

# COMP318

## Ontologies and Semantic Web

# Knowledge Graphs - Part 3

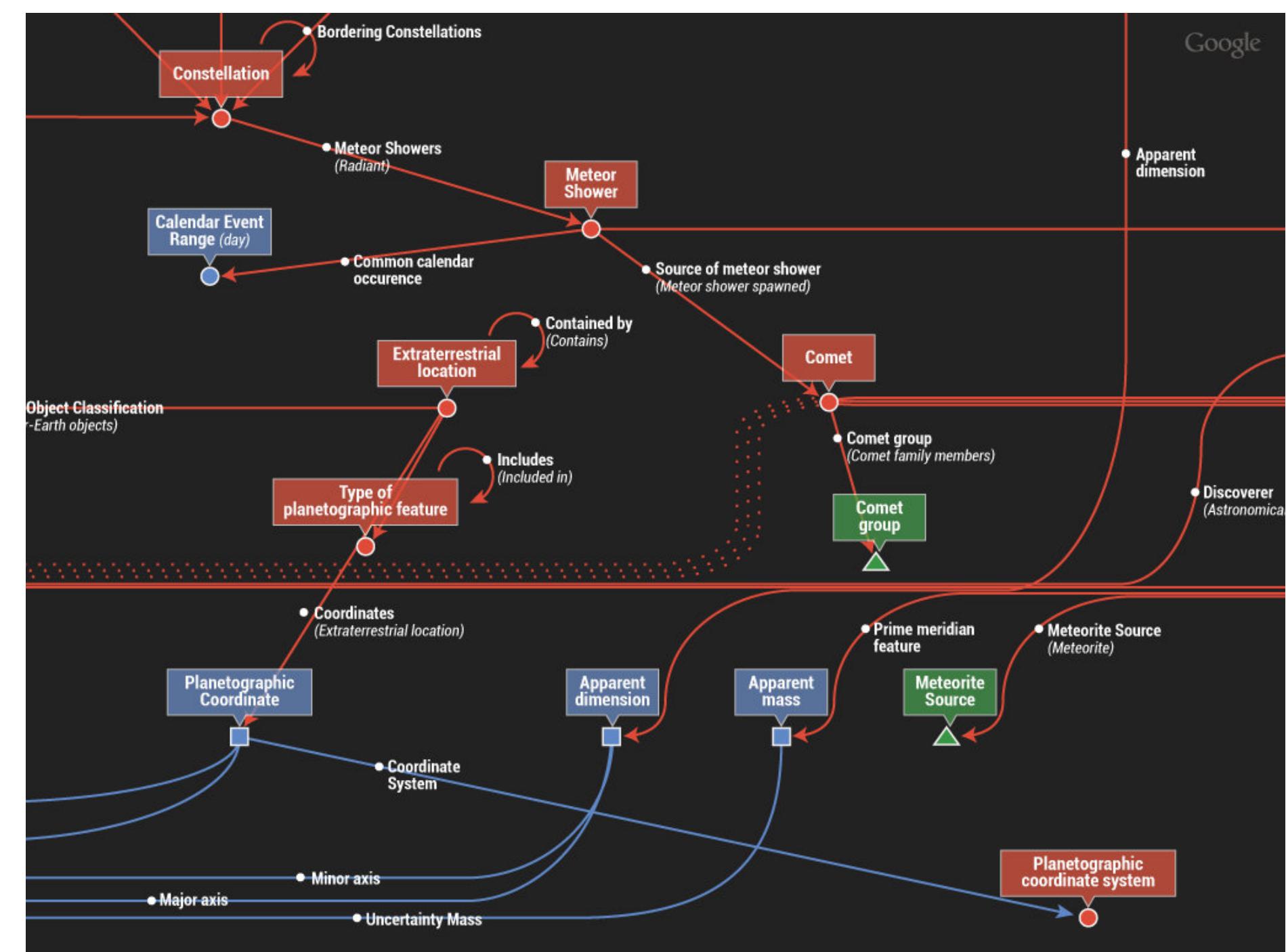
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# What is a knowledge graph

- Given a set of entities E, and relations R, a KG is a directed multi-relational graph G that contains triples of type (s, p, o)
  - $G \subseteq E \times R \times E : (s, p, o) \in G$
  - describes entities and relations
  - defines a schema interrelating arbitrary entities on various topical domains



