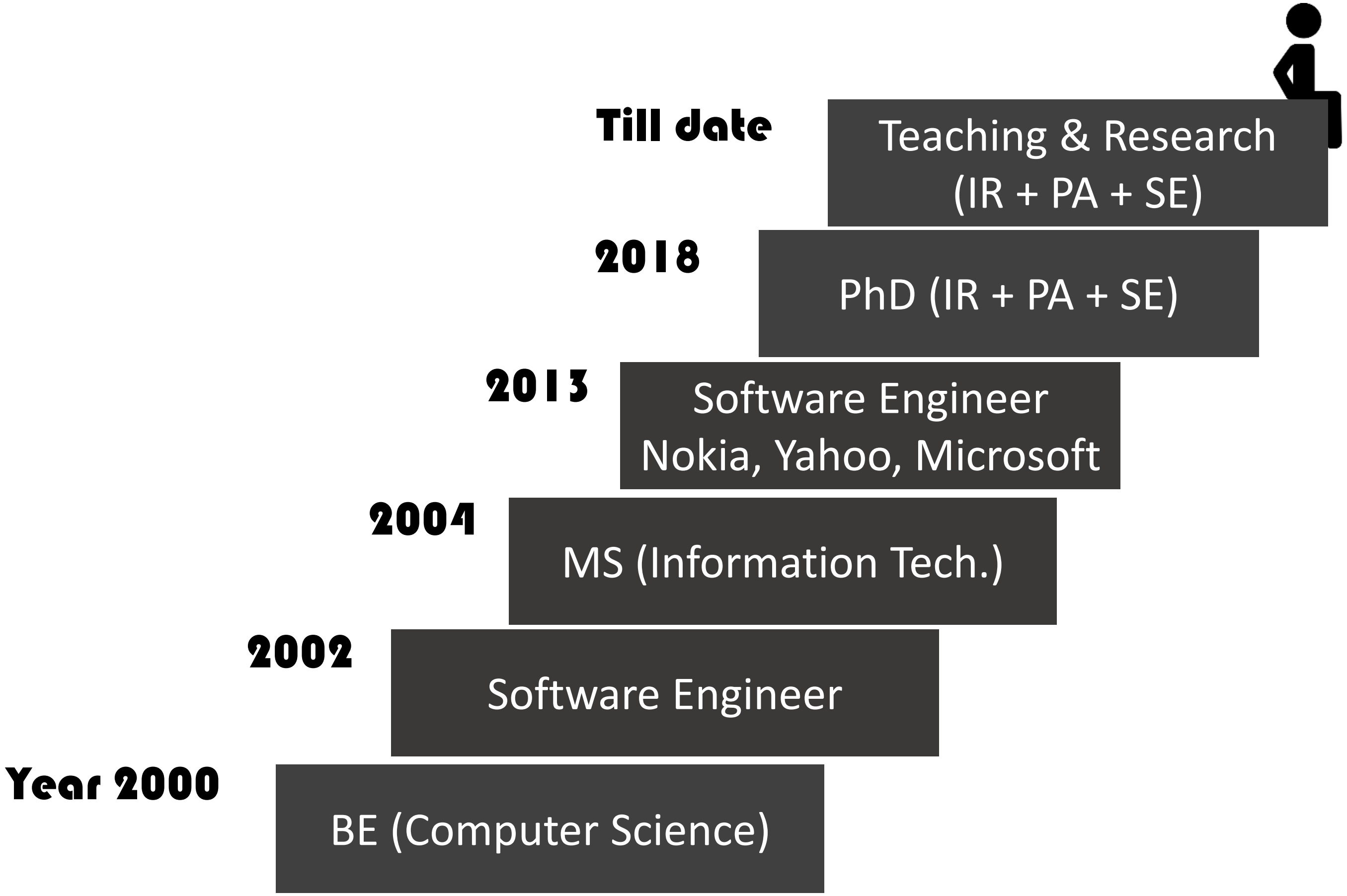
http://vvtesh.co.in

Chennai Mathematical Institute

To know that we know what we know, and to know that we do not know what we do not know, that is true knowledge—Nicolaus Copernicus

About Me



Year 2000 – BE (Computer Science)

2002 – Software Engineer

2004 – MS (Information Tech.)

2013 – Software Engineer
Nokia, Yahoo, Microsoft

2018 – PhD (IR + PA + SE)

Till date – Teaching & Research
(IR + PA + SE)

Agenda

Knowledge Graphs – Going Beyond Data!

Will Discuss

- ✓ Concepts
- ✓ Illustrations
- ✓ Intuitions
- ✓ Purpose
- ✓ Properties

Will not Discuss

- ⃠ Details
- ⃠ Definitions
- ⃠ Formalism
- ⃠ Derivations
- ⃠ Proofs

Three Parts

(1) Knowledge Graphs, (2) Tools and Techniques, (3) Two Algorithms

Story 1

Knowledge Graphs

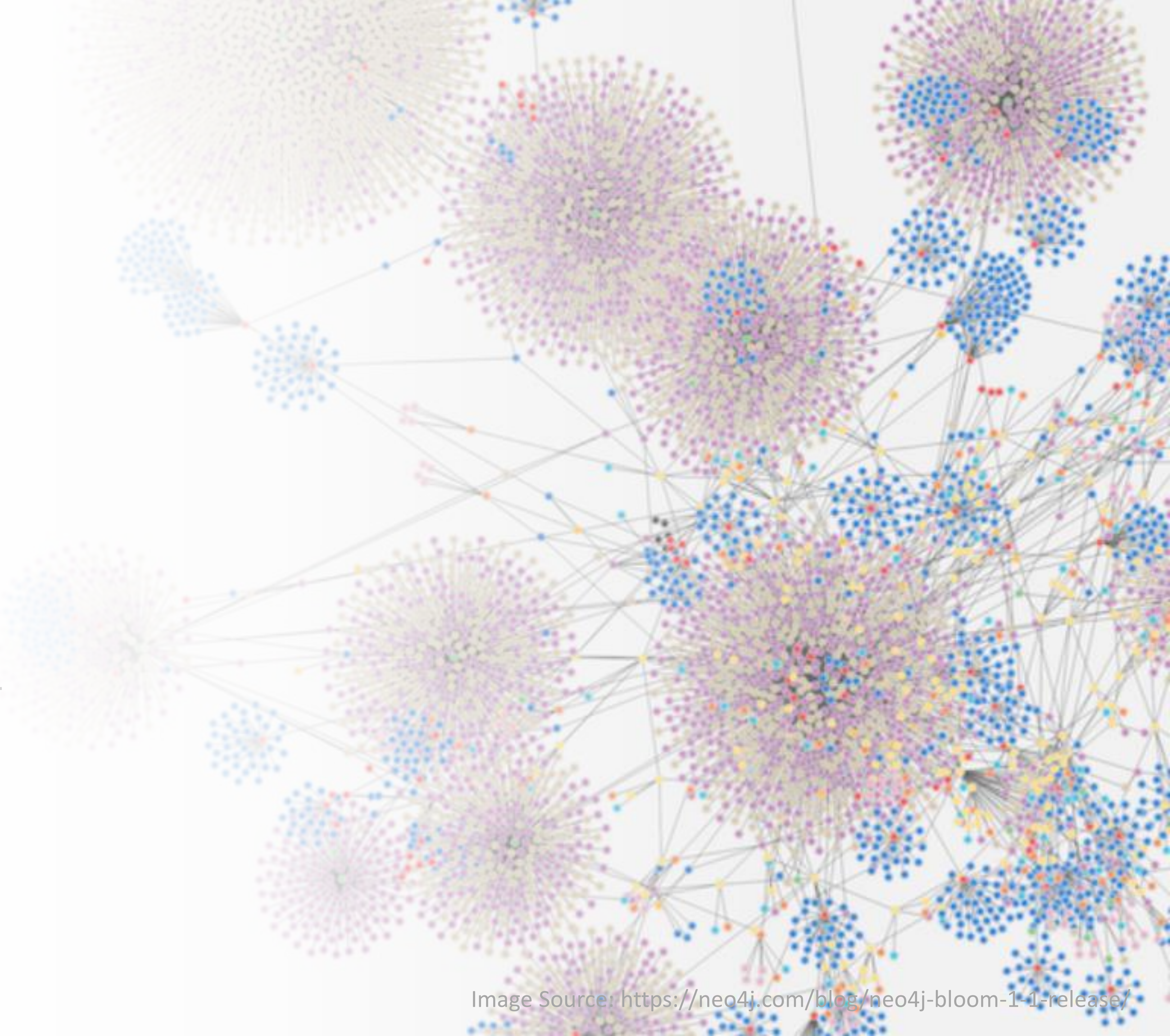
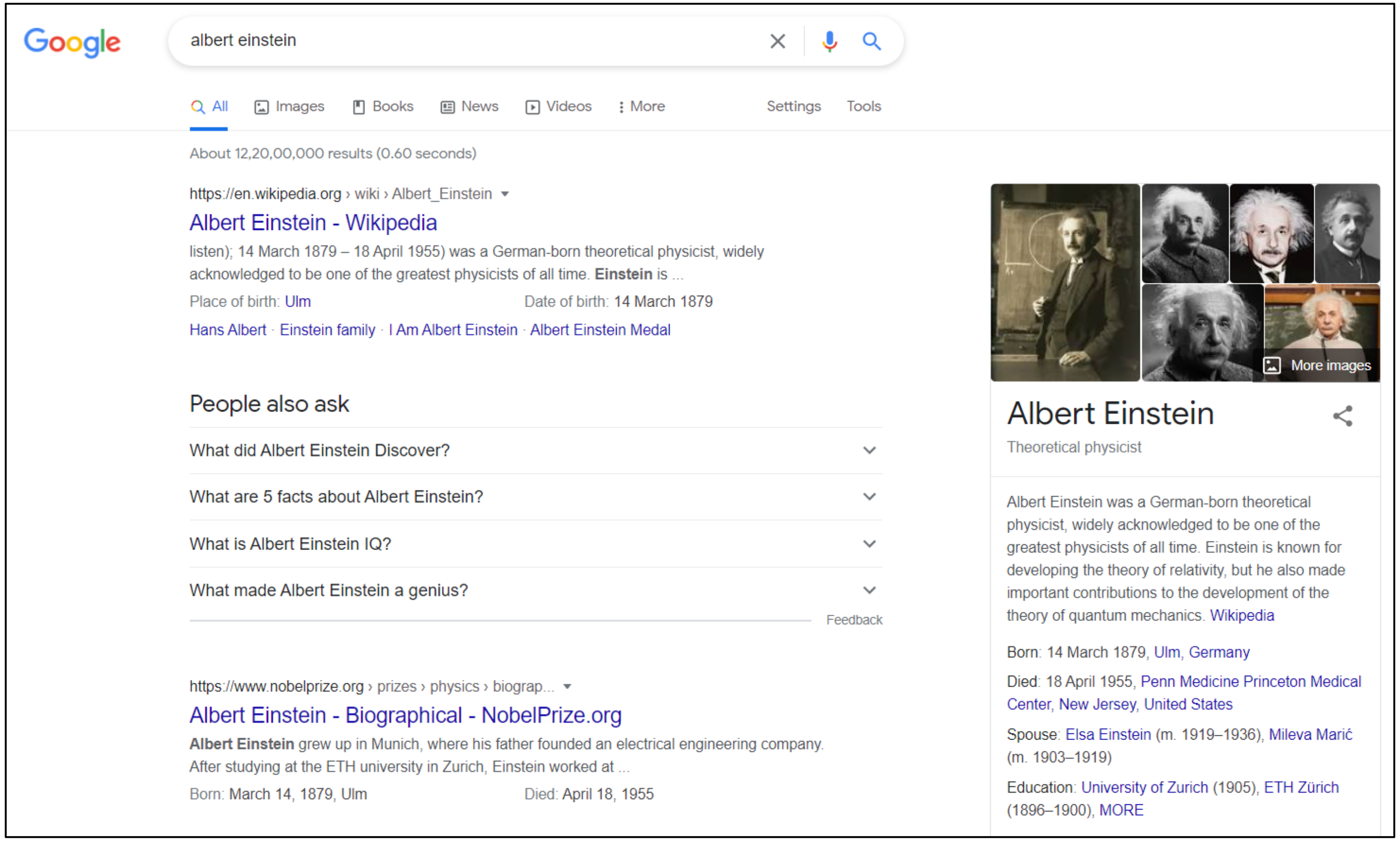


Image Source: https://neo4j.com/blog/neo4j-bloom-1-1-release/

Beyond Searching for Documents

We search for entities. Not always documents!



About 12,20,00,000 results (0.60 seconds)

https://en.wikipedia.org › wiki › Albert_Einstein

Albert Einstein - Wikipedia

listen); 14 March 1879 – 18 April 1955) was a German-born theoretical physicist, widely acknowledged to be one of the greatest physicists of all time. **Einstein** is ...

Place of birth: Ulm

Date of birth: 14 March 1879

Hans Albert · Einstein family · I Am Albert Einstein · Albert Einstein Medal

People also ask

What did Albert Einstein Discover?

What are 5 facts about Albert Einstein?

What is Albert Einstein IQ?

What made Albert Einstein a genius?

https://www.nobelprize.org › prizes › physics › biograp...

Albert Einstein - Biographical - NobelPrize.org

Albert Einstein grew up in Munich, where his father founded an electrical engineering company. After studying at the ETH university in Zurich, Einstein worked at ...

