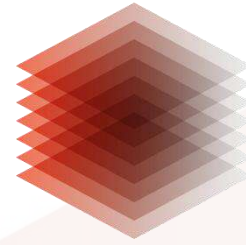
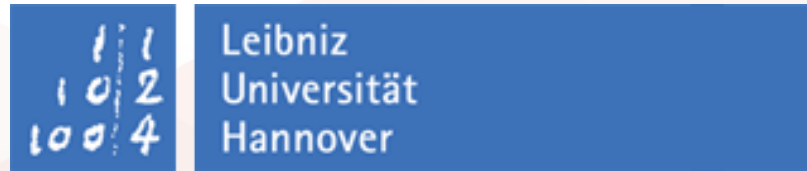


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TIB



# Towards Knowledge Graph based Representation, Augmentation and Exploration of Scholarly Communications

**Prof. Dr. Sören Auer**

Faculty of Electrical Engineering & Computer Science

Leibniz University of Hannover

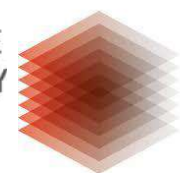
TIB Technische Informationsbibliothek



11  
102  
1004

Leibniz  
Universität  
Hannover

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TIB

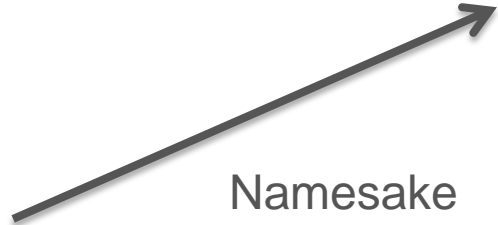




## Gottfried Wilhelm Leibniz

\* 21. Juni/ 1. Juli 1646 in Leipzig

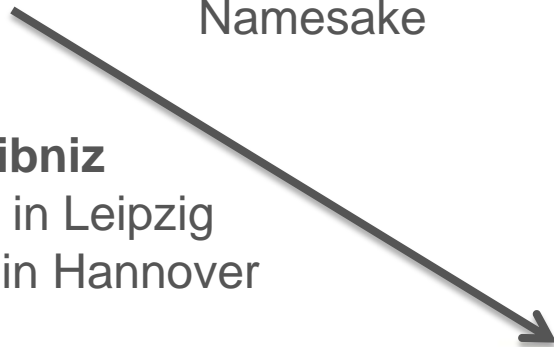
† 14. November 1716 in Hannover



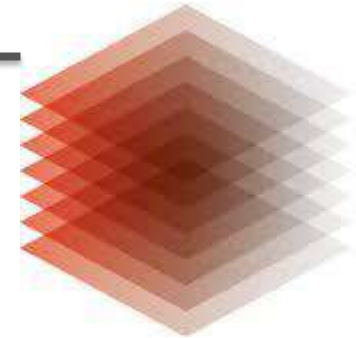
Namesake



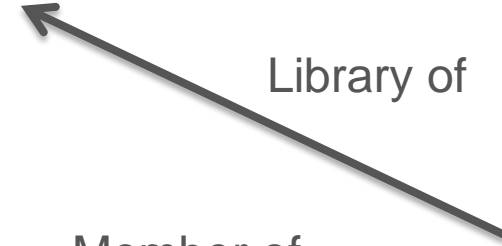
Namesake



Member of

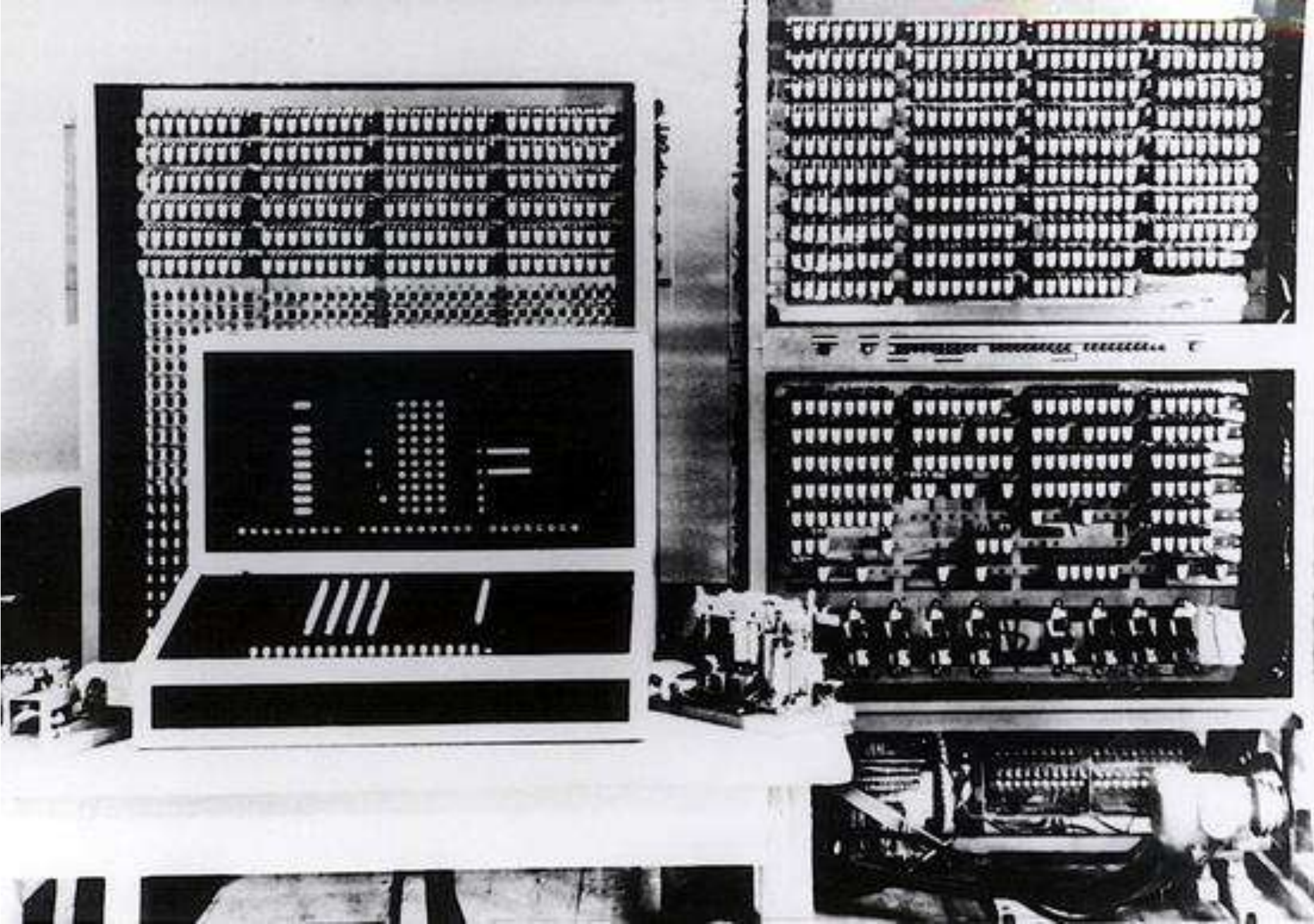


TIB



Library of





**Zuse Z3: the  
beginning of  
Computing –  
close to the  
hardware**

Foto: Konrad Zuse  
Internet  
Archiv/Deutsches  
Museum/DFG

32768	255			RST	56	BC	00000	BC'	00000
32769	255			RST	56	DE	00000	DE'	00000
32770	001	160	000	LD	BC,160	HL	00000	HL'	00000
32771	009			ADD	HL,BC				
32772	233			JP	(HL)	(BC)	(DE)	(HL)	(HL')
32773	000			NOP		243	243	243	243
32774	195	114	028	JP	7282				
32775	000			NOP		AF	00000	sz-h-onc	
32776	010			LD	A,(BC)	AF'	00000	sz-h-onc	
32777	000			NOP					
32778	000			NOP		IX	00000	IY	00000
32779	000			NOP		PC	32768	SP	17500
32780	124			LD	A,H				
32781	000			EX	AF,AF'			Stack:	00000
32782	200	124		BIT	Z,H	A	000		00000
32783	040	085		JR	Z,H,32875	B	000	C	000
32784	203	116		BIT	6,H	D	000	E	000
32785	062	001		LD	A,1	H	000	L	000
32786	202	047	029	JP	Z,7471				00000
32787	195	047	029	JP	7471	I	000	R	000
						IM	1	EI	00000



# Ingredients

## Carrot Cake



300g carrots  
160g sunflower oil  
55g soured cream  
3 eggs  
250g wholemeal flour

350g soft brown sugar  
2 tsp ground cinnamon  
½ tsp ground nutmeg  
1 tsp bicarbonate of soda  
½ tsp salt  
50g ground ginger



# Method

Preheat oven to 160°C

Sieve ginger, flour, nutmeg, salt, cinnamon, sugar & bicarbonate of soda into a bowl.