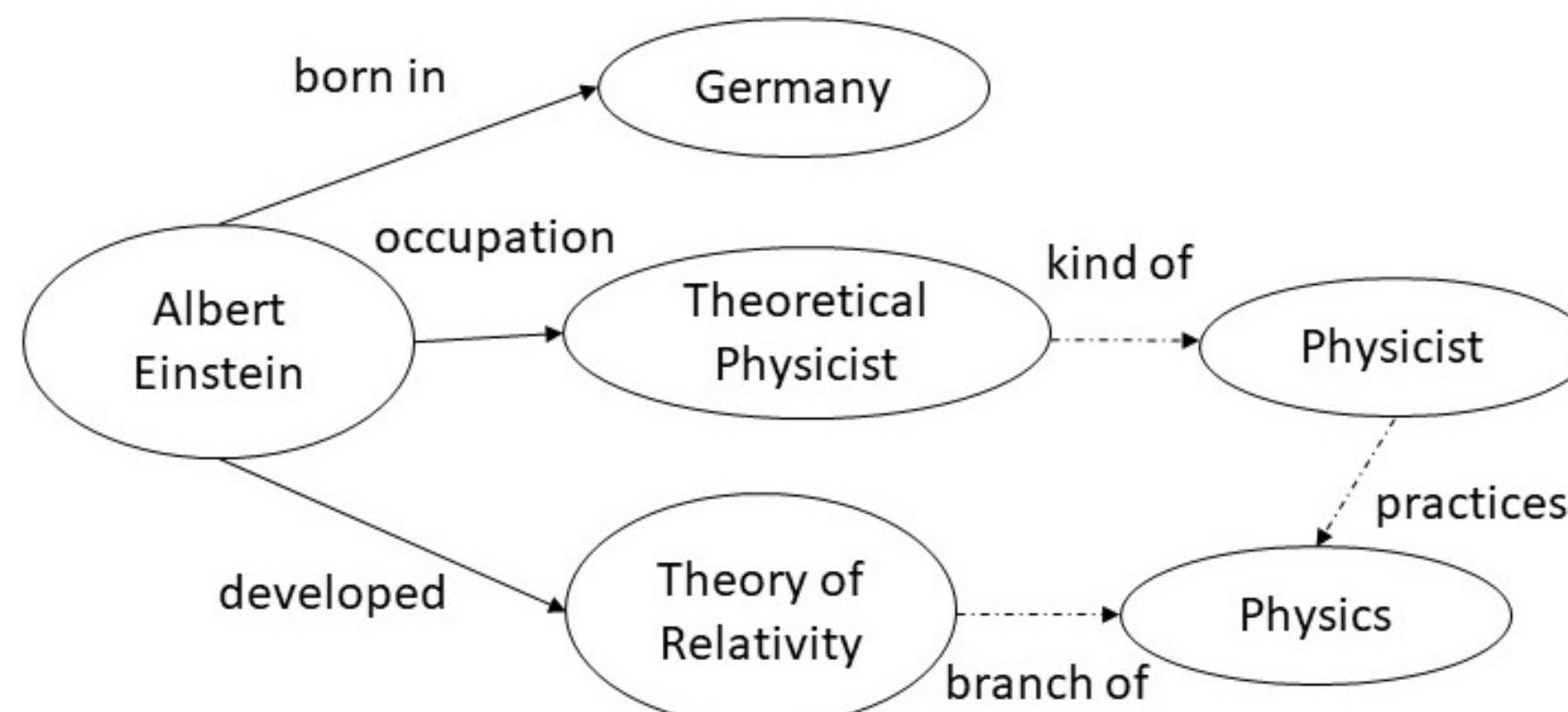
# Knowledge Graph representation

**Symbolic**

$s, p, o$

$p(s, o)$

$(s, p, o)$



**Vector**

$s, p, o \in \mathbb{R}^d$

**Symbols encode entities and relations**

**Entities and relations encoded in a (high) dimensional vector space**

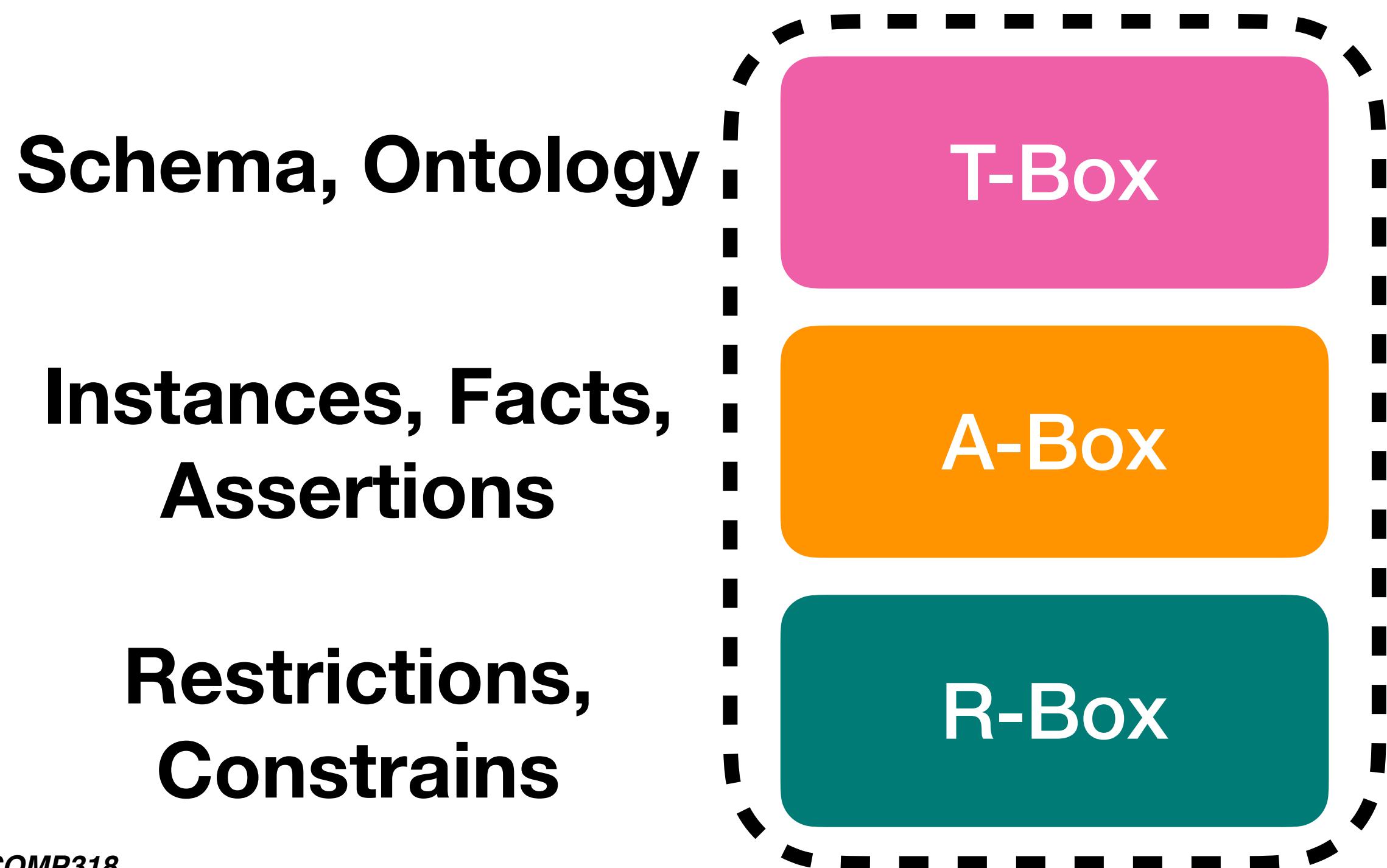
# Symbolic representation: triples



<b>RDJ</b>	<code>dbp:resides</code>	<b>SF</b> .	<b>Avengers</b>	<code>dbp:studio</code>	<b>Marvel</b> .
<b>RDJ</b>	<code>dbp:born</code>	<b>NY</b> .	<b>Avengers</b>	<code>dbp:starring</code>	<b>RDJ</b> .