Born: March 14, 1879, Ulm

Died: April 18, 1955

Albert Einstein

Theoretical physicist

Albert Einstein was a German-born theoretical physicist, widely acknowledged to be one of the greatest physicists of all time. Einstein is known for developing the theory of relativity, but he also made important contributions to the development of the theory of quantum mechanics. Wikipedia

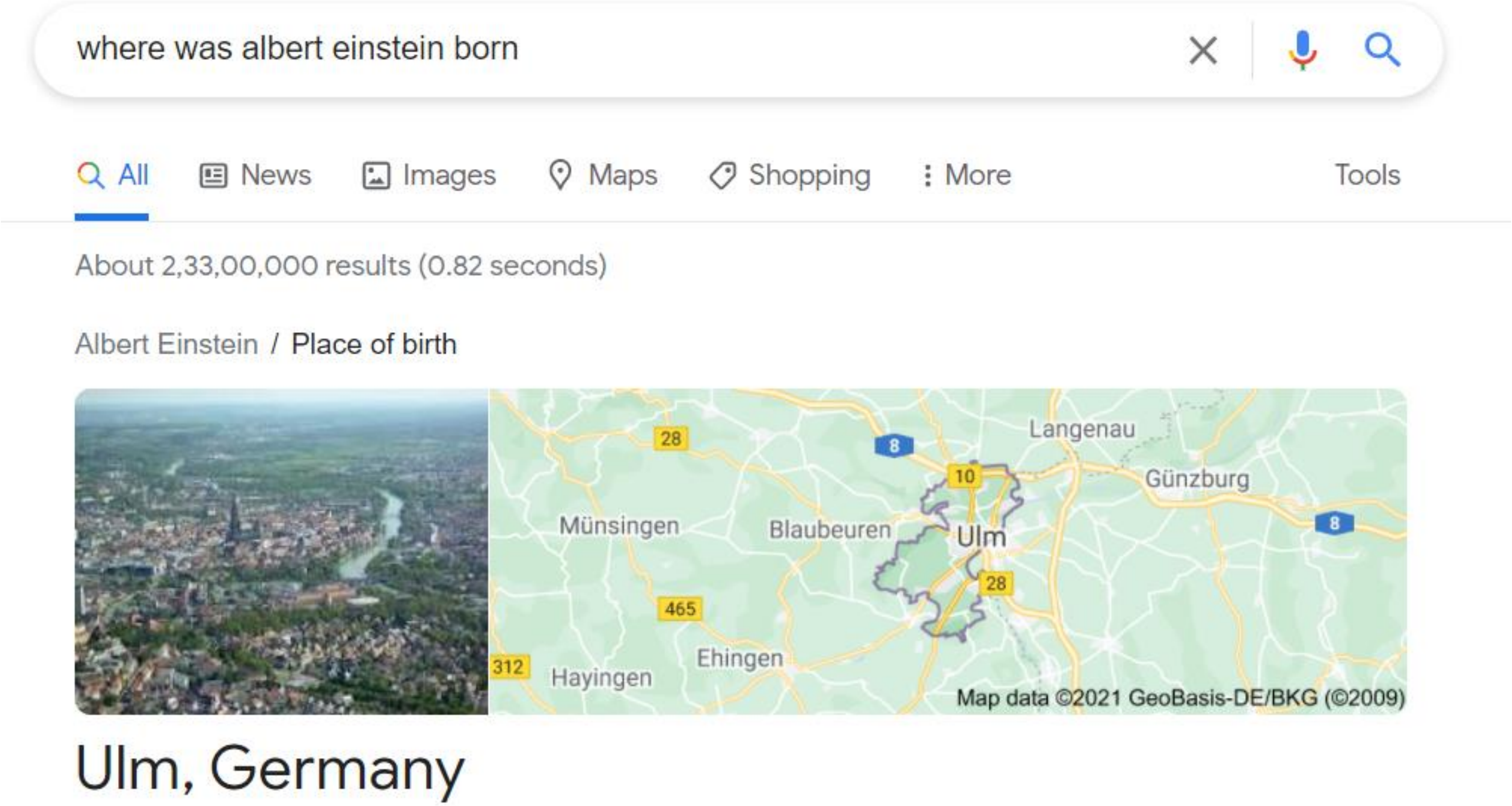
Born: 14 March 1879, Ulm, Germany

Died: 18 April 1955, Penn Medicine Princeton Medical Center, New Jersey, United States

Spouse: Elsa Einstein (m. 1919–1936), Mileva Marić (m. 1903–1919)

Education: University of Zurich (1905), ETH Zürich (1896–1900), MORE

We Need Answers!



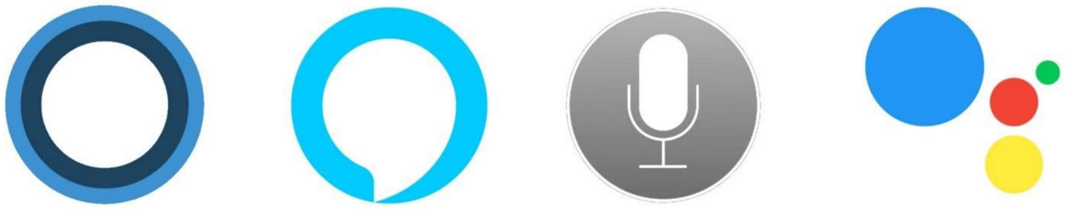
where was albert einstein born

About 2,33,00,000 results (0.82 seconds)

Albert Einstein / Place of birth

Ulm, Germany

In general, humans make decisions based on the world knowledge they have gathered over time. Why not machines?



"Hey Cortana" "Hey Alexa" "Hey Siri" "Hey Google"

Exploring data with a graphical representation

Demo 1

How do we capture knowledge?

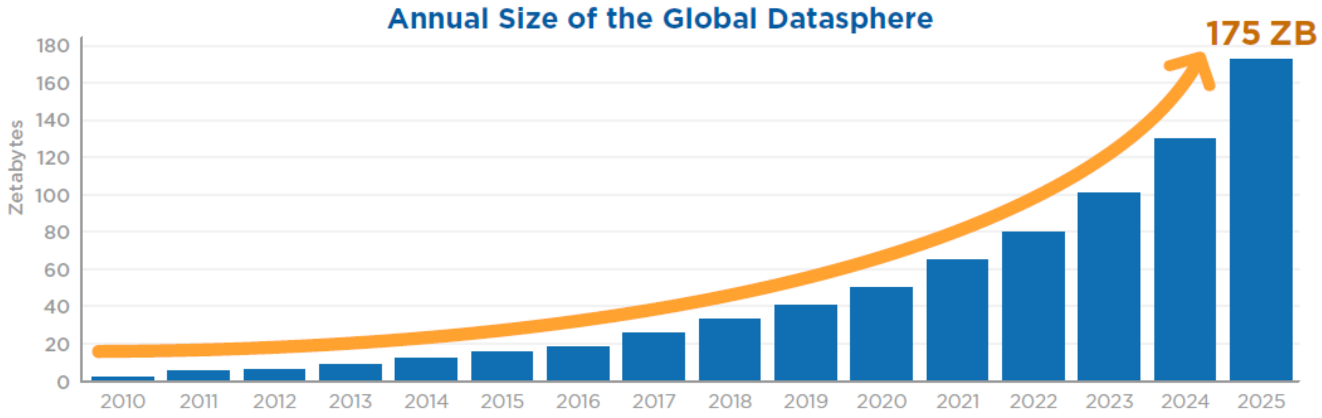
How do we represent this knowledge?

How do we access this knowledge?

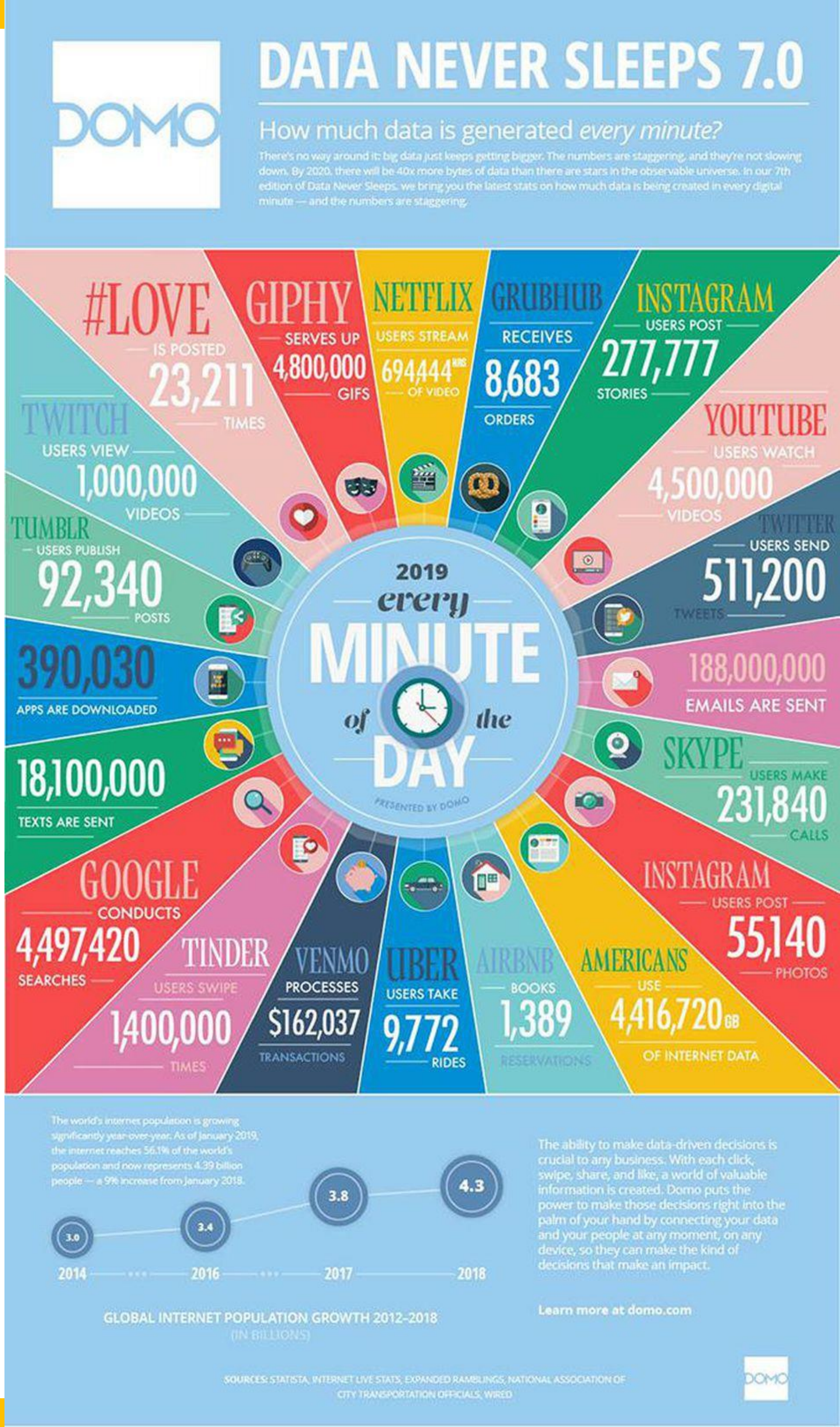
Data is Ubiquitous

But, how do we organize this data?

Figure 1 – Annual Size of the Global Datasphere



Source: IDC DataAge 2025 whitepaper, and DOMO.



There's no way around it: big data just keeps getting bigger. The numbers are staggering, and they're not slowing down. By 2020, there will be 40x more bytes of data than there are stars in the observable universe. In our 7th edition of Data Never Sleeps, we bring you the latest stats on how much data is being created in every digital minute — and the numbers are staggering.

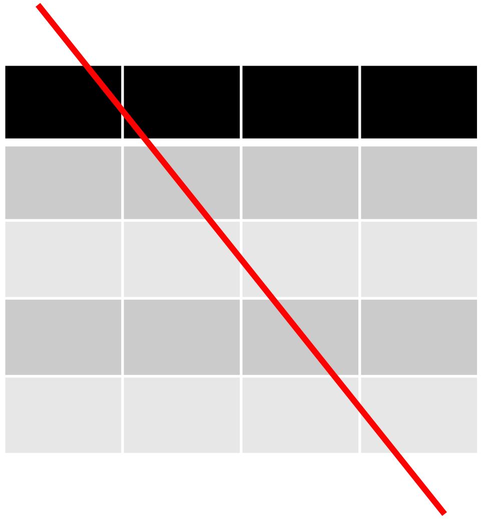
The world's internet population is growing significantly year-over-year. As of January 2019, the internet reaches 56.1% of the world's population and now represents 4.39 billion people — a 9% increase from January 2018.

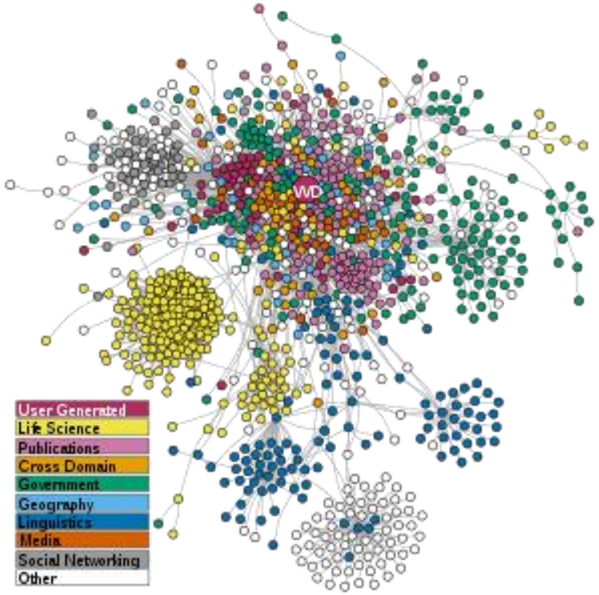
The ability to make data-driven decisions is crucial to any business. With each click, swipe, share, and like, a world of valuable information is created. Domo puts the power to make those decisions right into the palm of your hand by connecting your data and your people at any moment, on any device, so they can make the kind of decisions that make an impact.