Whisk eggs, soured cream and oil into large bowl.

Stir in sieved ingredients and chopped carrots.

Transfer to greased + lined cake tin.  
Bake for 1-1¼ hrs.

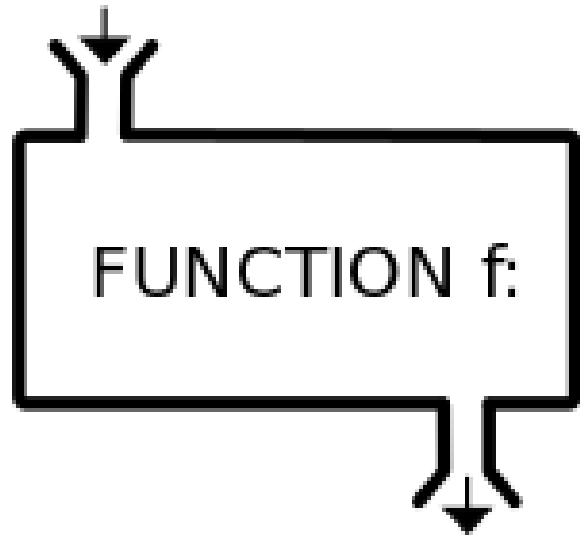
**We can make things more intuitive**



Picture: The illustrated recipes of Lucy Eldridge  
<http://thefoxisblack.com/2013/07/18/the-illustrated-recipes-of-lucy-eldridge/>

# Computing more intuitive: procedural programming

INPUT  $x$



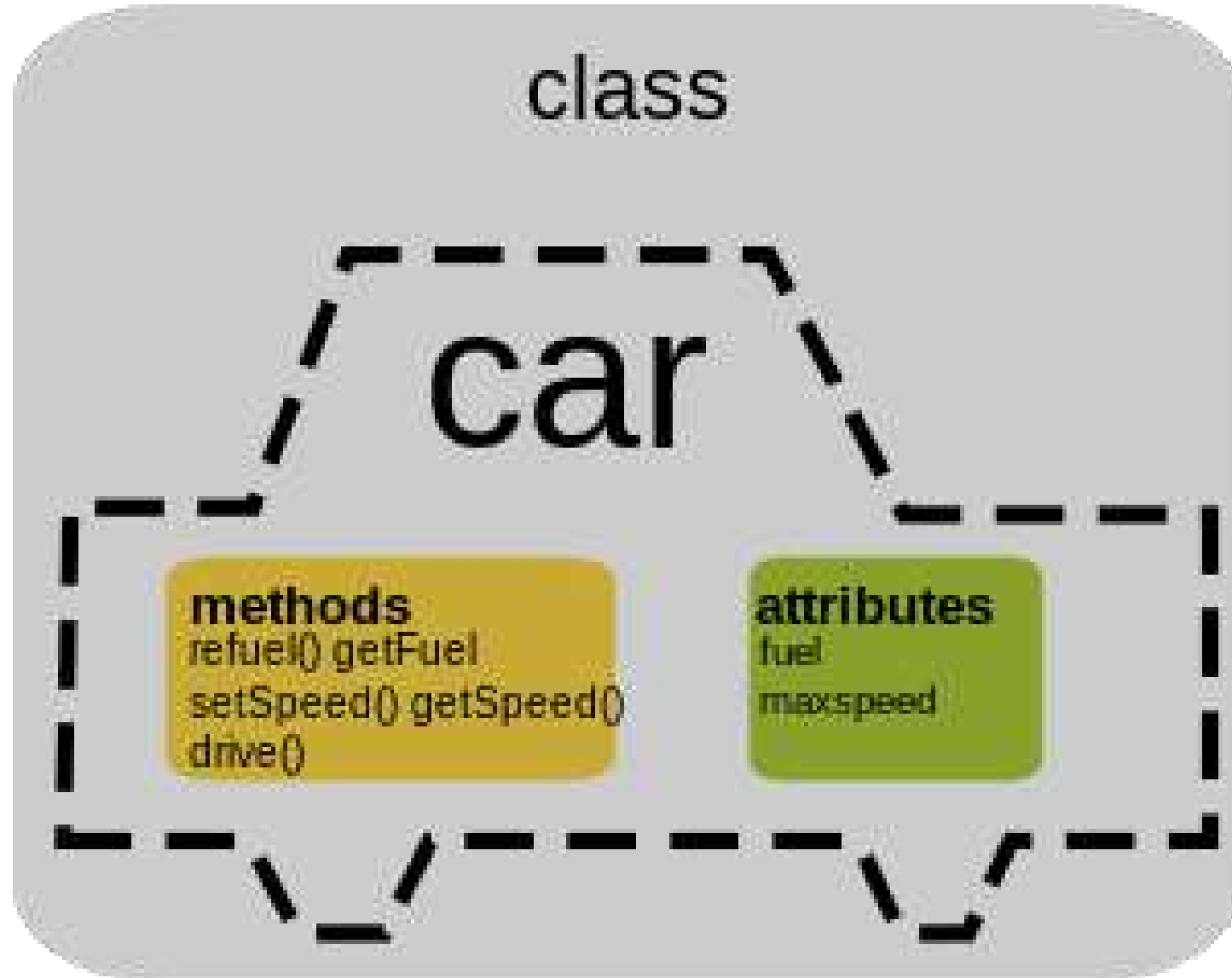
OUTPUT  $f(x)$

```
File Edit View Search Tools Documents Help
Open Save Undo
finalP3_pre-submit_v1.py
author_ = 'michael'
def poly(coefs):
    name = []
    def internal(x):
        store = []
        for idx, val in enumerate(coefs): store.append(val*x**idx)
        return sum(store)
    internal.coefs = coefs
    for idx, val in enumerate(coefs):
        if idx == 0 and val == 0:
            pass
        elif idx == 0 and val != 0:
            name.append(str(val))
        elif idx != 0 and val == 0:
            pass
        elif idx == 1 and val == 0:
            pass
        elif idx == 1 and val == 1:
```





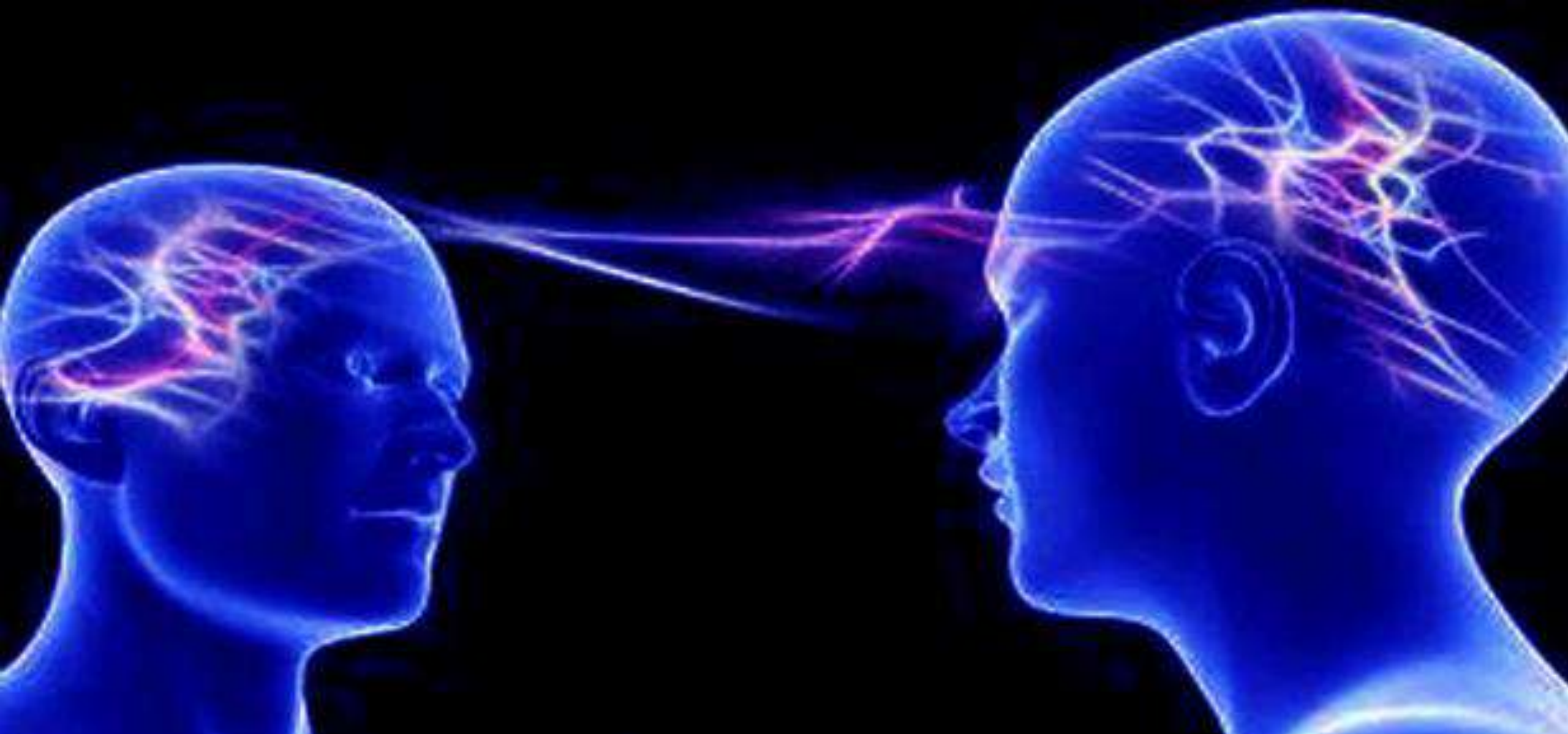
# Computing more intuitive: OO programming