<b>Sherlock_Holmes</b>	<code>dbp:studio</code>	<b>WB</b> .	<b>Iron_Man</b>	<code>dbp:studio</code>	<b>Marvel</b> .
<b>Sherlock_Holmes</b>	<code>dbp:starring</code>	<b>RDJ</b> .	<b>Iron_Man</b>	<code>dbp:starring</code>	<b>RDJ</b> .

# Ontology based model

- Logically consistent set of axioms
  - represented in some logical formalism: OWL & DL, RDFS...



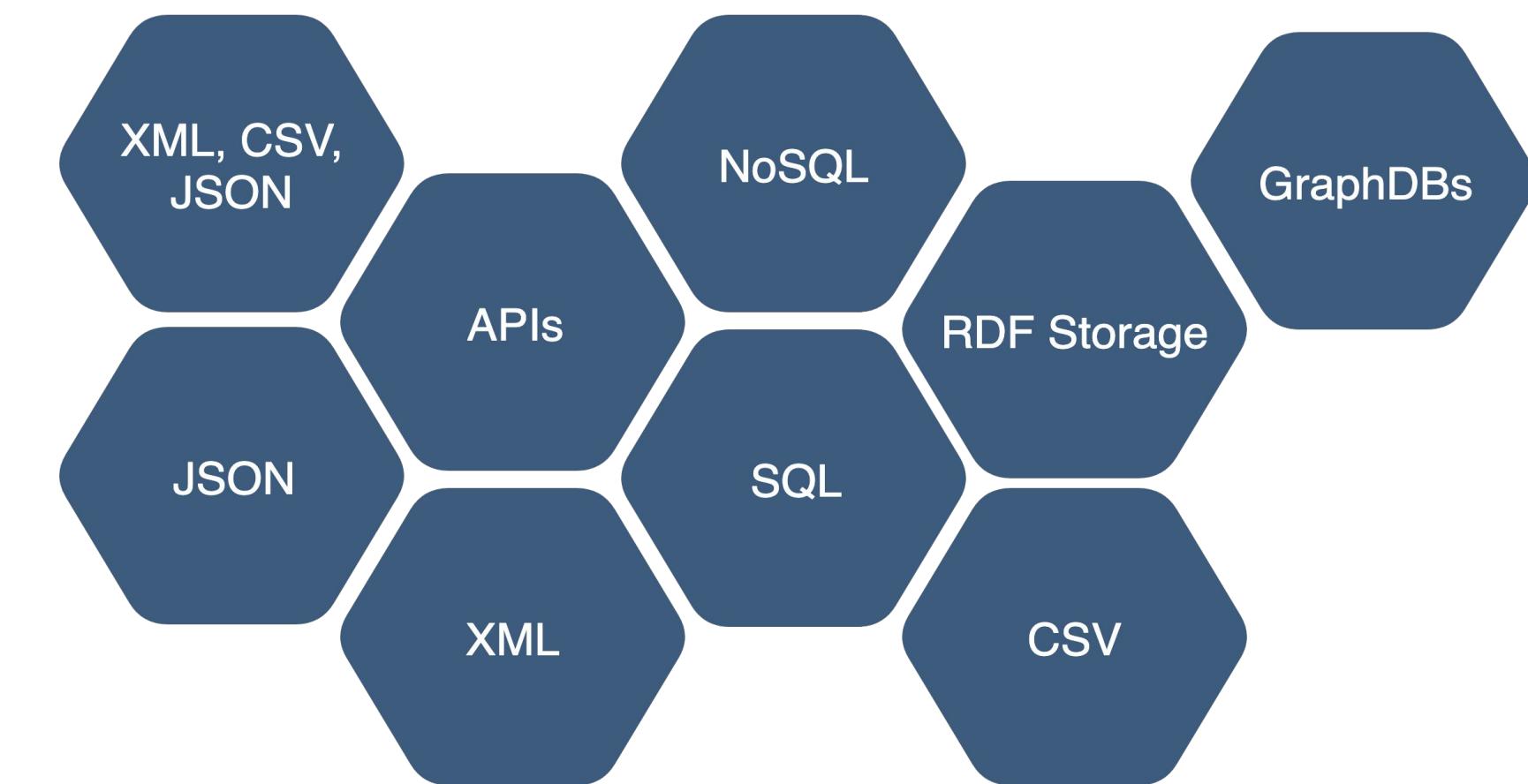
$\text{SuccessfulAuthor} \sqsubseteq \text{Author}$   
 $\text{notableWork} \sqsubseteq \text{created}$   
 $\text{Bestseller} \sqsubseteq \text{Creation}$