Learn more at domo.com

SOURCES: STATISTA, INTERNET LIVE STATS, EXPANDED RAMBLINGS, NATIONAL ASSOCIATION OF CITY TRANSPORTATION OFFICIALS, WIRED

A Graph Data Model

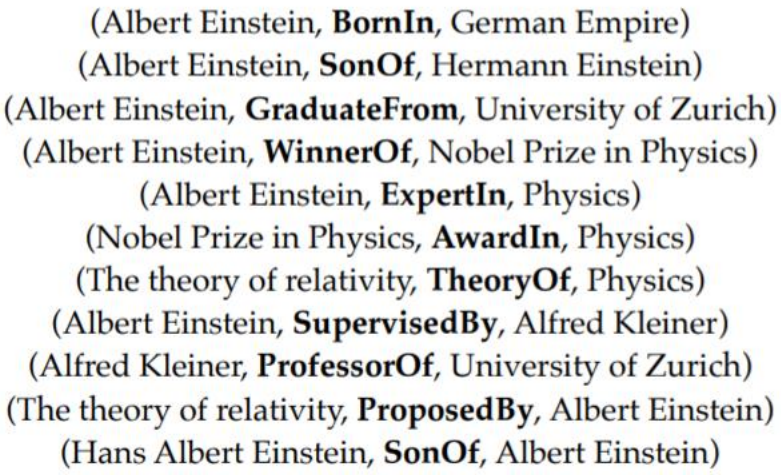




Real-world entities and relationships are better captured through graphs.

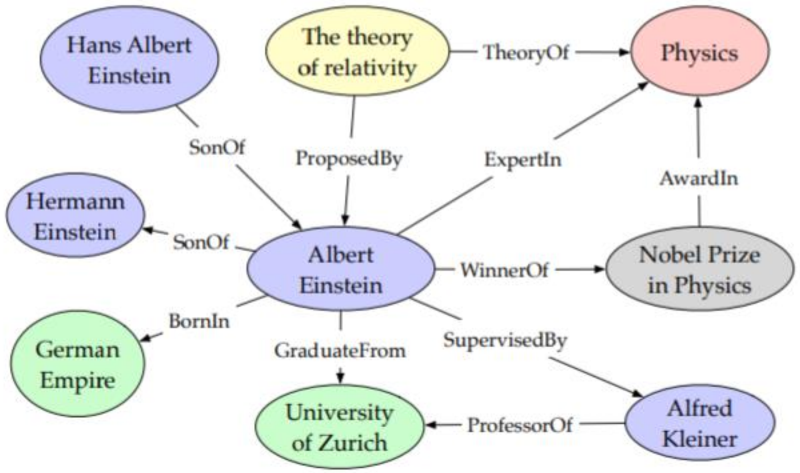
Knowledge Graphs

Subject – Predicate – Object Triples



(Albert Einstein, **BornIn**, German Empire)
(Albert Einstein, **SonOf**, Hermann Einstein)
(Albert Einstein, **GraduateFrom**, University of Zurich)
(Albert Einstein, **WinnerOf**, Nobel Prize in Physics)
(Albert Einstein, **ExpertIn**, Physics)
(Nobel Prize in Physics, **AwardIn**, Physics)
(The theory of relativity, **TheoryOf**, Physics)
(Albert Einstein, **SupervisedBy**, Alfred Kleiner)
(Alfred Kleiner, **ProfessorOf**, University of Zurich)
(The theory of relativity, **ProposedBy**, Albert Einstein)
(Hans Albert Einstein, **SonOf**, Albert Einstein)

Knowledge Graph



These facts are stored in a "knowledge base".

Read more at https://arxiv.org/pdf/2002.00388.pdf

Wikidata: A Free Open Knowledgebase

- Data
  - 94M items! Anyone can edit.
- Community Control
  - Contributors edit *the population number of Rome* but also decide whether there is such a number in the first place.
- Conflicting Data
  - Many facts are disputed. Several details are uncertain.
  - Allows conflicting data to co-exist.
  - There is no *true population of Rome*. There is a *population of Rome as published by the city of Rome in 2011*.
- Multilingual
- Easy Access
- Continuous Evolution

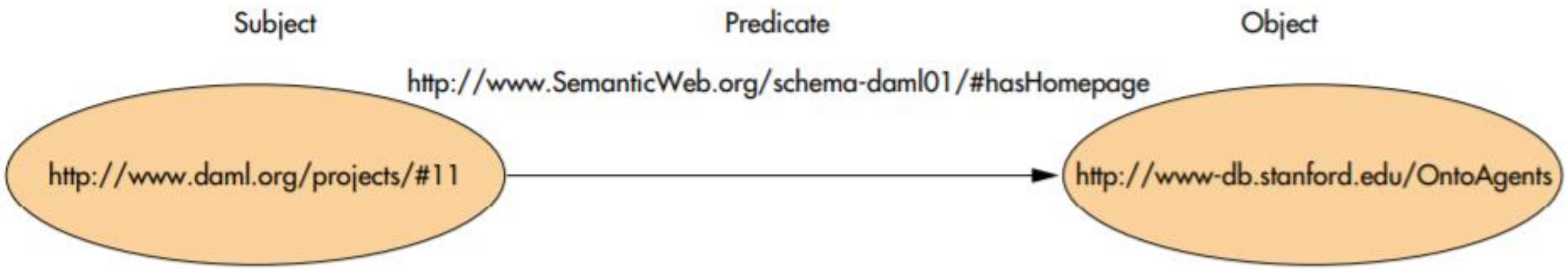
**We have many knowledgebases.
Interoperability is a concern ☹**

Solution: Resource Description Framework (RDF)

RDF is a directed, labeled graph data format for representing information in the Web.

Resource Description Framework (RDF)

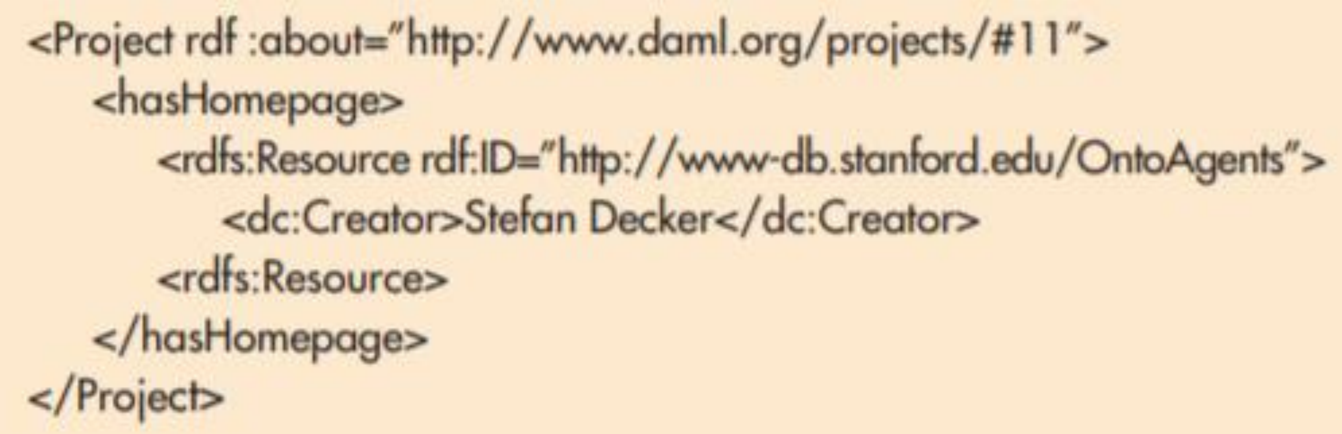
- Made of Subject-Predicate-Object Triples
- Uniform Resource Identifier (URI) disambiguates entities.


Subject
Predicate
Object
http://www.SemanticWeb.org/schema-daml01/#hasHomepage
http://www.daml.org/projects/#11
http://www-db.stanford.edu/OntoAgents

Source: http://www.contrib.andrew.cmu.edu/~mm6/95-733/PowerPoint/rdftutorial.pdf

RDF

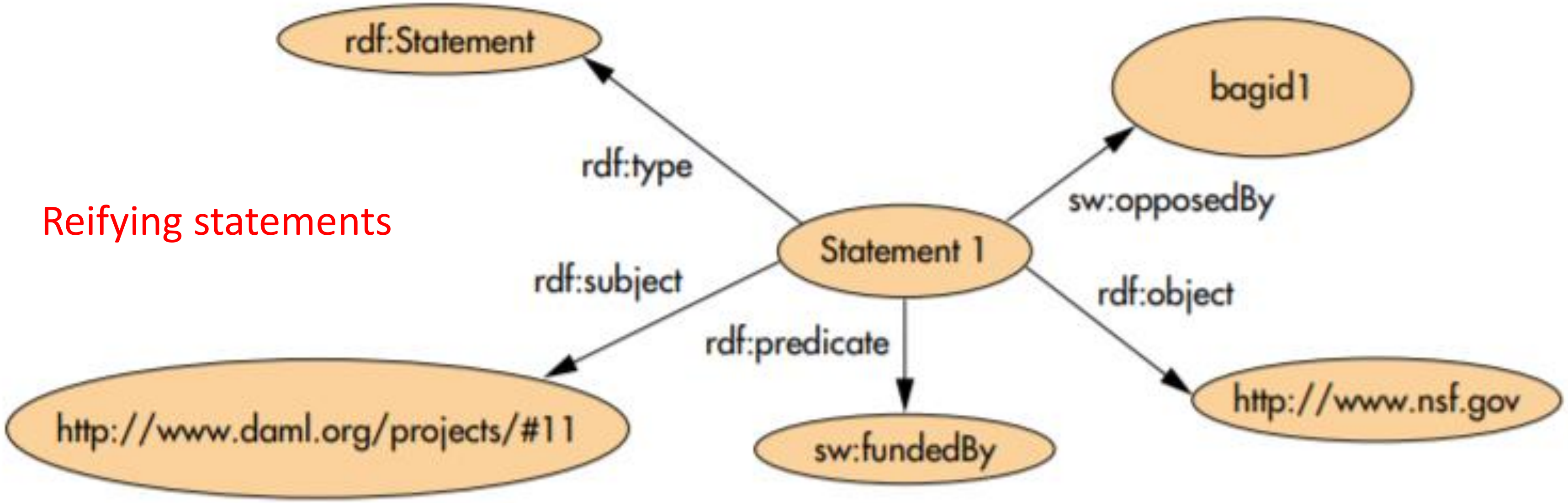
- Partial RDF Snippet



```
<Project rdf :about="http://www.daml.org/projects/#11">
    <hasHomepage>
        <rdfs:Resource rdf:ID="http://www-db.stanford.edu/OntoAgents">
            <dc:Creator>Stefan Decker</dc:Creator>
        <rdfs:Resource>
    </hasHomepage>
</Project>
```

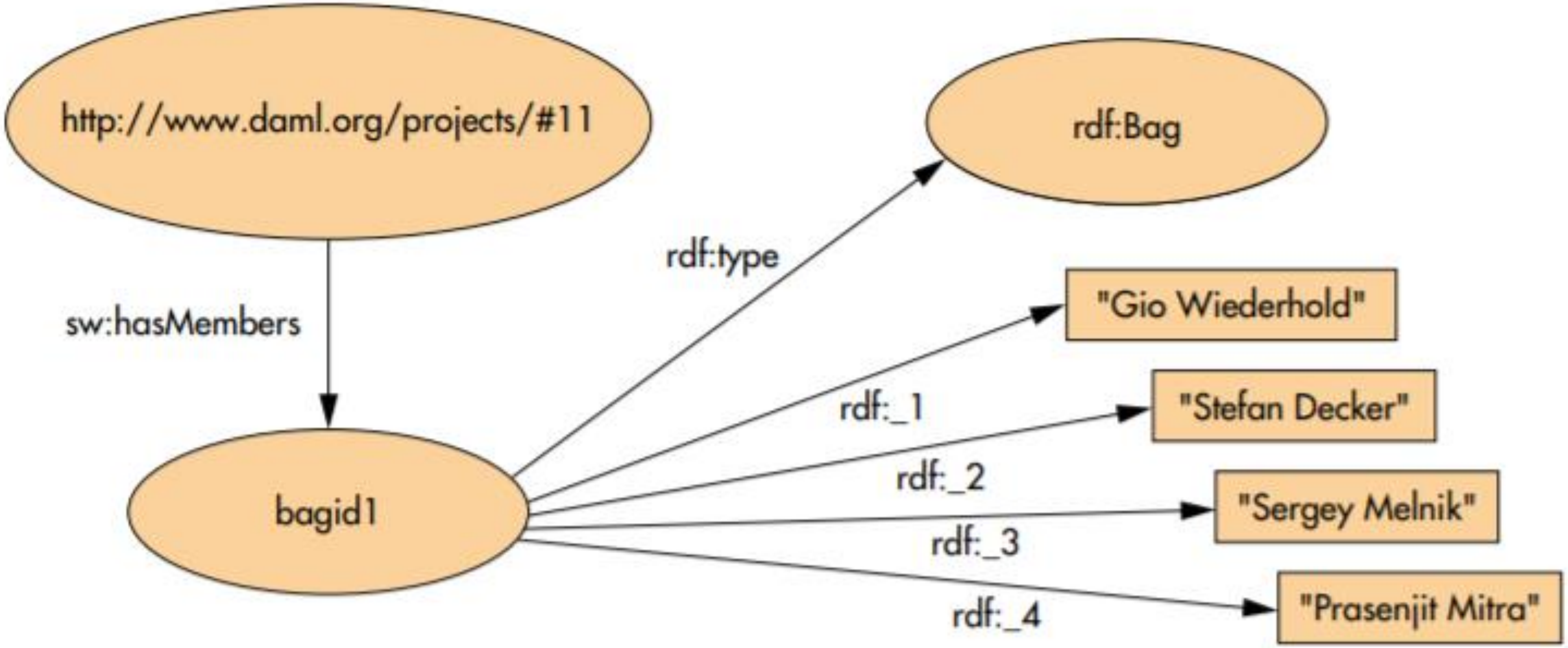
- These RDF Triples can be stored in a Triplestore
  - Such as RDFox and Jena TDB.
- These RDFs can get complex!