# Computing even more intuitive: with cognitive data?!



# Linked Data Principles



## Addressing the neglected third V (Variety)

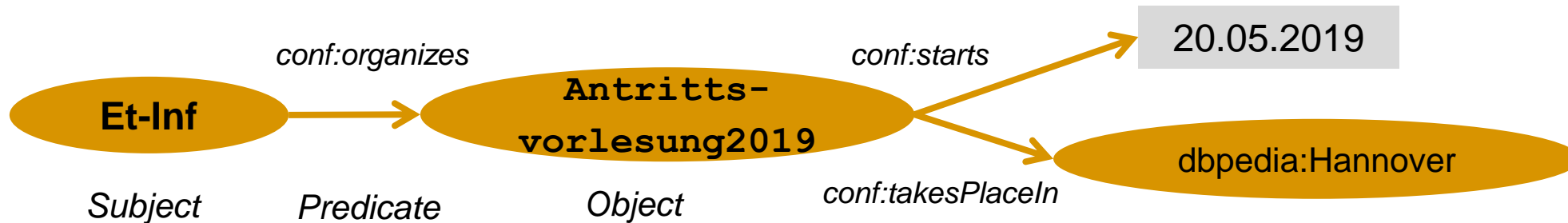
1. Use **URIs** to **identify** the “things” in your data
2. Use **http:// URIs** so people (and machines) can **look** them **up** on the web
3. When a URI is looked up, **return** a **description** of the thing **in** the W3C **Resource Description Format (RDF)**
4. Include **links to related things**

<http://www.w3.org/DesignIssues/LinkedData.html>



# RDF & Linked Data in a Nutshell

1. Graph based RDF data model consisting of S-P-O statements (facts)



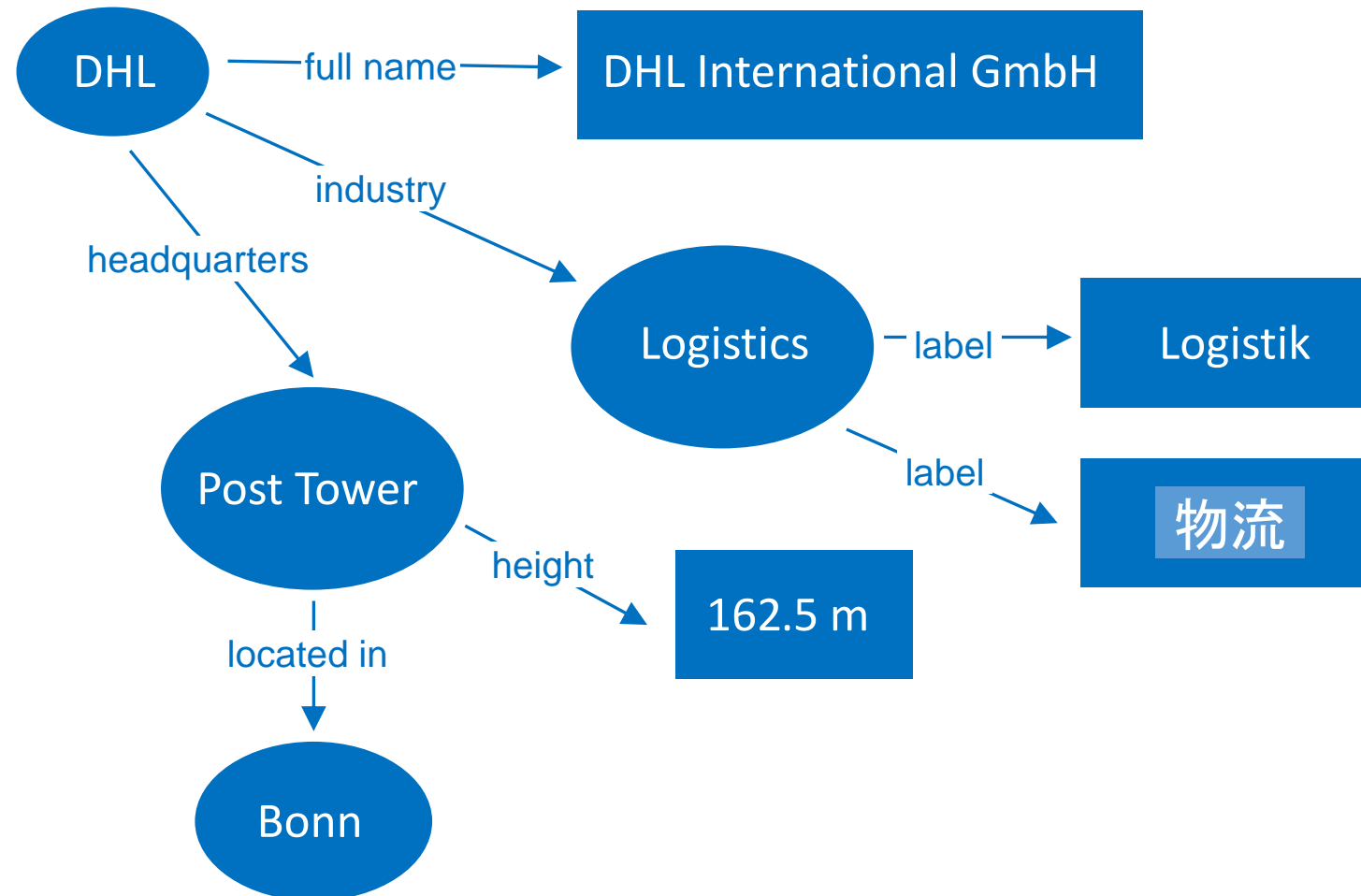
2. Serialised as RDF Triples:

<b>Et-Inf</b>	<b>conf:organizes</b>	<b>Antrittsvorlesung2019 .</b>
<b>Antrittsvorlesung2019</b>	<b>conf:starts</b>	<b>"2019-20-07"^^xsd:date .</b>
<b>Antrittsvorlesung2019</b>	<b>conf:takesPlaceAt</b>	<b>dbpedia:Hannover .</b>