$\text{SuccessfulAuthor}(\text{StanLee})$

$\text{SuccessfulAuthor} \sqsubseteq \geq 1 \text{ notableWork.Bestseller}$

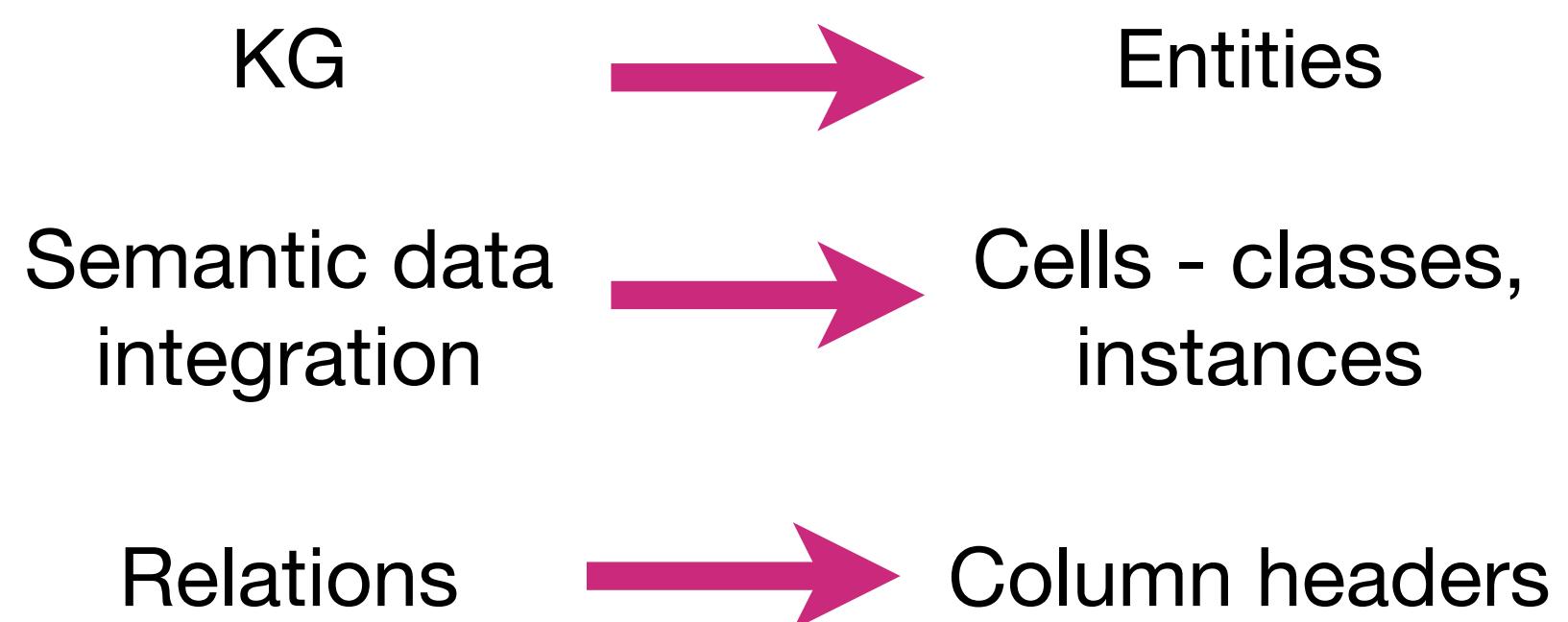
# Database and Data Integration

- KG as a support to create a unified view of heterogeneous sources
  - through semantic integration techniques e.g. alignment
- XML, CSV, Json data is transformed in a KG (physical or virtual)
  - Then queried as one logical source
  - Queries to be rewritten to match a particular source