Reifying Statements in RDF



Reifying statements

RDF


http://www.daml.org/projects/#11
sw:hasMembers
bagid1
rdf:type
rdf:Bag
rdf:_1
"Gio Wiederhold"
rdf:_2
"Stefan Decker"
rdf:_3
"Sergey Melnik"
rdf:_4
"Prasenjit Mitra"

SPARQL

- Assume a data graph:

```
<http://.../book1>  <http://... /title>  "SPARQL Book"
```

- Then, the SPARQL query:

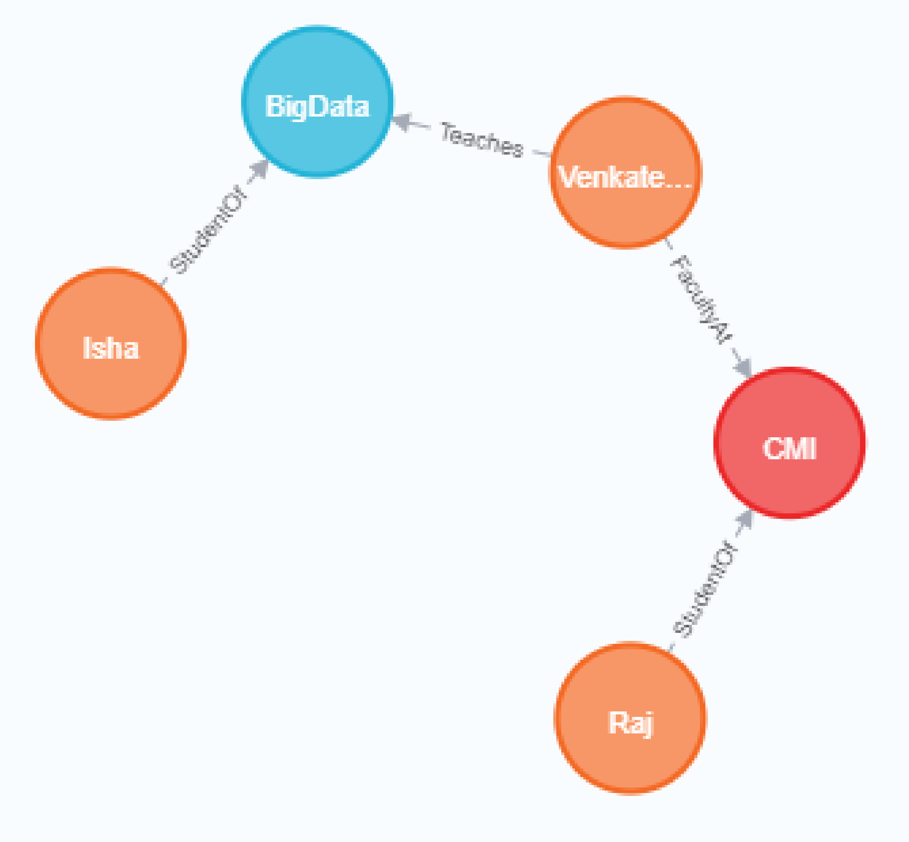
```
SELECT ?title  WHERE  {
  <http://.../book1> <http://.../title> ?title .
}
```

- Results in "SPARQL Book".
- Several tools support SPARQL
  - such as Apache Jena.

Try few SPARQL queries here - https://dbpedia.org/sparql/.

A Graph DB: Neo4j

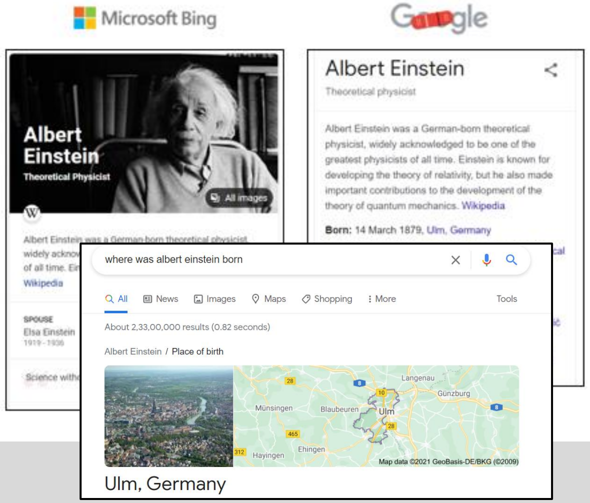
Demo 2



Any Graph DB can be used to store the triples.

Summary

Applications



Albert Einstein

Theoretical Physicist

Albert Einstein was a German-born theoretical physicist widely ackno… of all time. Ei…

Wikipedia

SPOUSE

Elsa Einstein

1919 - 1936

Science with…

Albert Einstein

Theoretical physicist

Albert Einstein was a German-born theoretical physicist, widely acknowledged to be one of the greatest physicists of all time. Einstein is known for developing the theory of relativity, but he also made important contributions to the development of the theory of quantum mechanics. Wikipedia

Born: 14 March 1879, Ulm, Germany

where was albert einstein born

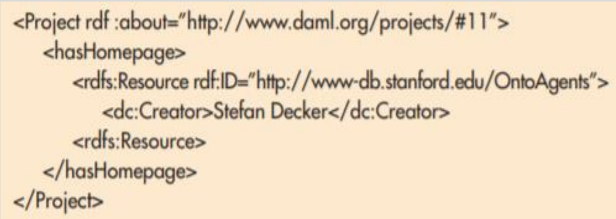
All | News | Images | Maps | Shopping | More | Tools

About 2,33,00,000 results (0.82 seconds)

Albert Einstein / Place of birth

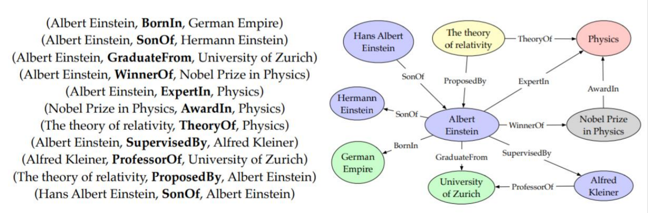
Ulm, Germany

Triplestore
(E.g.: Jena TDB, Neo4j with SPARQL/Cypher interface)



```
<Project rdf :about="http://www.daml.org/projects/#11">
    <hasHomepage>
        <rdfs:Resource rdf:ID="http://www-db.stanford.edu/OntoAgents">
            <dc:Creator>Stefan Decker</dc:Creator>
        <rdfs:Resource>
    </hasHomepage>
</Project>
```

RDF



(Albert Einstein, **BornIn**, German Empire)
(Albert Einstein, **SonOf**, Hermann Einstein)
(Albert Einstein, **GraduateFrom**, University of Zurich)
(Albert Einstein, **WinnerOf**, Nobel Prize in Physics)
(Albert Einstein, **ExpertIn**, Physics)
(Nobel Prize in Physics, **AwardIn**, Physics)
(The theory of relativity, **TheoryOf**, Physics)
(Albert Einstein, **SupervisedBy**, Alfred Kleiner)
(Alfred Kleiner, **ProfessorOf**, University of Zurich)
(The theory of relativity, **ProposedBy**, Albert Einstein)
(Hans Albert Einstein, **SonOf**, Albert Einstein)

Triples

World Knowledge

Story 2

Tools and Technologies

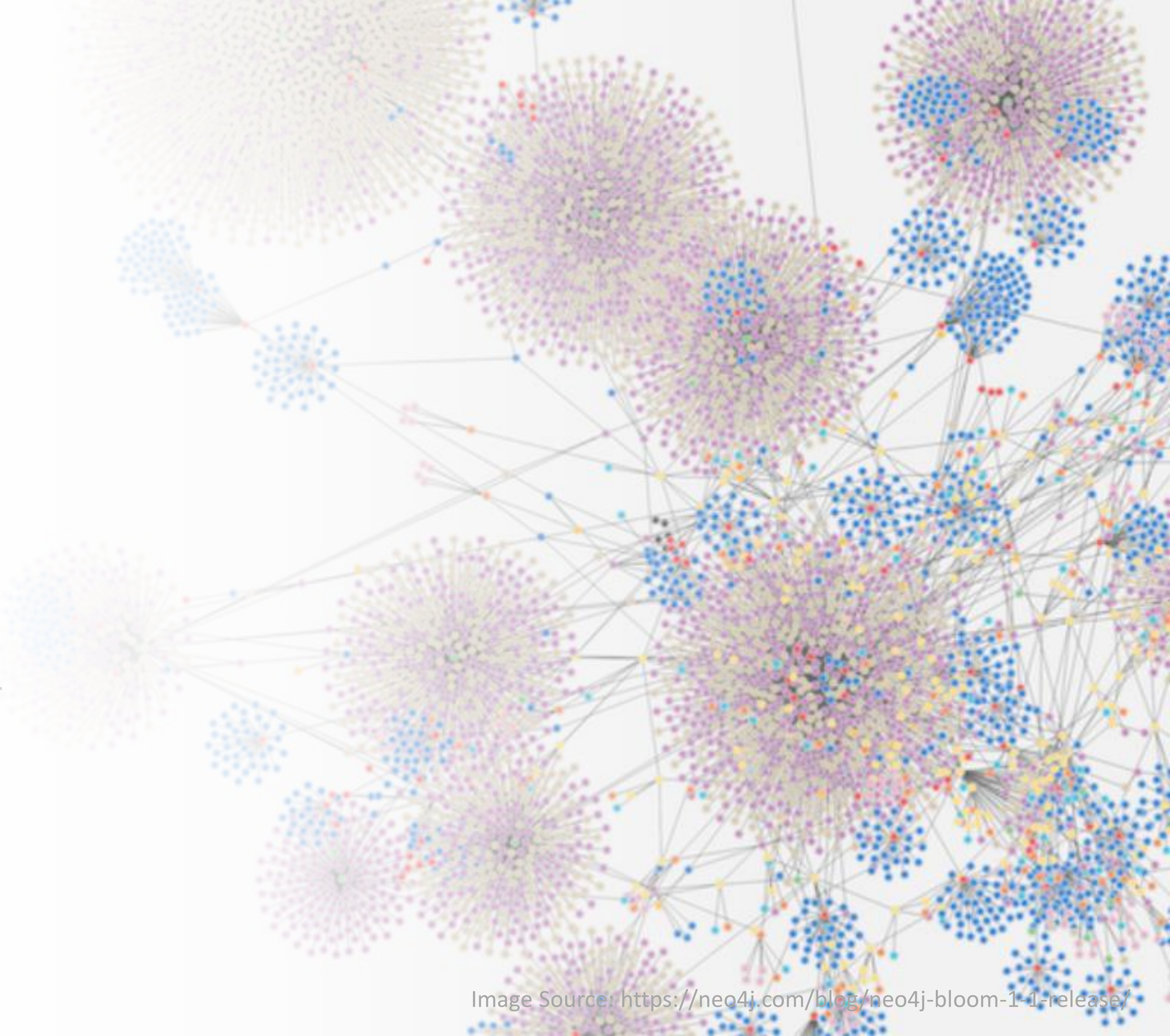
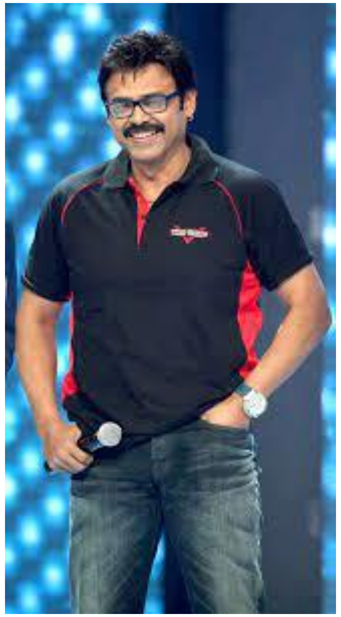


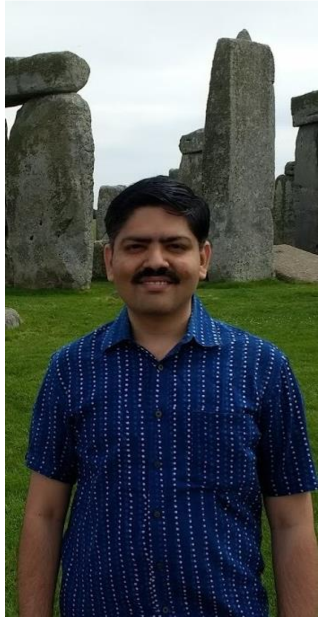
Image Source: https://neo4j.com/blog/neo4j-bloom-1-1-release/

Match the Text with the Image

Venkatesh did his schooling in Don Bosco, Egmore, Chennai. He got his MBA from the Middlebury Institute of International Studies at Monterey, USA. After his return to India, he wanted to get into film production but instead, became an actor in Telugu films.

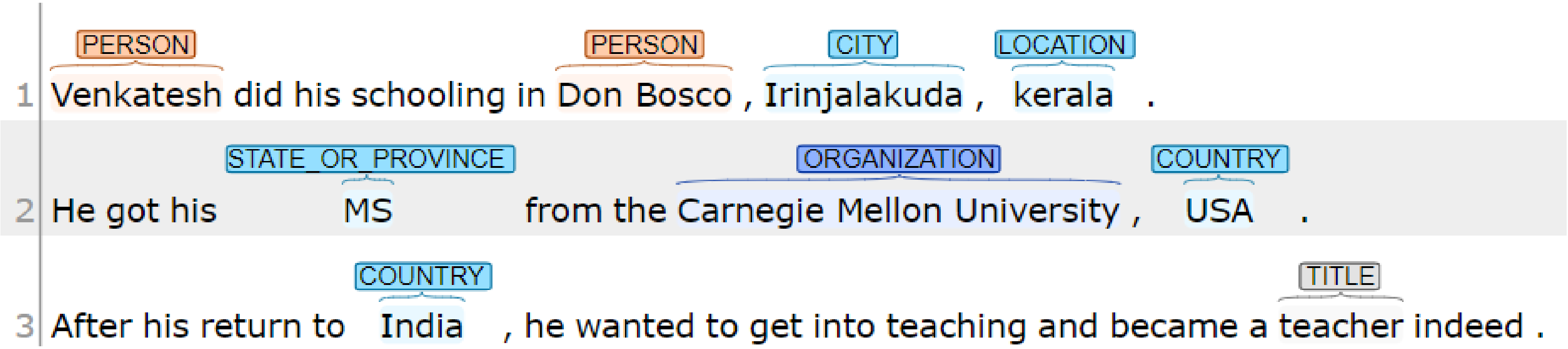
Venkatesh did his schooling in Don Bosco, Irinjalakuda, kerala. He got his MS from the Carnegie Mellon University, USA. After his return to India, he wanted to get into teaching and became a teacher indeed.