3. Publication under URL in Web, Intranet, Extranet

# Linked Data

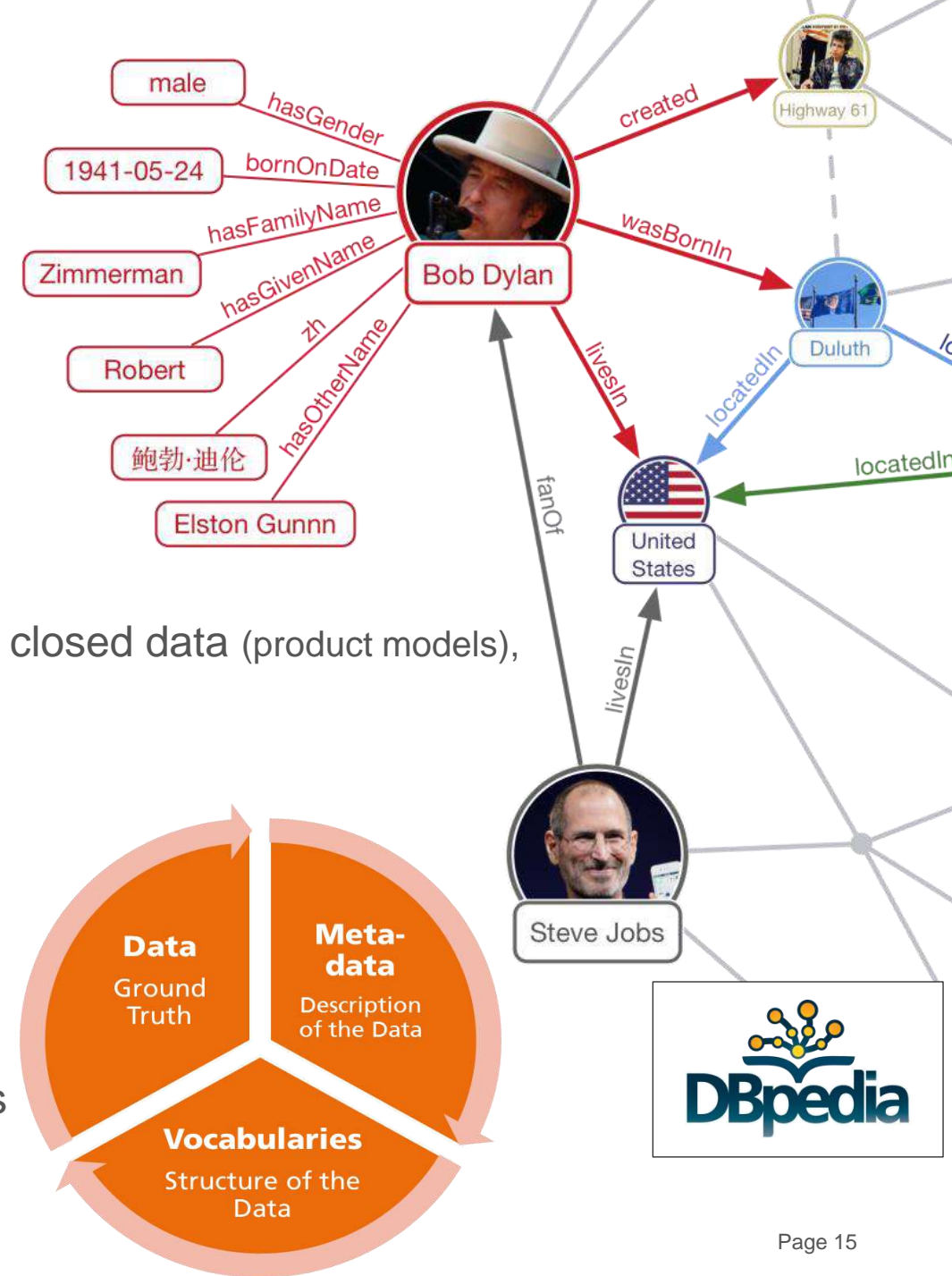
## Creating Knowledge Graphs with RDF

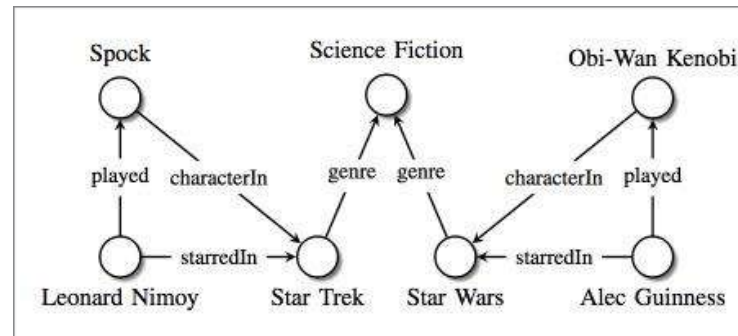




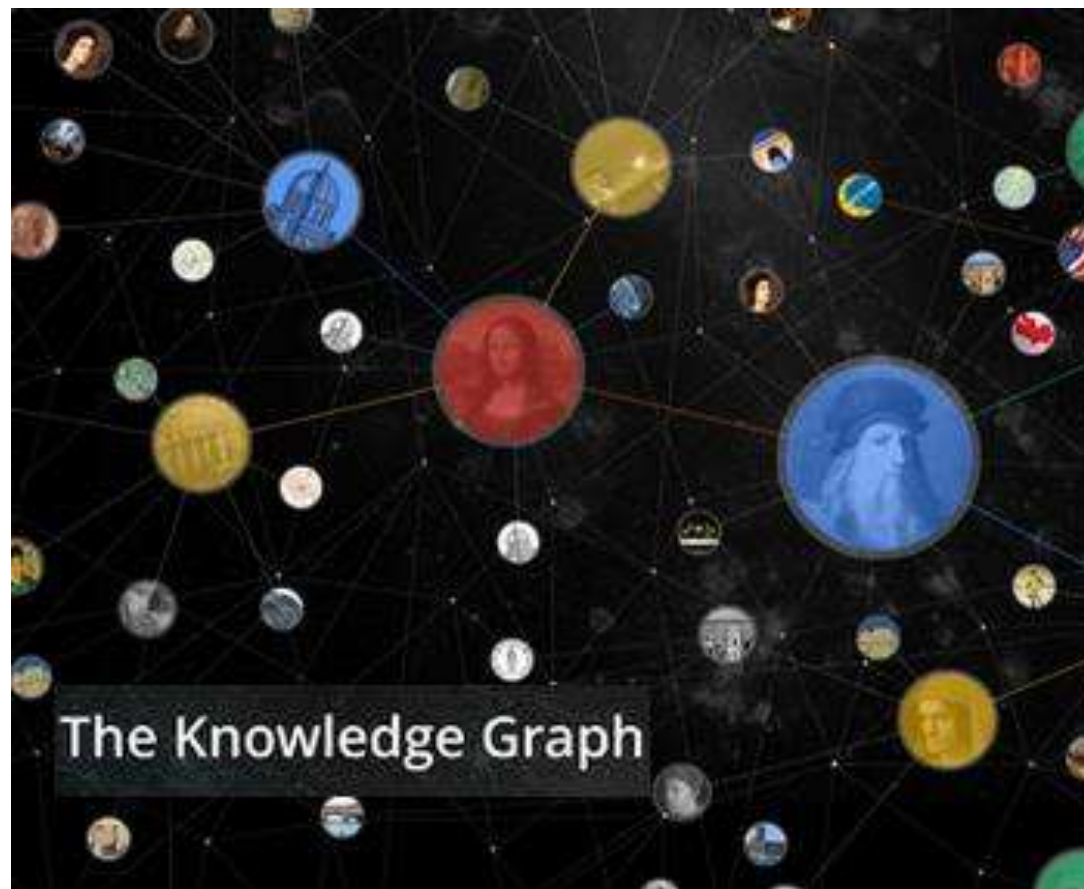
# Knowledge Graphs – A definition

- Fabric of concept, class, property, relationships, entity desc.
- Uses a knowledge representation formalism (RDF, OWL)
- Holistic knowledge (multi-domain, source, granularity):
  - **instance data** (ground truth),
    - open (e.g. DBpedia, WikiData), private (e.g. supply chain data), closed data (product models),
  - derived, aggregated data,
  - **schema data** (vocabularies, ontologies)
  - **meta-data** (e.g. provenance, versioning, documentation licensing)
  - comprehensive **taxonomies** to categorize entities
  - **links** between internal and external data
  - **mappings** to data stored in other systems and databases





Source:  
[https://pic2.zhimg.com/v2-878ad2a55c440b18c889394a7abaa5d3\\_1200x500.jpg](https://pic2.zhimg.com/v2-878ad2a55c440b18c889394a7abaa5d3_1200x500.jpg)



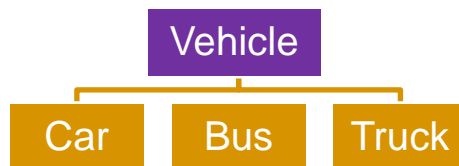
<a href="#">GND</a>	
<b>Link zu diesem Datensatz</b>	<a href="http://d-nb.info/gnd/1021356255">http://d-nb.info/gnd/1021356255</a>
<b>Typ</b>	Person (piz)
<b>Person</b>	Appelbaum, Anne
<b>Geschlecht</b>	weiblich
<b>Zeit</b>	Lebensdaten: 1908-1998
<b>Land</b>	Deutschland (XA-DE); USA (XD-US)
<b>Geografischer Bezug</b>	Wirkungsort: <a href="#">New York, NY</a>
<b>Beruf(e)</b>	<a href="#">Psychologin</a>
<b>Beziehungen zu Personen</b>	<a href="#">Cassirer, Ernst (Vater)</a>
<b>Beteiligt an</b>	1 Publikation  1. <i>Nachgelassene Manuskripte und Texte / Bd. 1. Zur Metaphysik der symbolischen Formen</i> 1995



# RDF mediates between different Data Models & bridges between Conceptual and Operational Layers

## Electronics

Id	Title	Screen
5624	SmartTV	104 cm
5627	Tablet	21 cm



$$\forall x : Human(x) \Leftrightarrow Male(x) \vee Female(x)$$

$$\nexists x : Male(x) \wedge Female(x)$$

## Tabular / Relational Data

```

Prod:5624  rdf:type      Electronics
Prod:5624  rdfs:label    "SmartTV"
Prod:5624  hasScreenSize "104"^^unit:cm
...
  