# Database and Data Integration

Author	Notable work	DOB
Stan Lee	Iron Man	28/12/1922
Bob Kane	Batman	24/10/1915



```
:notable_work rdfs:domain :Author;
  rdfs:range :Creation.
:dob rdfs:domain :Author;
  rdfs:range xsd:Date.

:StanLee rdf:type :Author ;
  :notable_work :IronMan;
  :dob "28/12/1922" .

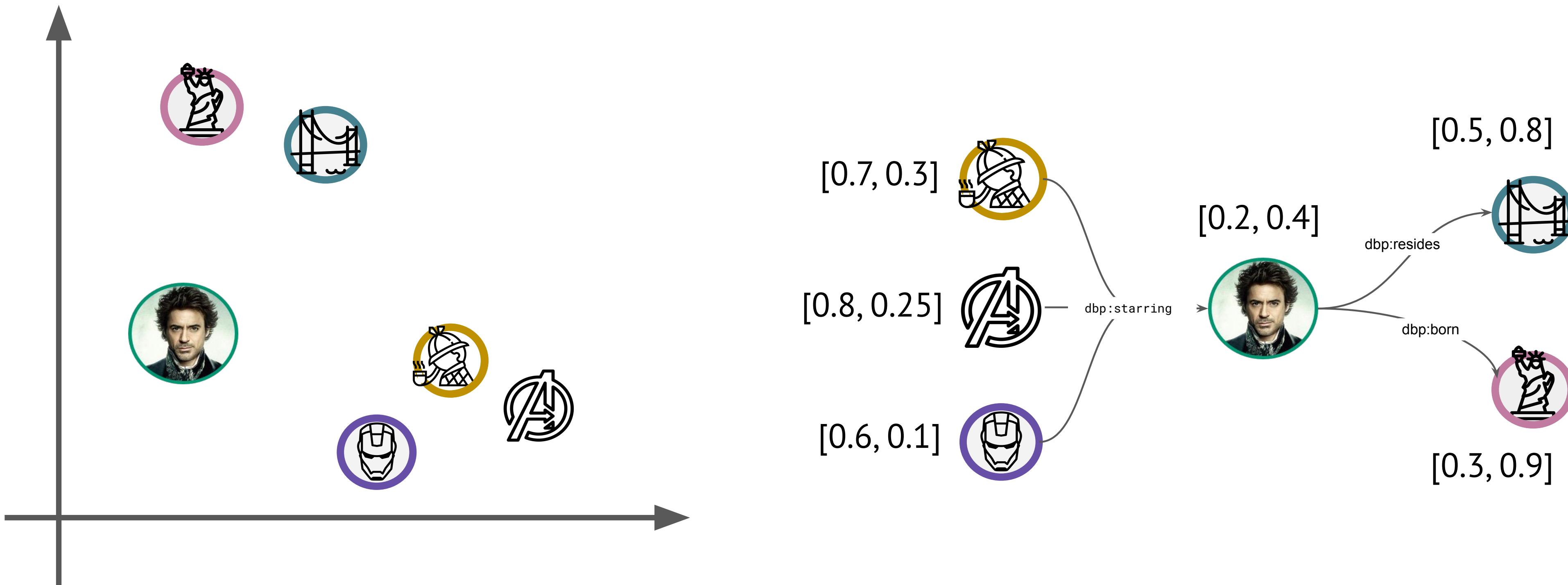
:BobKane rdf:type :Author .
  :notable_work :IBatman;
  :dob "24/10/1915" .

:IronMan rdf:type :Creation .
:Batman rdf:type :Creation .
```