We Have Two Problems

- Given the input text
  - Recognize the entities – NER.
  - Disambiguate them – Entity Linking.



1 Venkatesh did his schooling in Don Bosco , Irinjalakuda , kerala .

2 He got his MS from the Carnegie Mellon University , USA .

3 After his return to India , he wanted to get into teaching and became a teacher indeed .

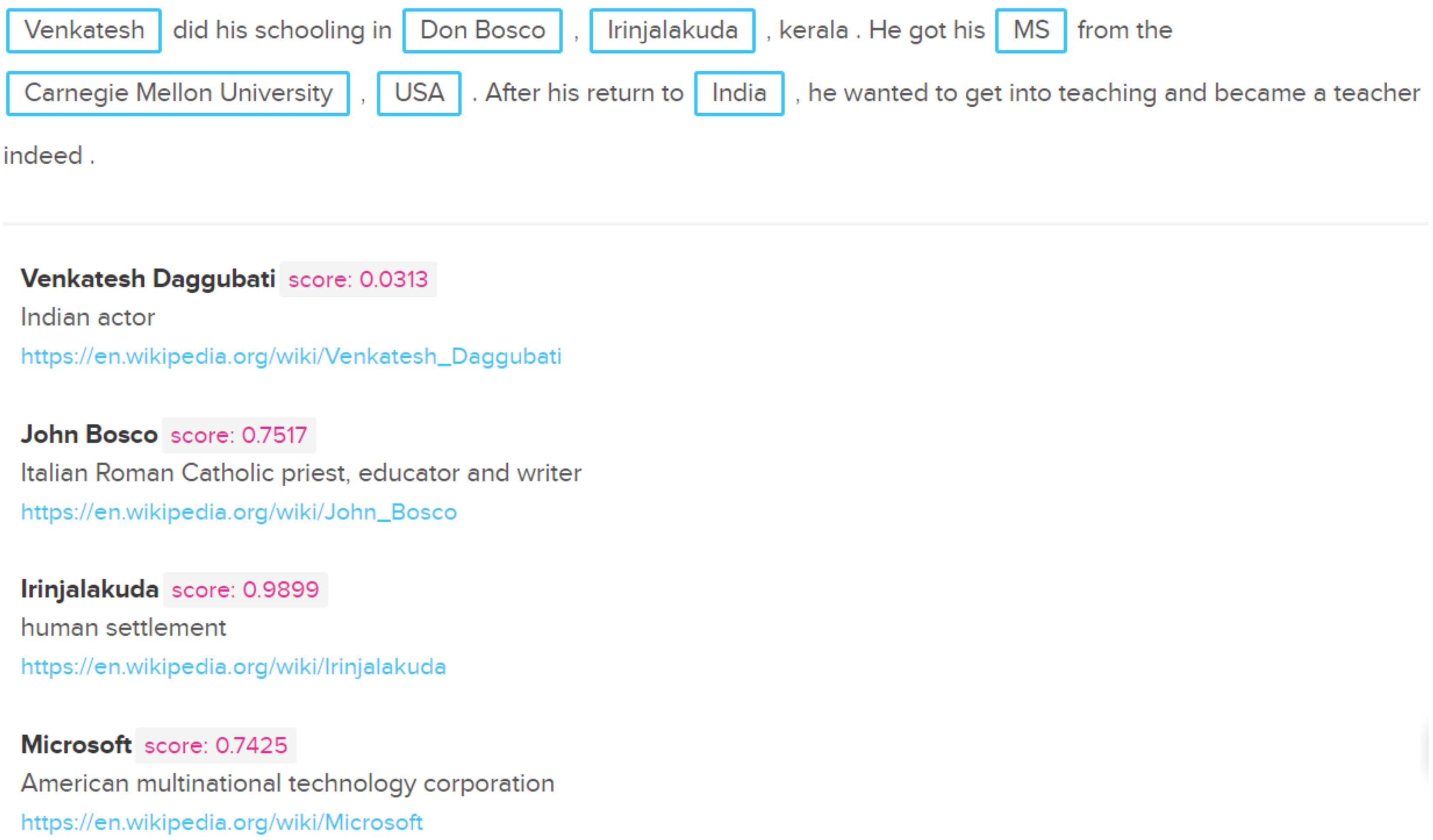
Try it at https://corenlp.run/

CoreNLP

- Extracted the following triples:

Subject	Predicate	Object
Venkatesh	per:statesorprovinces_of_residence	MS
Venkatesh	per:schools_attended	Carnegie Mellon University

Codeq NER and Linking



Venkatesh did his schooling in Don Bosco , Irinjalakuda , kerala . He got his MS from the Carnegie Mellon University , USA . After his return to India , he wanted to get into teaching and became a teacher indeed .

Venkatesh Daggubati score: 0.0313
Indian actor
https://en.wikipedia.org/wiki/Venkatesh_Daggubati

John Bosco score: 0.7517
Italian Roman Catholic priest, educator and writer
https://en.wikipedia.org/wiki/John_Bosco

Irinjalakuda score: 0.9899
human settlement
https://en.wikipedia.org/wiki/Irinjalakuda

Microsoft score: 0.7425
American multinational technology corporation
https://en.wikipedia.org/wiki/Microsoft

https://api.codeq.com/demo-nel

More Tools

- CYC – A Machine Reasoning Platform
  - OpenCYC (KB + Reasoning Engine)
    - 239K terms, 2M triples
  - ResearchCYC
    - 500K concepts, 26K relations
- Stanford Open Information Extraction (OpenIE)
  - Refers to the extraction of relation tuples, typically binary relations, from plain text
  - Barack Obama was born in Hawaii would create a triple (Barack Obama; was born in; Hawaii)

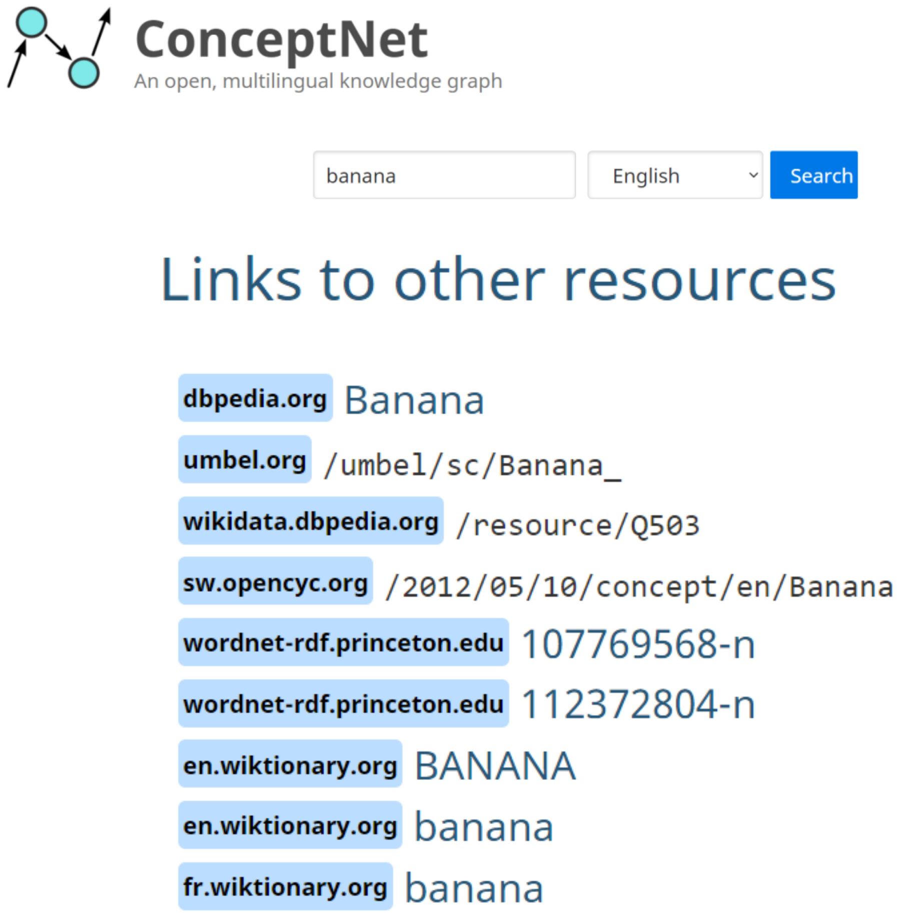
https://cyc.com/
https://www.ime.usp.br/~fr/opencyc/ OpenCyC does not exist anymore.
https://en.wikipedia.org/wiki/Cyc#ResearchCyc
https://nlp.stanford.edu/software/openie.html

Tools Need Resources and We Have Many

- Dbpedia
    - 228 million entities
- Wiktionary
    - 6.6M dictionary entries
- Freebase
    - Google’s Knowledge Graph was powered partly by Freebase. Does not exist now.
- Yago
    - A large knowledge base about people, cities, countries, movies, and organizations.

ConceptNet

- A freely-available semantic network, designed to help computers understand the meanings of words.
- Has ~15 million facts in English
- Uses Crowdsourced knowledge
  - Open Mind Common Sense, Wiktionary, DBPedia, Yahoo Japan / Kyoto University project



Links to other resources

dbpedia.org	Banana
umbel.org	/umbel/sc/Banana_
wikidata.dbpedia.org	/resource/Q503
sw.opencyc.org	/2012/05/10/concept/en/Banana
wordnet-rdf.princeton.edu	107769568-n
wordnet-rdf.princeton.edu	112372804-n
en.wiktionary.org	BANANA
en.wiktionary.org	banana
fr.wiktionary.org	banana

[Havasi et al., RANLP ‘07; Speer and Havasi, LREC ‘12]

Summary

Demo 3

- Several tools and technologies exist to help you build the knowledge graph.
  - CoreNLP
  - Codeq
  - ConceptNet
  - CyC
  - OpenIE
- Caveat: They may not be perfect.

Story 3

Two Algorithms

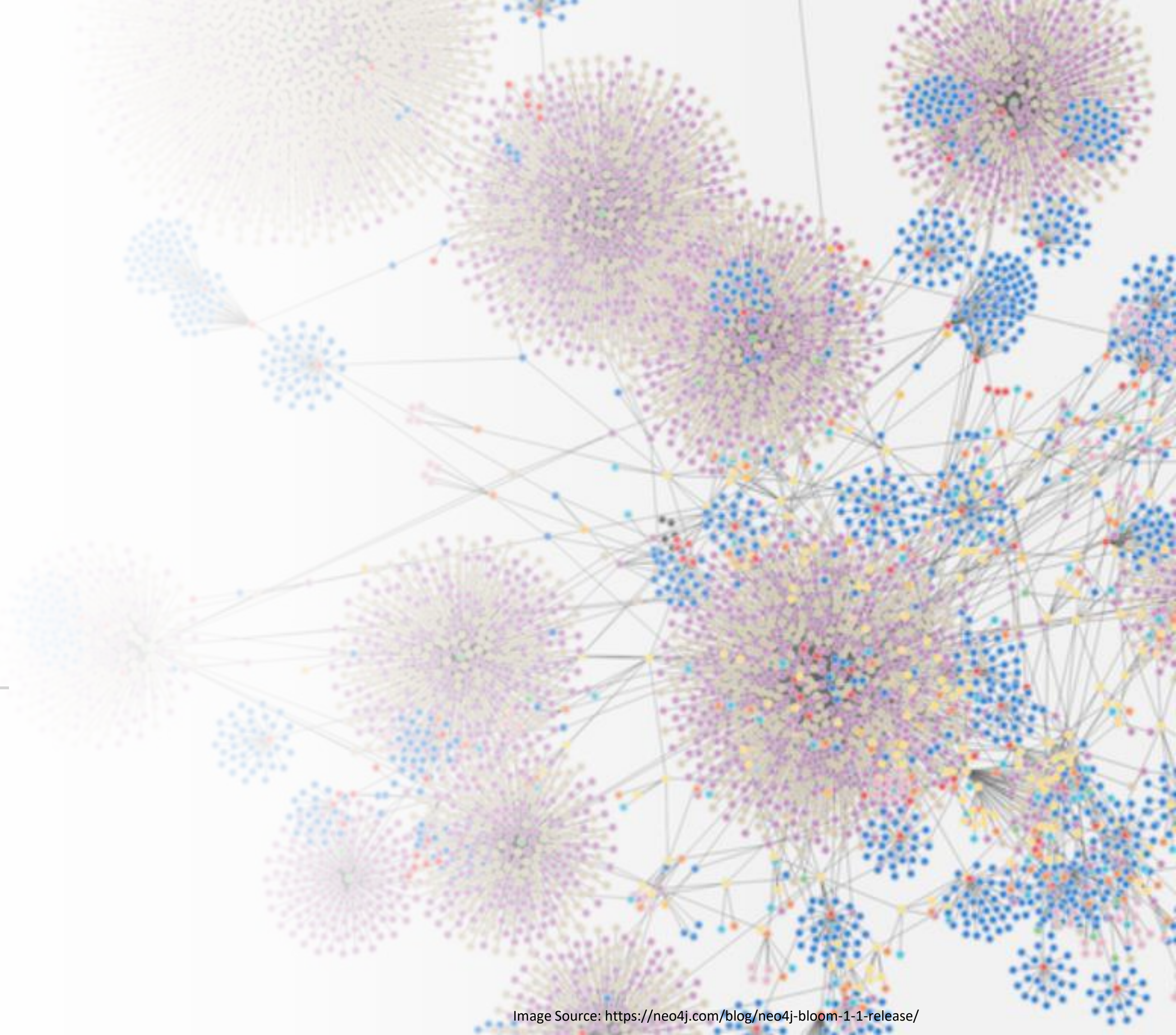
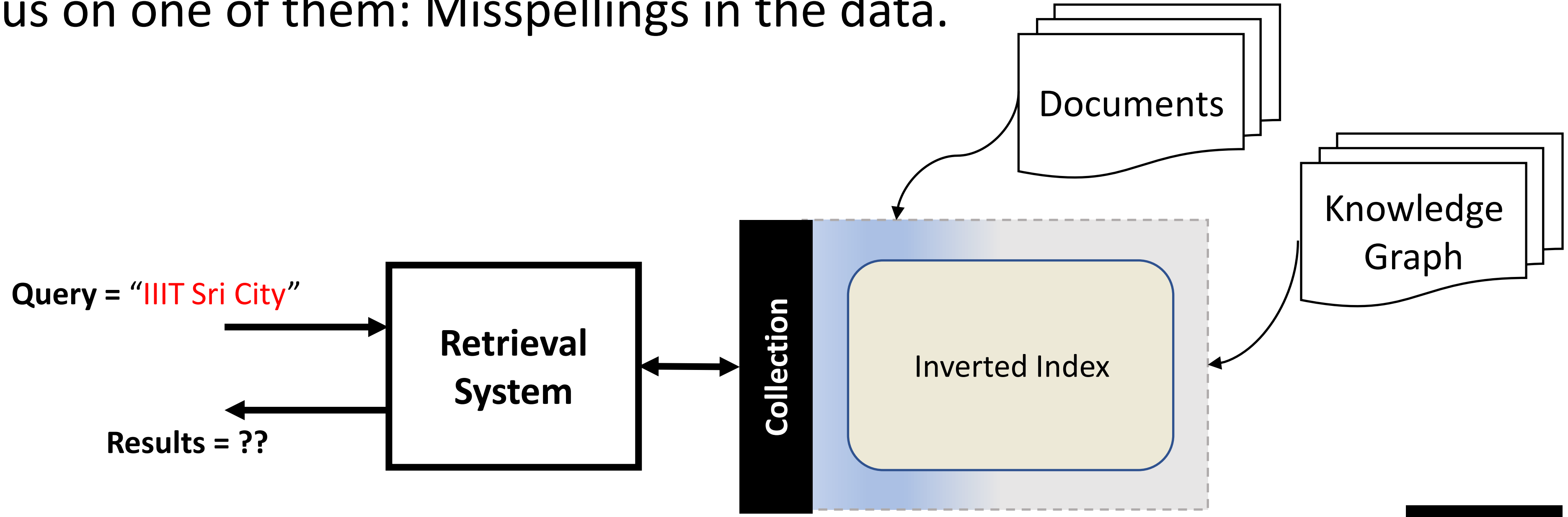