```

## Taxonomic / Tree Data

```

Vehicle  rdf:type      owl:Thing
Car       rdfs:subClassOf Vehicle
Bus       rdfs:subClassOf Vehicle
...
  
```

## Logical Axioms / Schema

```

Male      rdfs:subClassOf Human
Female    rdfs:subClassOf Human
Male      owl:disjointWith Female
...
  
```



# The Trinity of Semantic Integration



USE IN A SINGLE ORGANIZATION

INTRA-ORGANIZATIONAL USE



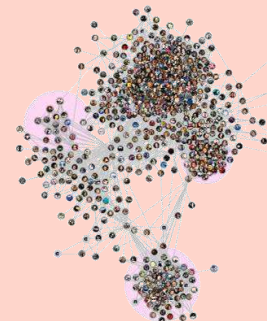
## Semantic Data Lakes

- Storage facility for enterprise / research data
- Use Big Data (HDFS) management
- Focus on scalable data access



## Knowledge Graphs

- Complex fabric of concepts & relationships
- Focus on heterogenous, multi-domain knowledge representation

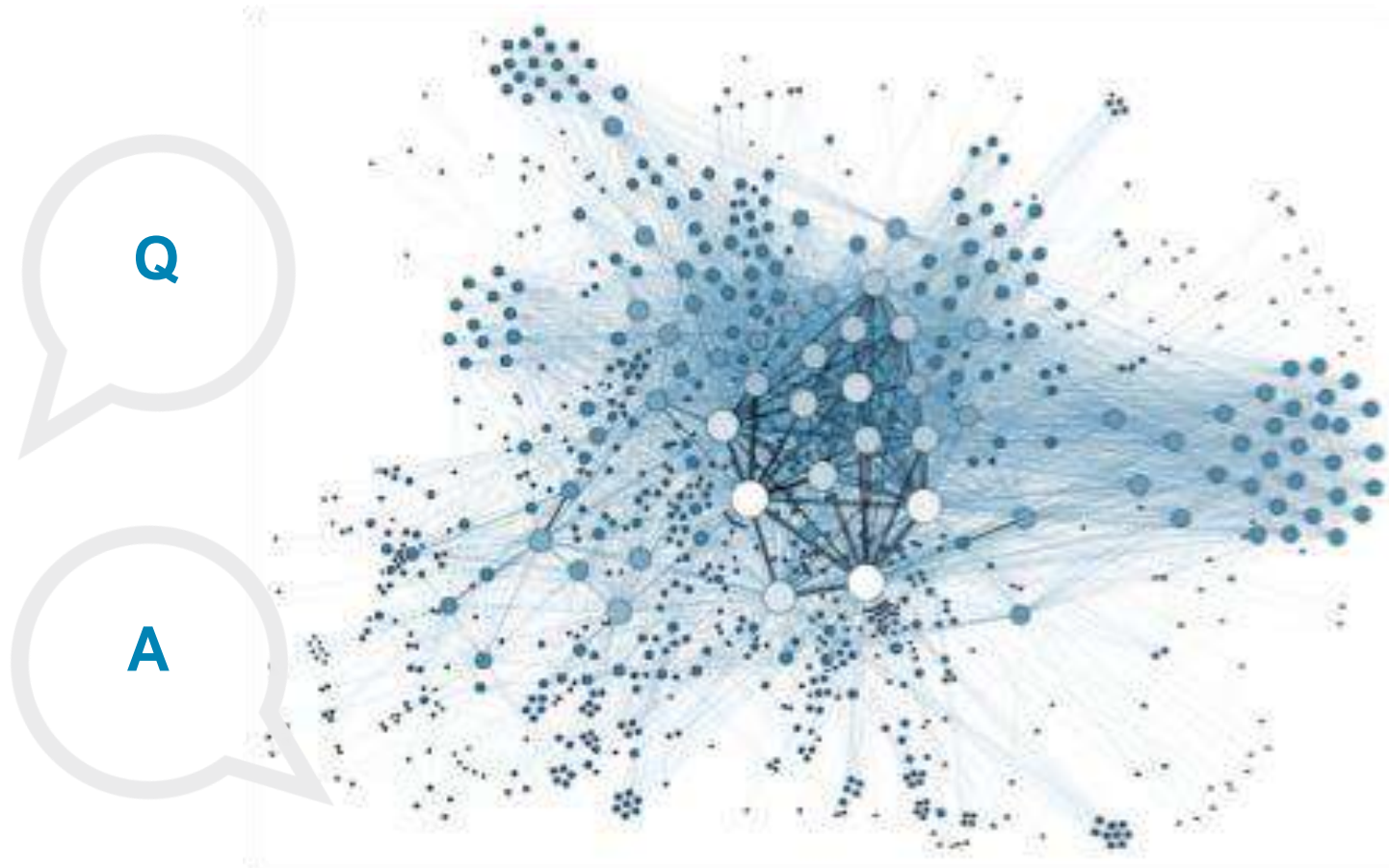


## Data Spaces

- Community of organizations agreeing on standards for data access / security / semantics / governance / licenses
- Focus on data sharing & exchange



## WDAqua project vision



- Answer **natural language questions**
- Exploit knowledge encoded in the **Web of Data**
- Provide **QA services** to citizens, communities, and industry

**Web of Data**

**Who is the director of  
Clockwork Orange?**





**Who is the director of  
Clockwork Orange?**



**Understand a  
spoken question**

Who is the director of  
Clockwork Orange?



Understand a  
spoken question

Analyse  
question

**Who is the director of  
Clockwork Orange?**



**Understand a  
spoken question**

**Analyse  
question**

**Find data to  
answer the  
question**



**Who is the director of  
Clockwork Orange?**



**Understand a  
spoken question**

**Analyse  
question**

**Find data to  
answer the  
question**

**Present the  
answer**

Who is the director of Clockwork Orange?



Understand a spoken question

Analyse question

Find data to answer the question

Present the answer

Data source:

QAnswer Who is the director of A Clockwork Orange? About FAQ

Confidence : 97 % SPARQL LIST DID YOU MEAN 25 DIRECT ANSWER

Is this the right answer ? Yes No

*A Clockwork Orange (1971 dystopian crime film directed by...) / director*

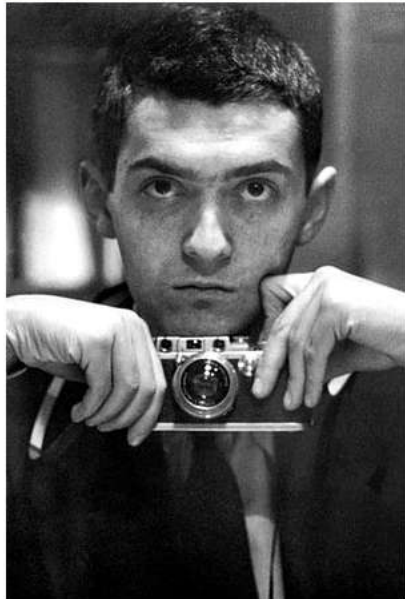
**Stanley Kubrick** + W

Stanley Kubrick (; July 26, 1928 – March 7, 1999) was an American film director, screenwriter, and producer. He is frequently cited as one of the greatest and most influential filmmakers in cinematic history. His films, which are mostly adaptations of novels or short stories, cover a wide range of genres, and are noted for their realism, dark humor, unique cinematography, extensive set designs, and evocative use of music. Kubrick was raised in the Bronx, New York City, and attended William Howard Taft High School from 1941 to 1945. He was a keen amateur photographer from a young age, and began making films in the mid-1950s, but displayed a keen interest in directing after working as a photographer for the New York Times in the 1950s; he began making films in 1956, and made his first major film, *Paths of Glory*, in 1956. This was followed by two collaborations with Kirk Douglas, the war picture *Paths of Glory* (1957) and the historical epic *Spartacus* (1960). His reputation as a filmmaker in Hollywood grew, and he was approached by Warner Bros. to film what would become *One-Eyed Jacks* (1961), the film *Brando* eventually decided to direct it himself. Creative differences arising from his work with Douglas and the film studios, a dislike of the Hollywood industry, and a growing interest in the crime film in America convinced Kubrick to move to the United States.

**Summary**

country of citizenship [United States of America](#)

DBpedia



**Which publications and health reports are related to Alzheimer in Greece?**



**Understand a spoken question**

**Analyse question**

**Find data to answer the question**

**Present the answer**



Which publications and health reports are related to Alzheimer in Greece?