# Vector representation: triples

$$E \in \mathbb{R}^{N_e \times d}$$

$$R \in \mathbb{R}^{N_r \times d}$$



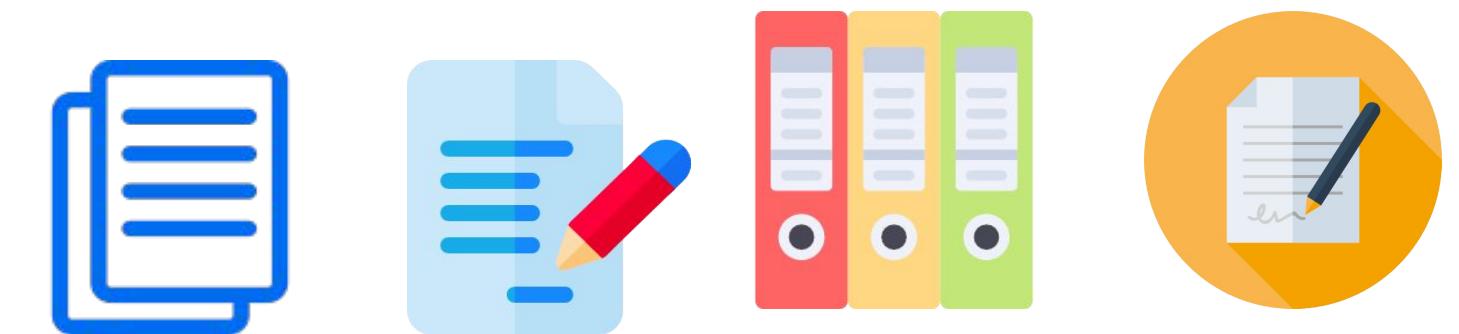
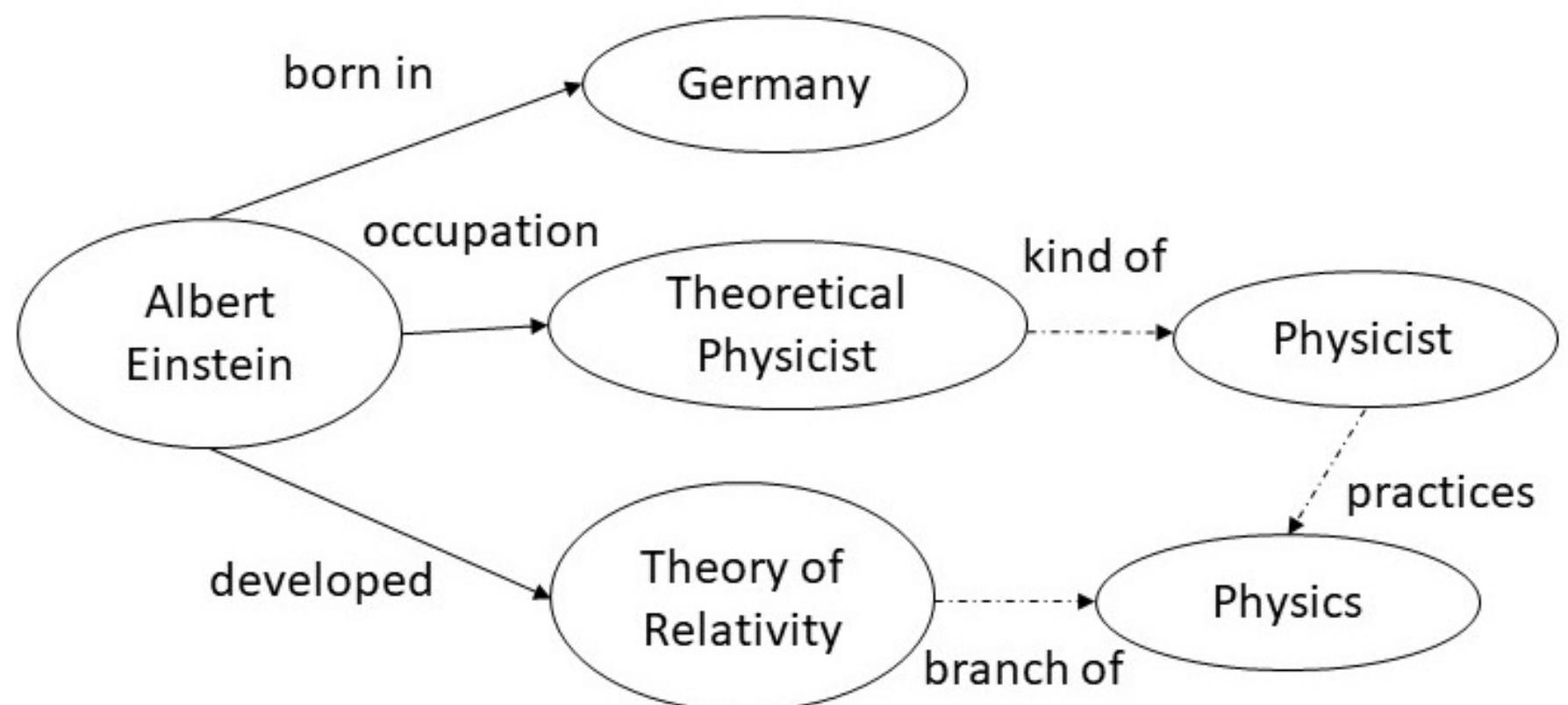
# Building KG from text

- **Albert Einstein** was a **German**-born **theoretical physicist** who developed the **theory of relativity**

Knowledge Graph

Information Retrieval

Unstructured Sources



# NLP Named entity recognition

## Entities in a Knowledge Graph

**apple** (Q89)

fruit of the apple tree  
apples

**Apple** (Q1754545)

1990 album by Mother Love bone

**Apple** (Q213710)

UK international record label; imprint of Apple Corps Ltd.  
LC 01074 | LC 1074 | Apple Records

**Apple Inc.** (Q312)

American producer of hardware, software, and services, based in Cupertino, California  
Apple Computer, Inc. | Apple Computer | Apple Computer Inc | Apple | Apple Incorporated | Apple Computer Incorporated | 



Who is the CEO of **Apple**?