Image Source: https://neo4j.com/blog/neo4j-bloom-1-1-release/

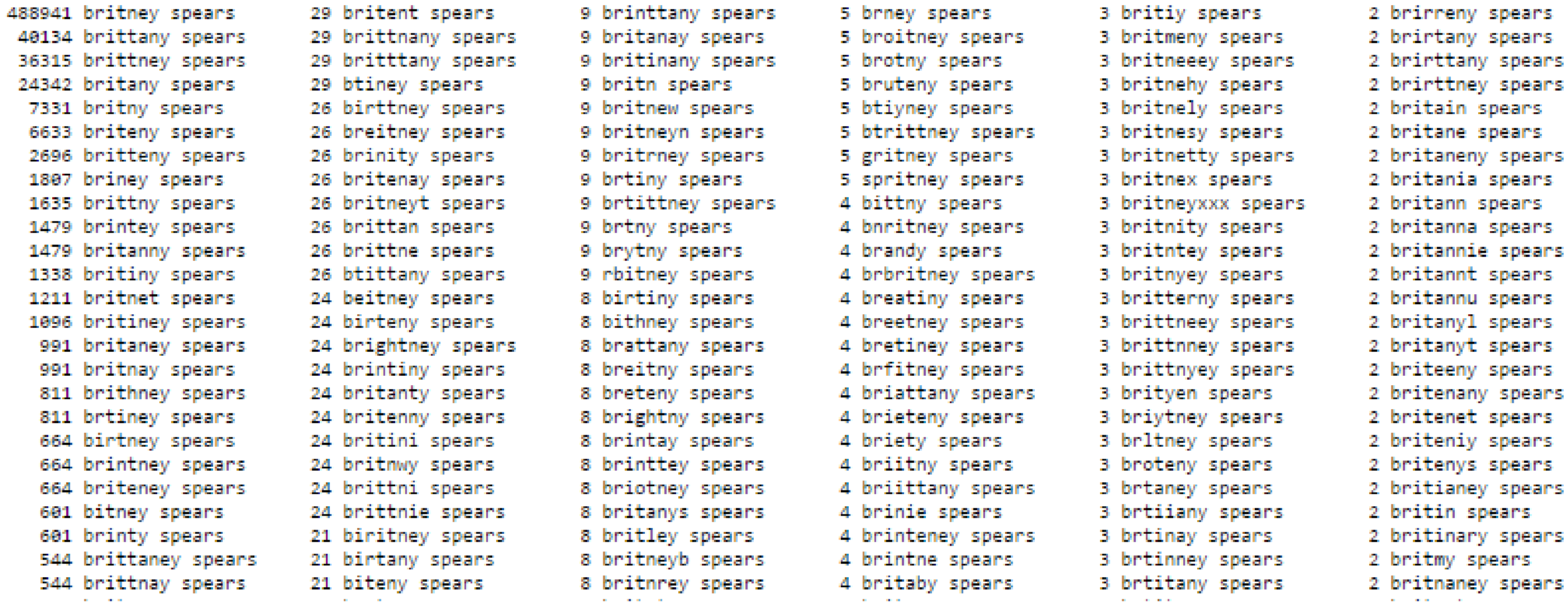
Entity Retrieval

- Retrieving entities – not documents.
- Knowledge graphs are very useful for this purpose.
- However, both KG construction and ER have common problems
    - We focus on one of them: Misspellings in the data.



Notorious Britney

The data below shows some of the misspellings detected by our spelling correction system for the query [britney spears], and the count of how many different users spelled her name that way. -- Google.



```
488941 britney spears      29 britent spears      9 brinttany spears    5 brney spears        3 britiy spears        2 brirreny spears
 40134 brittany spears     29 brittnany spears    9 britanay spears     5 broitney spears     3 britmeny spears      2 brirtany spears
 36315 brittney spears     29 britttany spears    9 britinany spears    5 brotny spears       3 britneeey spears     2 brirttany spears
 24342 britany spears      29 btiney spears       9 britn spears        5 bruteny spears      3 britnehy spears      2 brirttney spears
  7331 britny spears       26 birttney spears     9 britnew spears      5 btiyney spears      3 britnely spears      2 britain spears
  6633 briteny spears      26 breitney spears     9 britneyn spears     5 btrittney spears    3 britnesy spears      2 britane spears
  2696 britteny spears     26 brinity spears      9 britrney spears     5 gritney spears      3 britnetty spears     2 britaneny spears
  1807 briney spears       26 britenay spears     9 brtiny spears       5 spritney spears     3 britnex spears       2 britania spears
  1635 brittny spears      26 britneyt spears     9 brtittney spears    4 bittny spears       3 britneyxxx spears    2 britann spears
  1479 brintey spears      26 brittan spears      9 brtny spears        4 bnritney spears     3 britnity spears      2 britanna spears
  1479 britanny spears     26 brittne spears      9 brytny spears       4 brandy spears       3 britntey spears      2 britannie spears
  1338 britiny spears      26 btittany spears     9 rbitney spears      4 brbritney spears    3 britnyey spears      2 britannt spears
  1211 britnet spears      24 beitney spears      8 birtiny spears      4 breatiny spears     3 britterny spears     2 britannu spears
  1096 britiney spears     24 birteny spears      8 bithney spears      4 breetney spears     3 brittneey spears     2 britanyl spears
   991 britaney spears     24 brightney spears    8 brattany spears     4 bretiney spears     3 brittnney spears     2 britanyt spears
   991 britnay spears      24 brintiny spears     8 breitny spears      4 brfitney spears     3 brittnyey spears     2 briteeny spears
   811 brithney spears     24 britanty spears     8 breteny spears      4 briattany spears    3 brityen spears       2 britenany spears
   811 brtiney spears      24 britenny spears     8 brightny spears     4 brieteny spears     3 briytney spears      2 britenet spears
   664 birtney spears      24 britini spears      8 brintay spears      4 briety spears       3 brltney spears       2 briteniy spears
   664 brintney spears     24 britnwy spears      8 brinttey spears     4 briitny spears      3 broteny spears       2 britenys spears
   664 briteney spears     24 brittni spears      8 briotney spears     4 briittany spears    3 brtaney spears       2 britianey spears
   601 bitney spears       24 brittnie spears     8 britanys spears     4 brinie spears       3 brtiiany spears      2 britin spears
   601 brinty spears       21 biritney spears     8 britley spears      4 brinteney spears    3 brtinay spears       2 britinary spears
   544 brittaney spears    21 birtany spears      8 britneyb spears     4 brintne spears      3 brtinney spears      2 britmy spears
   544 brittnay spears     21 biteny spears       8 britnrey spears     4 britaby spears      3 brtitany spears      2 britnaney spears
```

Source: https://archive.google.com/jobs/britney.html

Correcting Misspellings

- There are many approaches. We focus on two major approaches:
  - finding “**nearest**” term using ***Edit Distance.***
  - Finding “**similar sounding terms**” using ***Phonetic Hash***.

Algorithm 1: Finding Nearest Term with Edit Distance

- Given two strings S_1 and S_2, the minimum number of operations to convert one to the other
- Operations are typically character-level
    - Insert, Delete, Replace
    - E.g., the edit distance from ***dof*** to ***dog*** is 1
    - From ***cat*** to ***act*** is 2
    - From ***cat*** to ***dog*** is 3.

*Here, we do not consider transposition.

Quiz

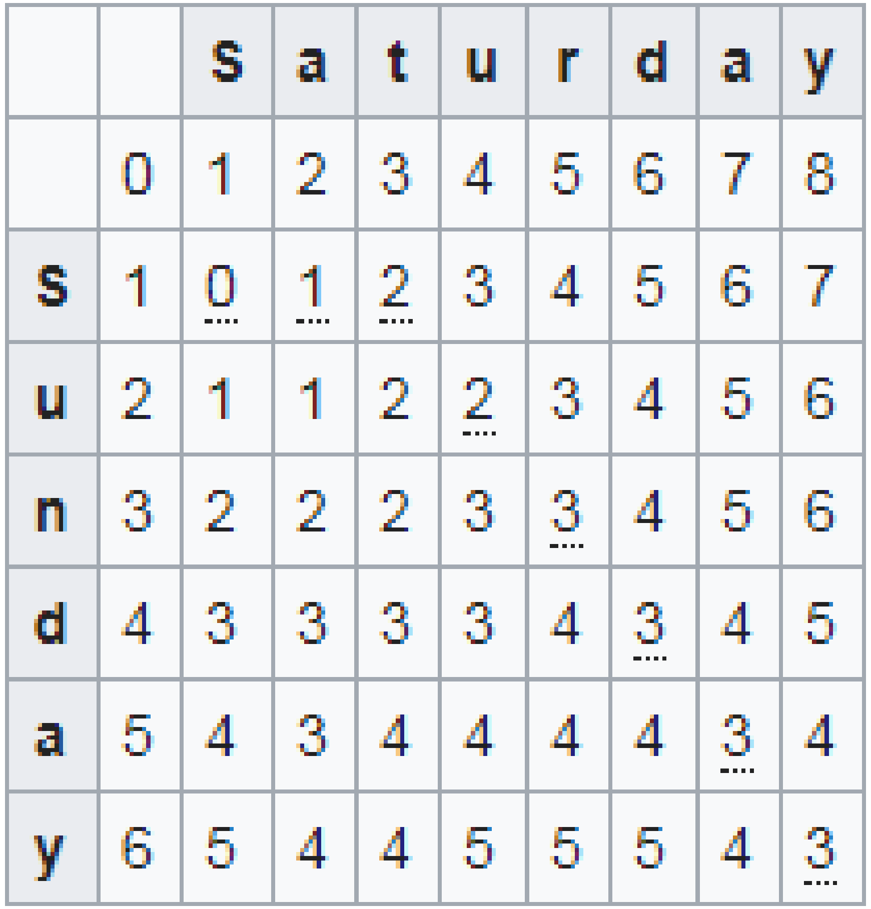
What is the edit distance between Sunday and Saturday?

*You are allowed to perform only Insert, Delete, and Replace operations.

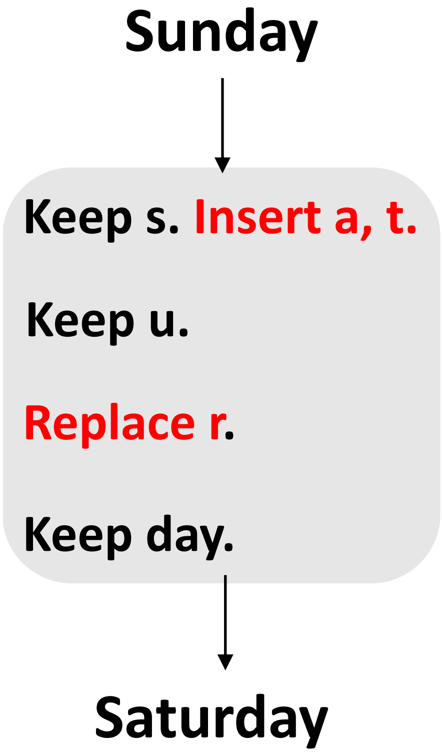
Answer

- Saturday = Sunday = S*day
- Problem is same as
  - What is the edit distance between atur and un?
  - Answer
    - Delete a,t. Replace r with n.
    - 3.