Understand a spoken question

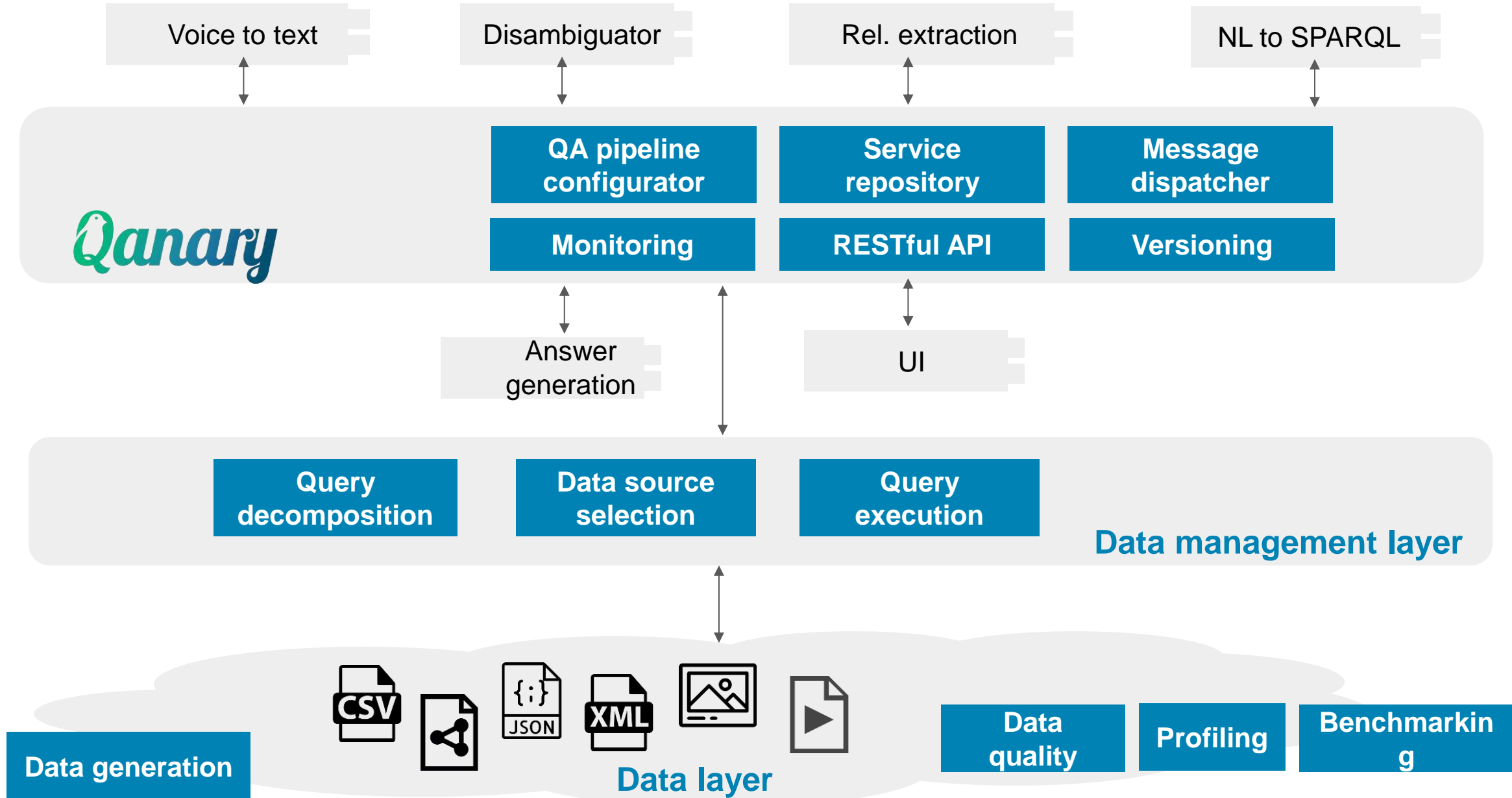
Analyse question

Find data to answer the question

Present the answer

Data sources





Who is the director of  
Clockwork Orange?



**Demo:**  
<http://wdaqua.eu/qa>

Understand a  
spoken question

Analyse  
question

Find data to  
answer the  
question

Present the  
answer

# How did information flows change in the digital era?



# Computer



**Commodore C64**

Abb. 1-6

**GLEICH ZUM MITNEHMEN!**

In Ihrem OTTO wohnen Einrichtungshaus. Mehr darüber Seite 1026.

1 Farbmonitor 598.-

2 Grün-Monitor 198.-

3 Datasette 99.-

4 »C 64 C« 448.-

5 »MAUS« 129.-

6 Joystick 19.90

7 Floppy »VC 1541« ab 448.-

8 5 1/4-Disketten

9 Diskettenkasten 29.90

10 39.90

11 ab 39.95

12 59.90

13 49.90

14 ab 39.95

15-17 49.-

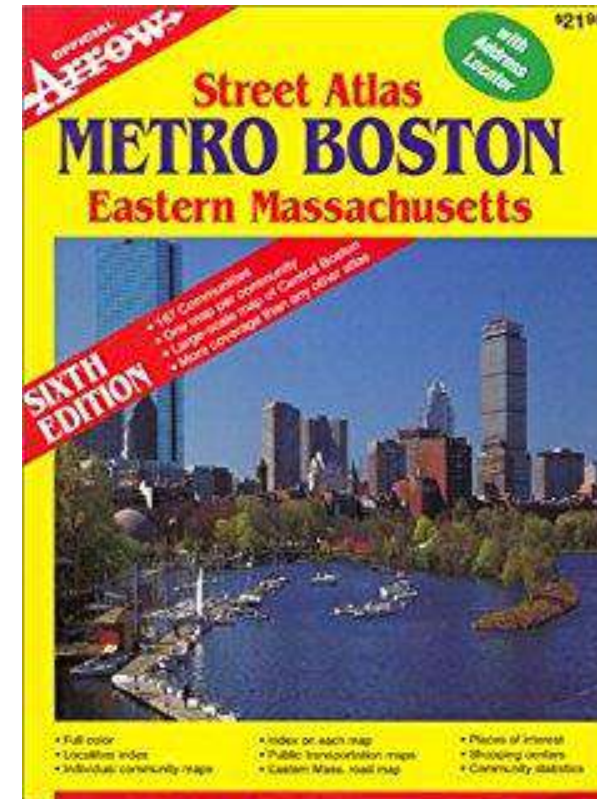
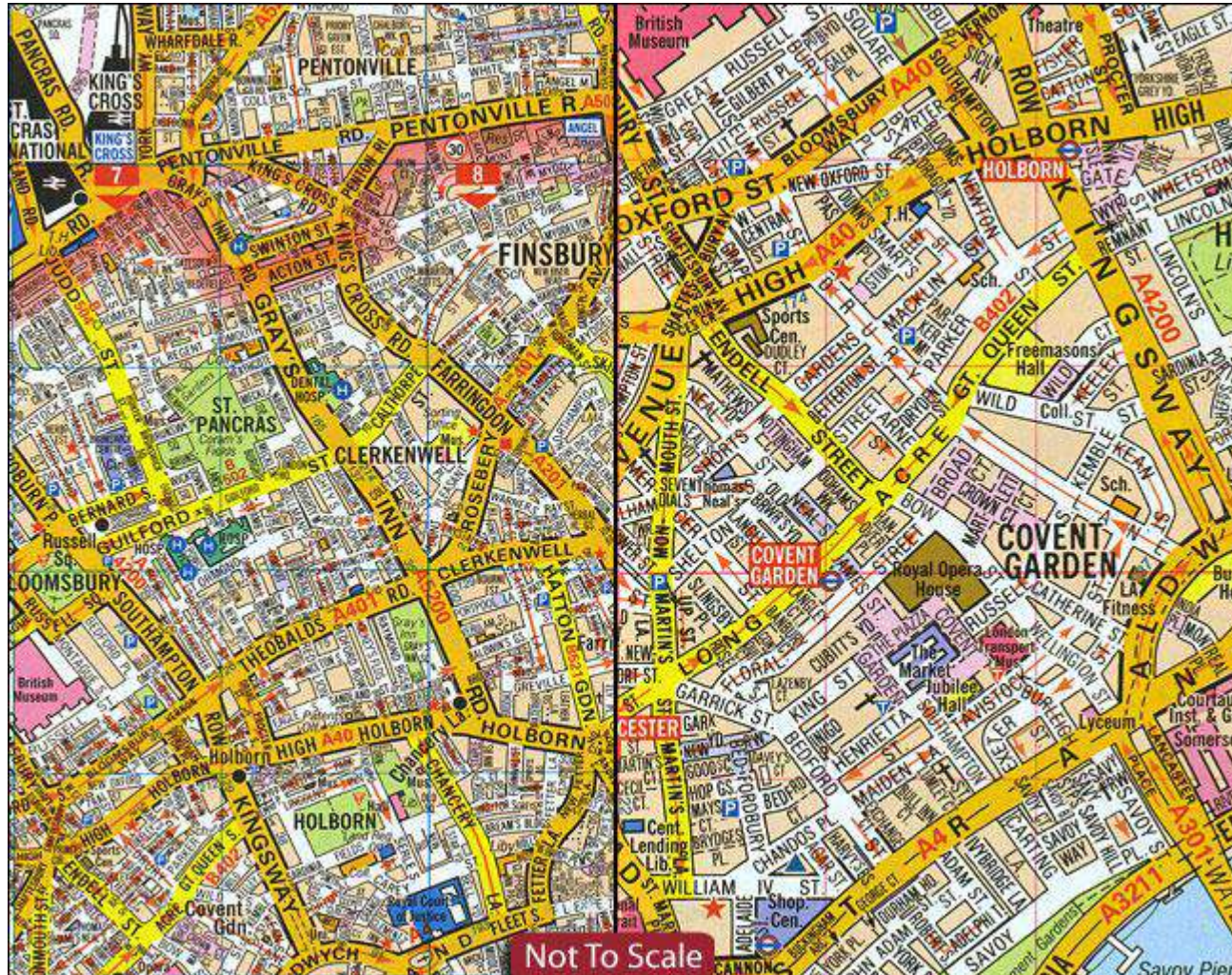
GEOS