{ **Apple** belongs to which genus? }



movie character

{ **Downey** played **Iron Man** in which year? }

comic character

Who is the alter ego of **Iron man**?

# NLP Relation linking

List of known relations

Surface forms (synonyms),  
easily multi-lingual

Relations constraints

Relations hierarchy

Most used types of  
subjects and objects

Name all the movies in which Robert Downey Jr **acted?**

Find me all the films **casting** Robert Downey Jr ?

List all the movies **starring** Robert Downey Junior?

RDJ **has acted** in which movies?

**cast member** (P161)

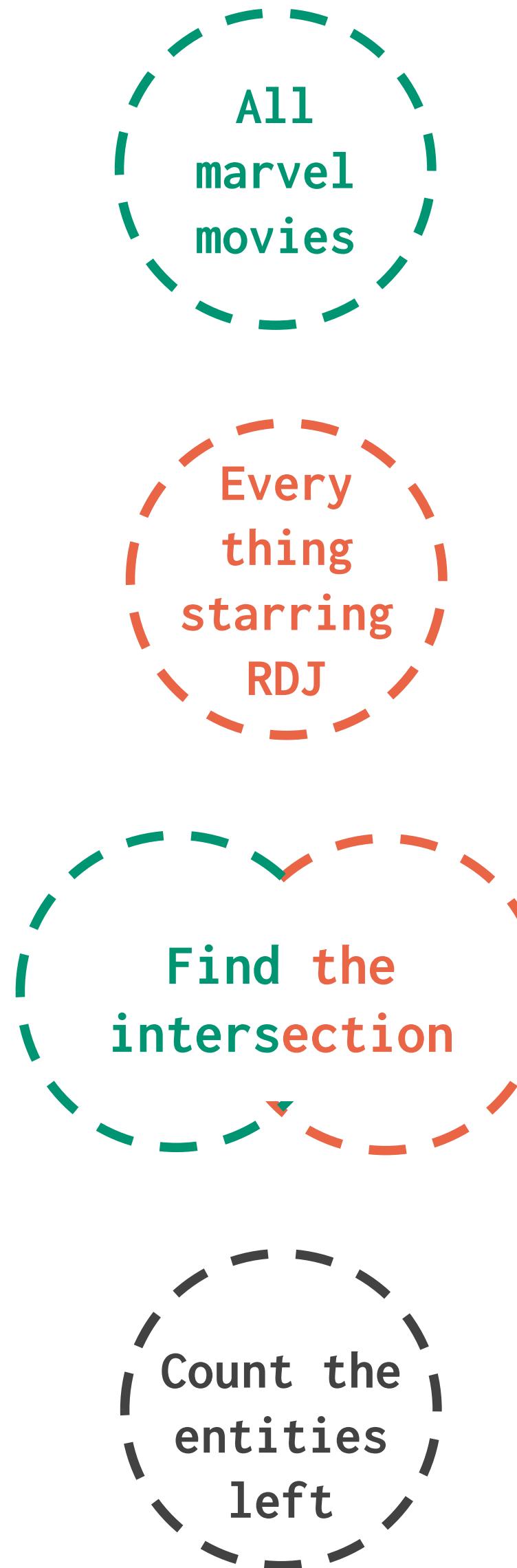
actor in the subject production |  
starring | film starring | actor | actress | contestant or a play

wdt:P161

**performer** (P175)

actor, musician, band or other performer associated with this role or musical work  
artist | musician | played by | portrayed by | recorded by | recording by | dancer | actor | musical artist

# NLP Question Answering

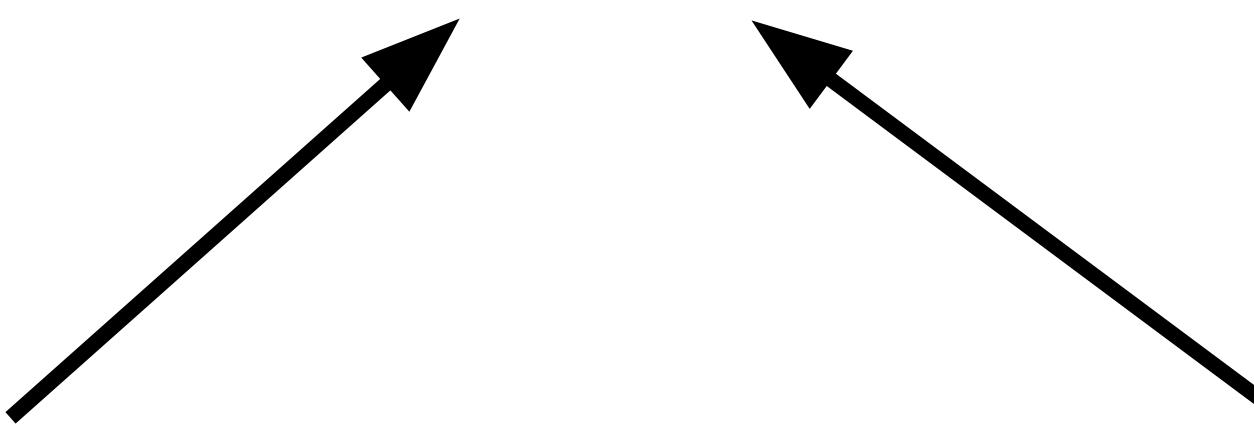


How many **Marvel movies** was **Robert Downey Jr.** **casted** in?

```
SELECT COUNT(?uri) WHERE {  
    ?uri dbp:studio dbr:Marvel_Studios.  
    ?uri dbo:starring dbr:Robert_Downey_Jr  
}
```

# NLP Language modelling

Robert Downey Jr. portrayed [MASK] in the Marvel movie in 2008.