Levenshtein Example



		S	a	t	u	r	d	a	y
	0	1	2	3	4	5	6	7	8
S	1	0	1	2	3	4	5	6	7
u	2	1	1	2	2	3	4	5	6
n	3	2	2	2	3	3	4	5	6
d	4	3	3	3	3	4	3	4	5
a	5	4	3	4	4	4	4	3	4
y	6	5	4	4	5	5	5	4	3



Sunday

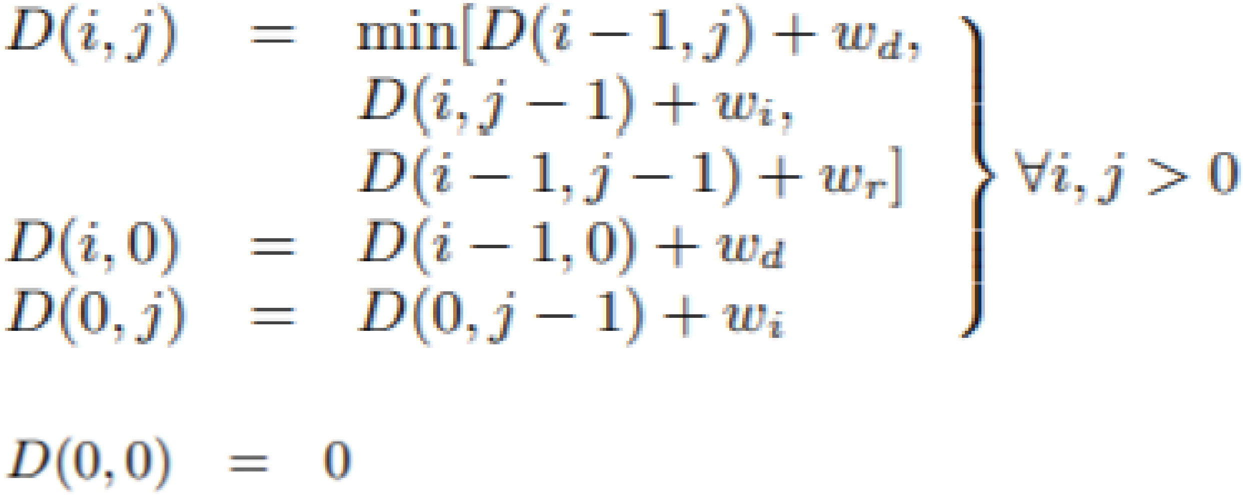
Keep s. Insert a, t.

Keep u.

Replace r.

Keep day.

Saturday



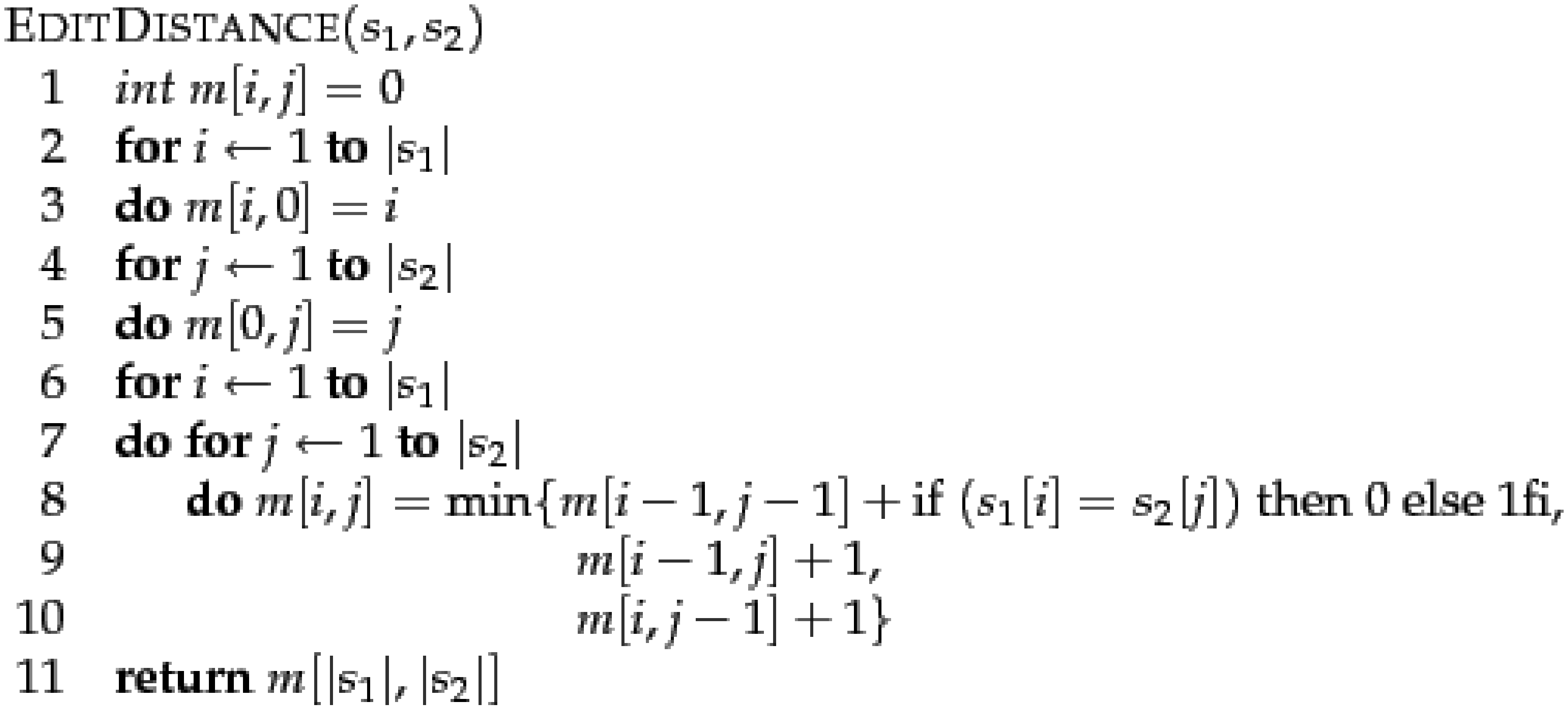
$$
\left.\begin{aligned}
D(i,j) &= \min[D(i-1,j)+w_d,\\
&\qquad D(i,j-1)+w_i,\\
&\qquad D(i-1,j-1)+w_r]\\
D(i,0) &= D(i-1,0)+w_d\\
D(0,j) &= D(0,j-1)+w_i
\end{aligned}\right\}\forall i,j>0
$$

$$D(0,0) = 0$$

Note: $w_r = 0$ *if* $a_i = a_j$ i.e., if the characters being compared are the same.

V. I. Levenshtein, Binary codes capable of correcting deletions insertions and reversals. Soviet Physics. 10, 707-710, 1966.

Levenshtein Algorithm



```
EditDistance($s_1, s_2$)
int $m[i, j] = 0$
for $i \leftarrow 1$ to $|s_1|$
do $m[i, 0] = i$
for $j \leftarrow 1$ to $|s_2|$
do $m[0, j] = j$
for $i \leftarrow 1$ to $|s_1|$
do for $j \leftarrow 1$ to $|s_2|$
     do $m[i, j] = \min\{m[i-1, j-1] +$ if $(s_1[i] = s_2[j])$ then 0 else 1fi,
                         $m[i-1, j] + 1,$
                         $m[i, j-1] + 1\}$
return $m[|s_1|, |s_2|]$
```

Algorithm 2: Soundex

- Homophones (sound alike but have different spellings and different meaning)
  - pair, pear
  - break, brake
  - cell, sell
  - cent, scent
  - knight, night

Donald Knuth

Algorithm 2: Soundex

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    - pair, pear
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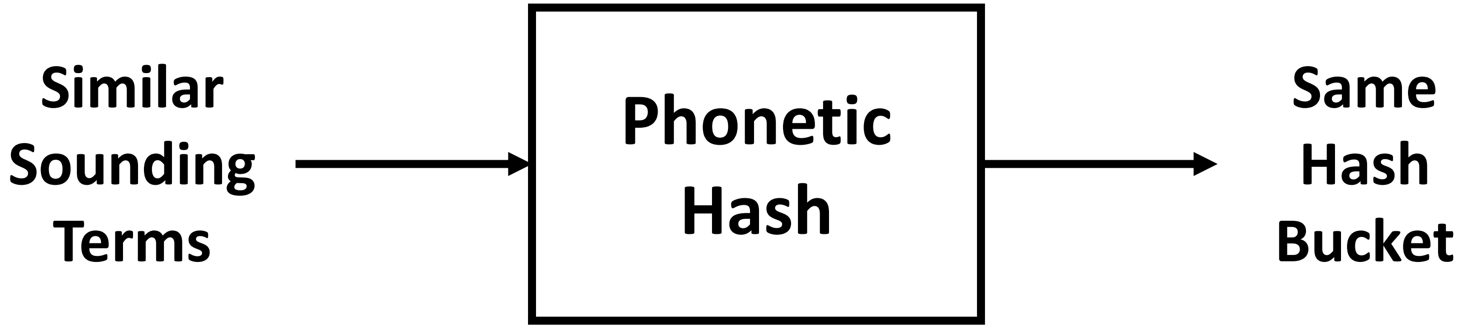
Soundex algorithm became more popular after it was discussed in “The Art of Programming”! Find a bug and take home 100_{16} (or 0x00000100) cents! i.e., 256 cents.

Main Idea



Similar Sounding Terms

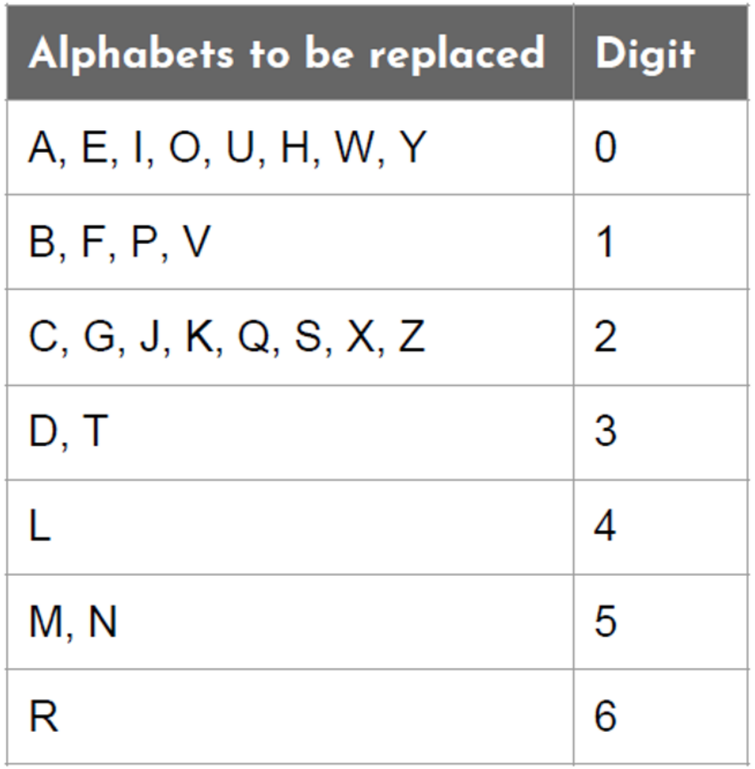
Phonetic Hash

Same Hash Bucket

Soundex Algorithms generate phonetic hash

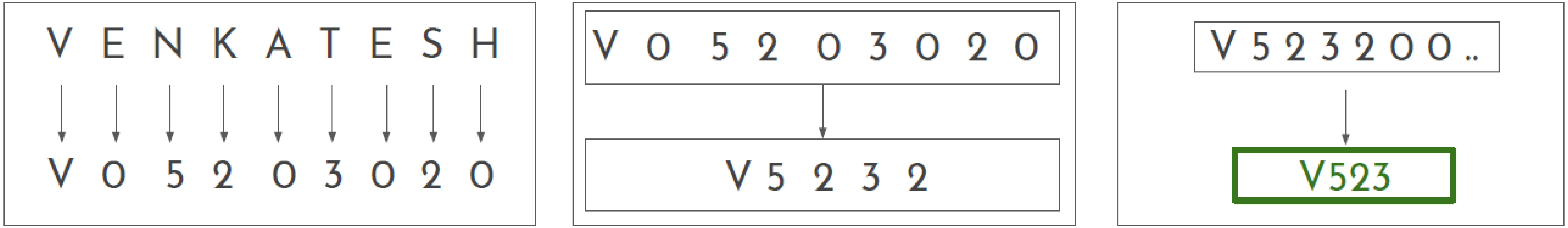
Standard Soundex Algorithm

1. Retain the first character.
2. Convert each character to digit using the rules in the table.
3. Repeatedly remove one out of each pair of consecutive identical digits.
4. Remove all the zeros.
5. Add trailing zeros, and return the first four positions.



Alphabets to be replaced	Digit
A, E, I, O, U, H, W, Y	0
B, F, P, V	1
C, G, J, K, Q, S, X, Z	2
D, T	3
L	4
M, N	5
R	6

An Example



VENKATESH

V 0 5 2 0 3 0 2 0

V 0 5 2 0 3 0 2 0

V 5 2 3 2

V 5 2 3 2 0 0 ..

V523

- Retain the first character
- Convert each character to digit using the rules of the algorithm.

- Repeatedly remove one out of each pair of consecutive identical digits.
- Remove all the zeros.

- Add trailing zeros, and return the first four positions.