BASF NewDisk

SANYO

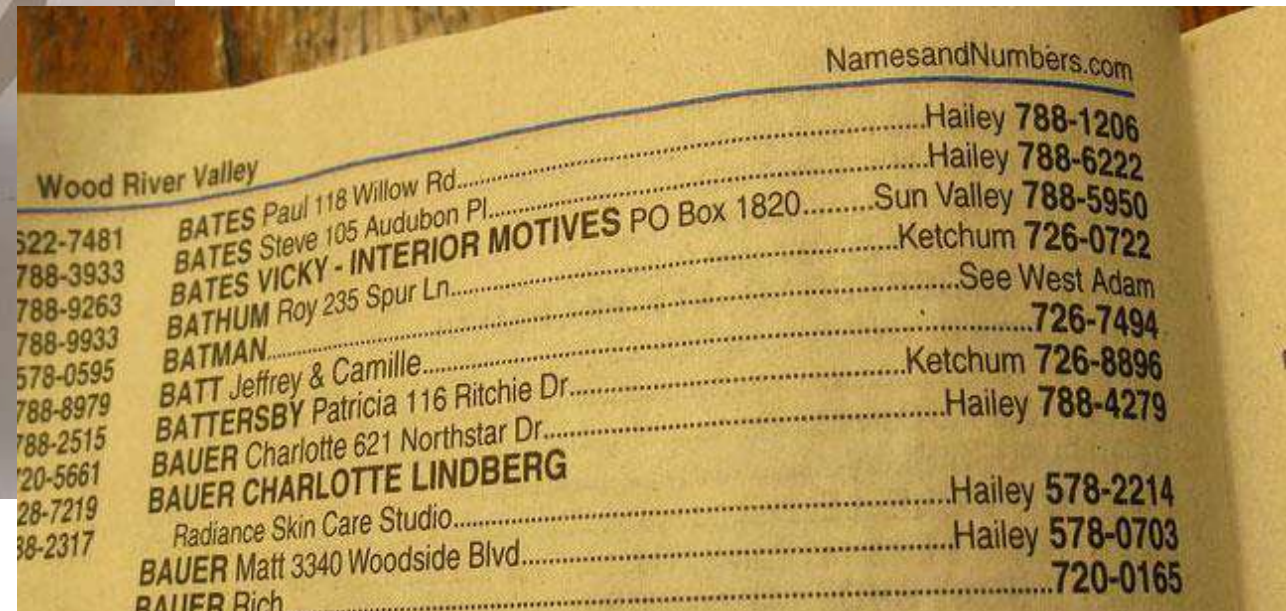


# Road Maps





# Phone Books



**How does it  
work today?**



SAMSUNG

GESPONSERT VON SAMSUNG

Entdecke hier die aktuellen Samsung Smartphones.

Jetzt einkaufen



Samsung Galaxy S9+ Smartphone (6,2 Zoll (15,7cm) 64GB interner Speicher, Dual SIM) ...

★★★★★ 229



Samsung Galaxy Note 9

★★★★★ 90



Samsung LED View Cover (EF-NG960) für das Galaxy S9, Violett

★★★★★ 144

prime



Sponsored

ZTE V9 Smartphone Parent, 32 GB, Black

★★★★★ 46

€149.99 €269.99

prime Get it by Saturday, Apr 20

FREE Delivery by Amazon



Sponsored

RUISEN-ONE-Twilight

★★★★★ 110

€79.99

prime Get it by Friday, Apr 26

FREE Delivery by Amazon

Best Seller



Huawei P20 lite Smartphone (14.83 cm (5.84 Inch), 64GB Internal Memory, 4GB RAM, 16 MP Plus 2 MP Camera, Android 8.0, EMUI 8.0) Black

Werbung

https://www.amazon.de/s?k=smartphone&amp;language=en\_GB&amp;crd=15141C1D4IVOJ&amp;sprefix=smartphon%2Caps%2C153&amp;ref=nb\_sb\_ss\_i\_1\_9, 04.2019



## Smartphones (4.691)\*

## Beliebteste Produkttypen

LTE Smartphone  
3.625 ProduktePhablet  
2.023 ProdukteAndroid Smartphone  
4.145 Produkte

## Preis

<input type="checkbox"/> bis 95 €	900
<input type="checkbox"/> 95 € bis 150 €	1.185
<input type="checkbox"/> 150 € bis 200 €	857
<input type="checkbox"/> 200 € bis 300 €	840
<input type="checkbox"/> ab 300 €	909

## Serie

<input type="checkbox"/> Apple iPhone	223
<input type="checkbox"/> Samsung Galaxy S	216
<input type="checkbox"/> Samsung Galaxy A	95
<input type="checkbox"/> Huawei P	165
<input type="checkbox"/> Huawei Mate	58

+ mehr

Ergebnisse in Smartphones werden angezeigt. Ergebnisse in allen Kategorien anzeigen.



## Samsung Galaxy S10

LTE Smartphone, 6,1 Zoll, Quad HD,  
8 GB RAM, Android 9.0 Pie, 16 Mega-  
pixel, 3.400 mAh, Speicher ...mehr

Note Ø 1,5 ★★★★★ 8

388 Angebote

664,99 – 1.341,40 €



## Apple iPhone Xr

LTE Smartphone, 6,1 Zoll, HD,  
3 GB RAM, iOS 12, 12 Megapixel,  
2.942 mAh, Gewicht 194 g

Note Ø 1,6 ★★★★★ 111

923 Angebote

695,00 – 1.284,01 €



## Huawei P30 Pro

LTE Smartphone, 6,47 Zoll, Full HD,  
Android 9.0 Pie, 40 Megapixel,  
4.200 mAh, Speicher erwe ...mehr

Note Ø 1,5 ★★★★★ 2

196 Angebote

739,00 – 1.391,11 €



## Xiaomi Mi 9

LTE Smartphone, 6,39 Zoll, Full HD,  
6 GB RAM, Android 9.0 Pie, 48 Mega-  
pixel, 3.300 mAh, Gewicht 173 g

Note Ø 2,0 ★★★★★ 4

52 Angebote

445,00 – 580,00 €



## Samsung Galaxy S10e

LTE Smartphone, 5,8 Zoll, Full HD,  
Android 9.0 Pie, 16 Megapixel,  
3.100 mAh, Speicher erwe ...mehr

Note Ø 1,8 ★★★★★ 2

294 Angebote

549,49 – 857,79 €



## Apple iPhone Xs

LTE Smartphone, 5,8 Zoll, Full HD,  
4 GB RAM, iOS 12, 12 Megapixel,  
2.658 mAh, Gewicht 177 g

Note Ø 1,6 ★★★★★ 235

482 Angebote

895,00 – 1.902,81 €



## Huawei P20

LTE Smartphone, 5,8 Zoll, Full HD,  
4 GB RAM, Android 9.0 Pie, 20 Mega-  
pixel, 3.400 mAh, Gewicht 165 g

Note Ø 1,8 ★★★★★ 222

194 Angebote

340,00 – 649,00 €



## Samsung Galaxy S10 Plus

LTE Smartphone, 6,4 Zoll, Quad HD,  
Android 9.0 Pie, 16 Megapixel,  
4.100 mAh, Speicher erweiterbar

Note Ø 1,6 ★★★★★ 3

247 Angebote

859,99 – 1.940,34 €

Anzeige

SIEMENS

TESTSIEGER  
Stiftung  
Warentest  
SEHR GUT  
(1,2)  
In der Kategorie großer  
Einbaufreezer  
Stiftung Warentest  
für Top  
Einbaufreezer  
Ausgabe 09/2017  
www.stiftung-warentest.de

Der Testsieger  
für optimale  
Frische.