## Knowledge Graph

- (Iron Man, cast member, Robert Downey Jr)
- (Iron Man, production company, Marvel)
- (Iron Man, released, 2008)
- (Robert Downey Jr, character role, Tony Stark)
- (Tony Stark, pseudonym, Iron Man)

Precise facts

Entities &  
relations

Explainability

## Unstructured Sources

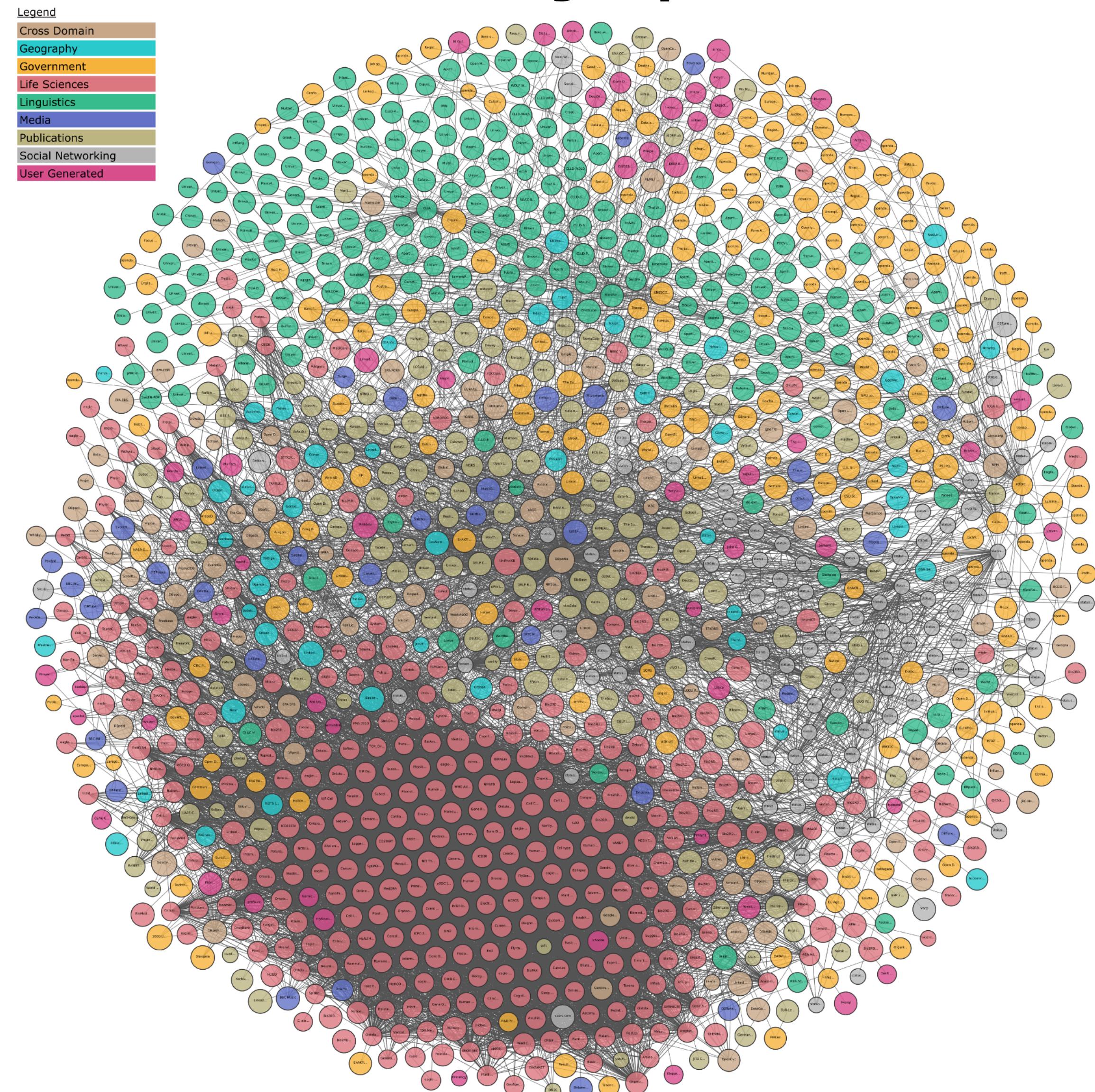


Large-scale text corpora  
(Wikipedia, OpenBooks, Reddit,  
CommonCrawl, etc)

# Platforms

- Allegrograph
- Amazon Neptune
- Neo4J

# How are they published?



# COMP318

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# End Knowledge Graphs - Part 3

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