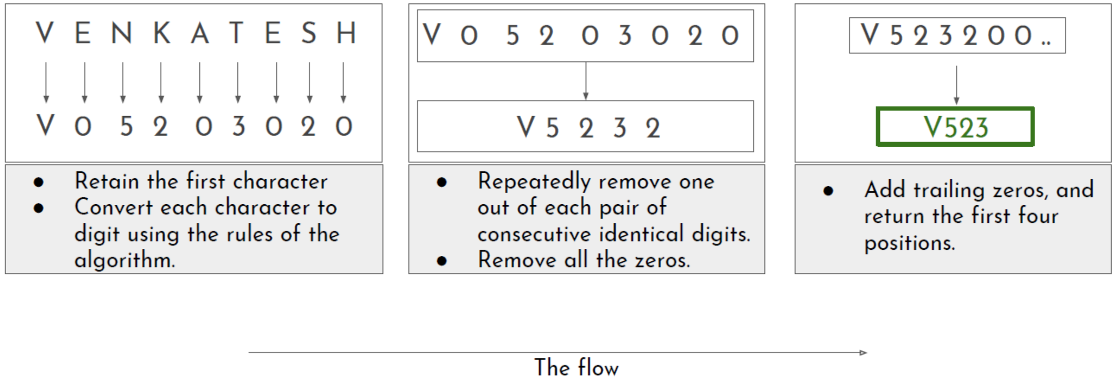
The flow

Summary

- Finding nearest term – Levenshtein’s Algorithm

$$\left.\begin{array}{rcl} D(i,j) &=& \min[D(i-1,j)+w_d, \\ && D(i,j-1)+w_i, \\ && D(i-1,j-1)+w_r] \\ D(i,0) &=& D(i-1,0)+w_d \\ D(0,j) &=& D(0,j-1)+w_i \end{array}\right\} \forall i,j>0$$

- Phonetic Hash – Soundex Algorithm



- Retain the first character
- Convert each character to digit using the rules of the algorithm.

- Repeatedly remove one out of each pair of consecutive identical digits.
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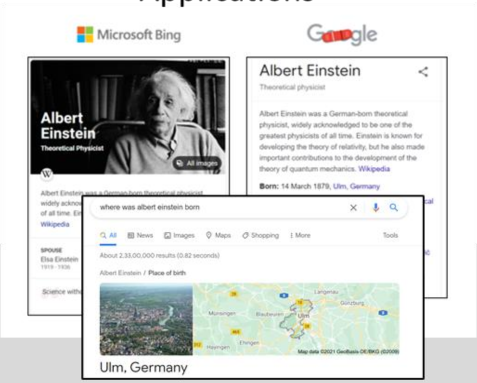
Applications



Albert Einstein was a German-born theoretical physicist, widely acknowledged to be one of the greatest physicists of all time. Einstein is known for developing the theory of relativity, but he also made important contributions to the development of the theory of quantum mechanics. Wikipedia

Born: 14 March 1879, Ulm, Germany

where was albert einstein born

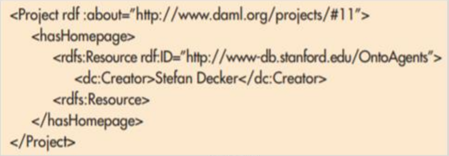
About 2,33,00,000 results (0.82 seconds)

Albert Einstein / Place of birth

Ulm, Germany

Triplestore
(E.g.: Jena TDB, Neo4j with SPARQL/Cypher interface)

⬆



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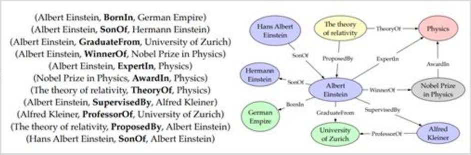
    <hasHomepage>
        <rdfs:Resource rdf:ID="http://www-db.stanford.edu/OntoAgents">
            <dc:Creator>Stefan Decker</dc:Creator>
        <rdfs:Resource>
    </hasHomepage>
</Project>
```

RDF

⬅

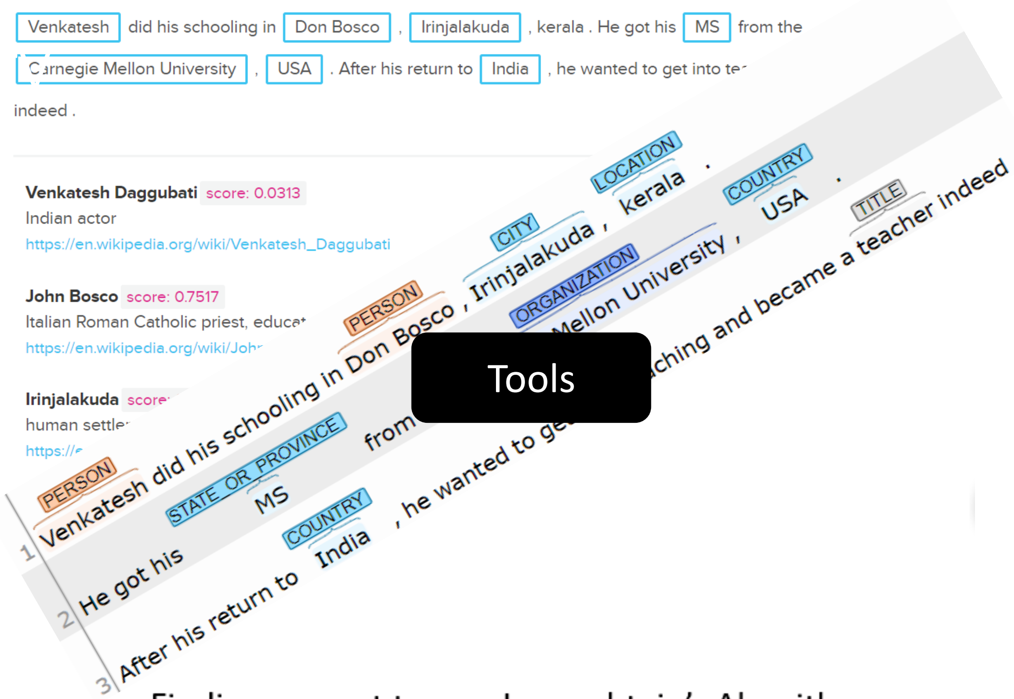


(Albert Einstein, **BornIn**, German Empire)
(Albert Einstein, **SonOf**, Hermann Einstein)
(Albert Einstein, **GraduateFrom**, University of Zurich)
(Albert Einstein, **WinnerOf**, Nobel Prize in Physics)
(Albert Einstein, **ExpertIn**, Physics)
(Nobel Prize in Physics, **AwardIn**, Physics)
(The theory of relativity, **TheoryOf**, Physics)
(Albert Einstein, **SupervisedBy**, Alfred Kleiner)
(Alfred Kleiner, **ProfessorOf**, University of Zurich)
(The theory of relativity, **ProposedBy**, Albert Einstein)
(Hans Albert Einstein, **SonOf**, Albert Einstein)

Triples

⬅

World Knowledge



Venkatesh did his schooling in Don Bosco , Irinjalakuda , kerala . He got his MS from the Carnegie Mellon University , USA . After his return to India , he wanted to get into te

indeed .

Venkatesh Daggubati score: 0.0313
Indian actor
https://en.wikipedia.org/wiki/Venkatesh_Daggubati

John Bosco score: 0.7517
Italian Roman Catholic priest, educat
https://en.wikipedia.org/wiki/Joh

Irinjalakuda score
human settle
https://

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After his return to India , he wanted to ge ching and became a teacher indeed .

Tools

Finding nearest term – Levenshtein's Algorithm

$$
\begin{aligned}
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&\quad\;\; D(i,j-1)+w_i, \\
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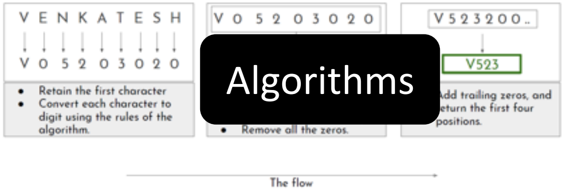
D(i,0) &= D(i-1,0)+w_d \\
D(0,j) &= D(0,j-1)+w_i
\end{aligned}
\Bigg\} \forall i,j>0
$$

Phonetic Hash – Soundex Algorithm



- Retain the first character
- Convert each character to digit using the rules of the algorithm.

- Remove all the zeros.

Add trailing zeros, and return the first four positions.

Algorithms

Future Directions

- Handling uncertain data
  - We do not like “population in rome is …”
  - We like “As per 2012 report, the population in rome is …”
- Knowledge Graph Embeddings
  - Represent entities in a continuous vector space
- Multimodal Knowledge Graphs
- Explainability and Knowledge Graphs
- Relationship Mining
- Interoperability of knowledgebases
- … and many applications in several domains.

Thank You

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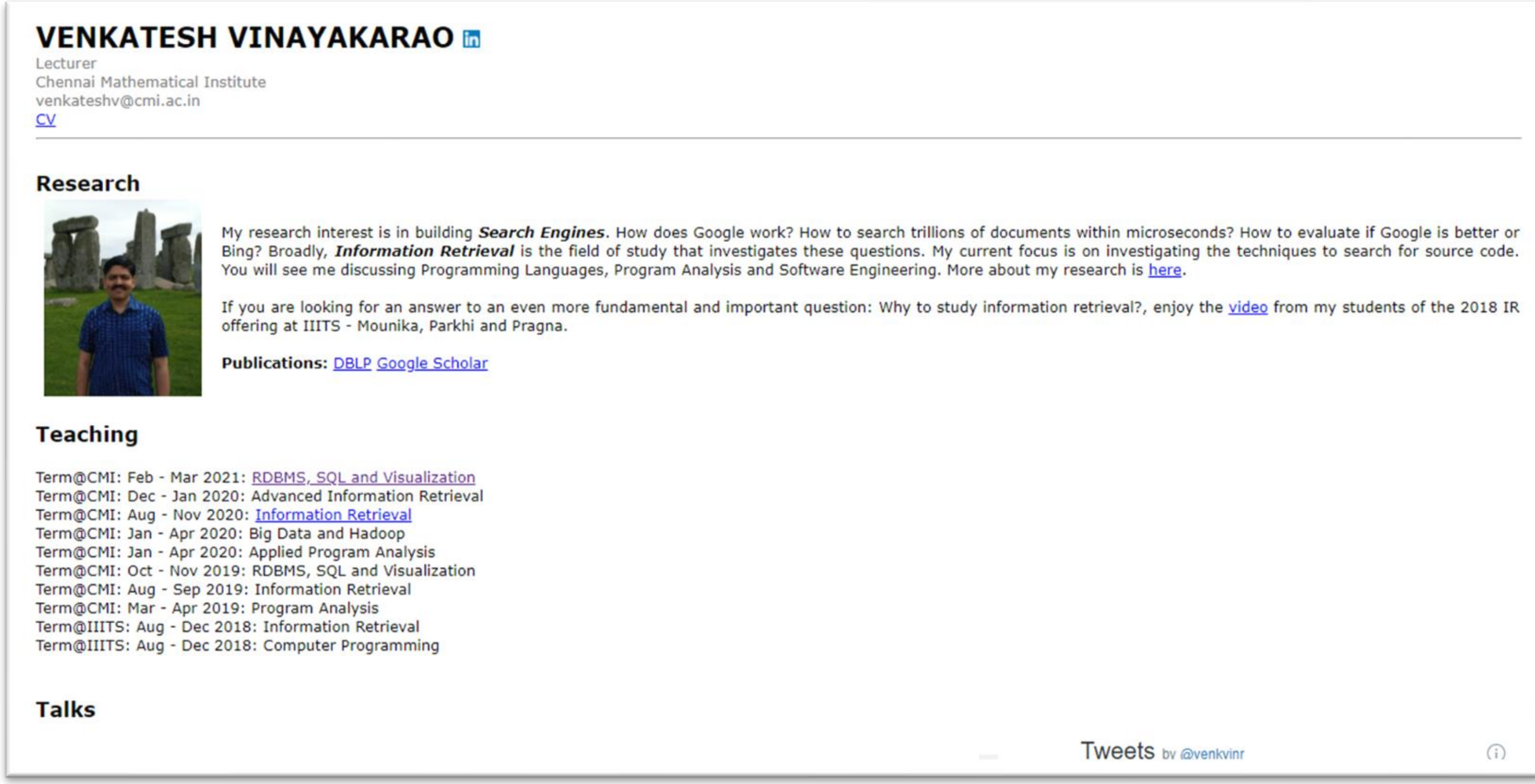
This slide deck is available at http://vvtesh.co.in/.



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CV

Research

My research interest is in building ***Search Engines***. How does Google work? How to search trillions of documents within microseconds? How to evaluate if Google is better or Bing? Broadly, ***Information Retrieval*** is the field of study that investigates these questions. My current focus is on investigating the techniques to search for source code. You will see me discussing Programming Languages, Program Analysis and Software Engineering. More about my research is here.

If you are looking for an answer to an even more fundamental and important question: Why to study information retrieval?, enjoy the video from my students of the 2018 IR offering at IIITS - Mounika, Parkhi and Pragna.

Publications: DBLP Google Scholar

Teaching

Term@CMI: Feb - Mar 2021: RDBMS, SQL and Visualization
Term@CMI: Dec - Jan 2020: Advanced Information Retrieval
Term@CMI: Aug - Nov 2020: Information Retrieval
Term@CMI: Jan - Apr 2020: Big Data and Hadoop
Term@CMI: Jan - Apr 2020: Applied Program Analysis
Term@CMI: Oct - Nov 2019: RDBMS, SQL and Visualization
Term@CMI: Aug - Sep 2019: Information Retrieval
Term@CMI: Mar - Apr 2019: Program Analysis
Term@IIITS: Aug - Dec 2018: Information Retrieval
Term@IIITS: Aug - Dec 2018: Computer Programming

Talks