Jetzt entdecken! >

Feedback





## The World of Publishing & Communication has profoundly changed

- **New means adapted to the new possibilities** were developed, e.g. „zooming“, dynamics
- **Business models** changed completely
- More focus on data, interlinking of **data / services and search** in the data
- Integration, **crowdsourcing** play an important role



# What about Scholarly Communication?

## Scientific publishing in the 17<sup>th</sup> century

One of the earliest research journals:  
*Philosophical Transactions of the Royal Society*

13

PHILOSOPHICAL  
TRANSACTIONS:  
GIVING SOME  
ACCOMPT  
OF THE PRESENT  
Undertakings, Studies, and Labours  
OF THE  
INGENIOUS  
IN MANY  
CONSIDERABLE PARTS  
OF THE  
WORLD.

Vol I.

For Anno 1665, and 1666.

In the SAVOY,  
Printed by T. N. for John Martyn at the Bell, a little with-  
out Temple-Bar, and James Allestry in Duck-Lane,  
Printers to the Royal Society.

Presented by the Author May. 30<sup>th</sup> 1667.



## Scholarly communication in 1865

# THE INTELLECTUAL OBSERVER.

JANUARY, 1865.

## CELESTIAL CHEMISTRY, AND THE PHYSICAL CONSTITUTION OF THE STARS AND NEBULÆ.

BY THOMAS W. BURE, F.R.A.S., F.C.S.

*(With a Coloured Plate.)*

FEW things are more remarkable in the present aspect of science than the manner in which its various departments come into contact one with another, thus aiding the student in a way quite unlooked for, and throwing light upon the subject of research from a quarter whence it was least expected. As when stones are thrown into water, so the circle of each science at first seems to be totally distinct from all the others, but gradually these separate circles enlarge and widen, until they intersect and produce larger circles and wider generalizations in the increasing domain of human knowledge. Thus, chemistry was, in the time of Davy, furnished with a new and powerful analytical agent in the shape of voltaic electricity, and the same agency, which is itself evoked by chemical action, has given us the long series of discoveries in electro magnetism, culminating in the splendid practical application of the electric telegraph. So, too, photography, which is essentially chemical in its nature, has been of the greatest service to the physicist in furnishing him with a constant and unerring record of the indications of his barometer, thermometer, and magnetic instru-

# Publishing in 1970s

## A Relational Model of Data for Large Shared Data Banks

E. F. CODD

*IBM Research Laboratory, San Jose, California*

Future users of large data banks must be protected from having to know how the data is organized in the machine (the internal representation). A prompting service which supplies such information is not a satisfactory solution. Activities of users at terminals and most application programs should remain unaffected when the internal representation of data is changed and even when some aspects of the external representation are changed. Changes in data representation will often be needed as a result of changes in query, update, and report traffic and natural growth in the types of stored information.

Existing noninferential, formatted data systems provide users with tree-structured files or slightly more general network models of the data. In Section 1, inadequacies of these models are discussed. A model based on  $n$ -ary relations, a normal form for data base relations, and the concept of a universal data sublanguage are introduced. In Section 2, certain operations on relations (other than logical inference) are discussed and applied to the problems of redundancy and consistency in the user's model.

**KEY WORDS AND PHRASES:** data bank, data base, data structure, data organization, hierarchies of data, networks of data, relations, derivability, redundancy, consistency, composition, join, retrieval language, predicate calculus, security, data integrity

**CR CATEGORIES:** 3.70, 3.73, 3.75, 4.20, 4.22, 4.29

The relational view (or model) of data described in Section 1 appears to be superior in several respects to the graph or network model [3, 4] presently in vogue for non-inferential systems. It provides a means of describing data with its natural structure only—that is, without superimposing any additional structure for machine representation purposes. Accordingly, it provides a basis for a high level data language which will yield maximal independence between programs on the one hand and machine representation and organization of data on the other.

A further advantage of the relational view is that it forms a sound basis for treating derivability, redundancy, and consistency of relations—these are discussed in Section 2. The network model, on the other hand, has spawned a number of confusions, not the least of which is mistaking the derivation of connections for the derivation of relations (see remarks in Section 2 on the “connection trap”).

Finally, the relational view permits a clearer evaluation of the scope and logical limitations of present formatted data systems, and also the relative merits (from a logical standpoint) of competing representations of data within a single system. Examples of this clearer perspective are cited in various parts of this paper. Implementations of systems to support the relational model are not discussed.

### 1.2. DATA DEPENDENCIES IN PRESENT SYSTEMS

The provision of data description tables in recently developed information systems represents a major advance toward the goal of data independence [5, 6, 7]. Such tables facilitate changing certain characteristics of the data representation stored in a data bank. However, the variety of data representation characteristics which can be changed *without logically impairing some application programs* is still quite limited. Further, the model of data with which users interact is still cluttered with representational prop-



# Scientific publishing today

## WE HAVE



## BUT

- Mainly based on PDF
- Is only partially machine-readable
- Does not preserve structure
- Does not allow embedding of semantics
- Does not facilitate interactivity / dynamicity / repurposing
- ...

## AGDISTIS - Graph-Based Disambiguation of Named Entities using Linked Data

Ricardo Usbeck<sup>1,2</sup>, Axel-Cyrille Ngonga Ngomo<sup>1</sup>, Michael Röder<sup>1,2</sup>, Daniel Gerber<sup>1</sup>, Sandro Athaide Coelho<sup>3</sup>, Sören Auer<sup>4</sup>, and Andreas Both<sup>2</sup>

<sup>1</sup> University of Leipzig, Germany, <sup>2</sup> R&D, Unister GmbH, Germany, <sup>3</sup> Federal University of Juiz de Fora, Brazil, <sup>4</sup> University of Bonn & Fraunhofer IAIS, Germany  
email: {usbeck|ngonga}@informatik.uni-leipzig.de

**Abstract.** Over the last decades, several billion Web pages have been made available on the Web. The ongoing transition from the current Web of unstructured data to the Web of Data yet requires scalable and accurate approaches for the extraction of structured data in RDF (Resource Description Framework) from these websites. One of the key steps towards extracting RDF from text is the disambiguation of named entities. While several approaches aim to tackle this problem, they still achieve poor accuracy. We address this drawback by presenting AGDISTIS, a novel knowledge-base-agnostic approach for named entity disambiguation. Our approach combines the Hypertext-Induced Topic Search (HITS) algorithm with label expansion strategies and string similarity measures. Based on this combination, AGDISTIS can efficiently detect the correct URIs for a given set of named entities within an input text. We evaluate our approach on eight different datasets against state-of-the-art named entity disambiguation frameworks. Our results indicate that we outperform the state-of-the-art approach by up to 29% F-measure.

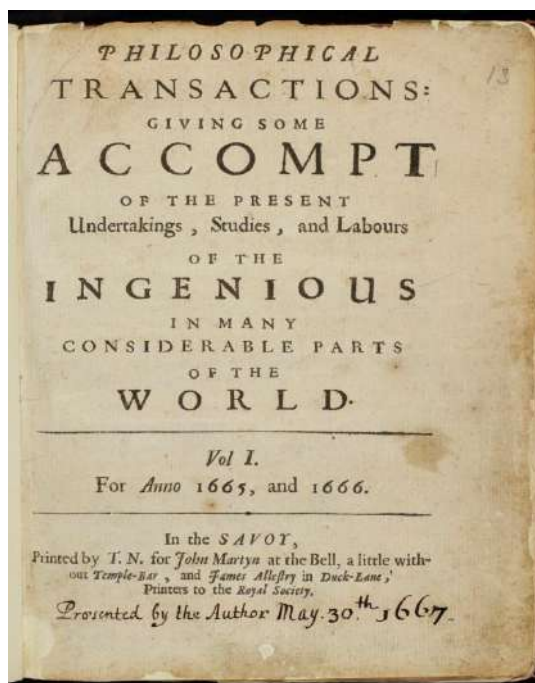
### 1 Introduction

The vision behind the Web of Data is to provide a new machine-readable layer to the Web where the content of Web pages is annotated with structured data (e.g., RDFa [1]). However, the Web in its current form is made up of at least 15 billion Web pages.<sup>1</sup> Most of these websites are unstructured in nature. Realizing the vision of a usable and up-to-date Web of Data thus requires scalable and accurate natural-language-processing approaches that allow extracting RDF from such unstructured data. Three tasks play a central role when extracting RDF from unstructured data: named entity recognition (NER), named entity disambiguation (NED), also known as entity linking [16], and relation extraction (RE). For the first sentence of Example 1, an accurate named entity recognition approach would return the strings Barack Obama and Washington, D.C.. A high-quality DBpedia-based named entity disambiguation (NED) approach would use these already recognized named entities and map the strings

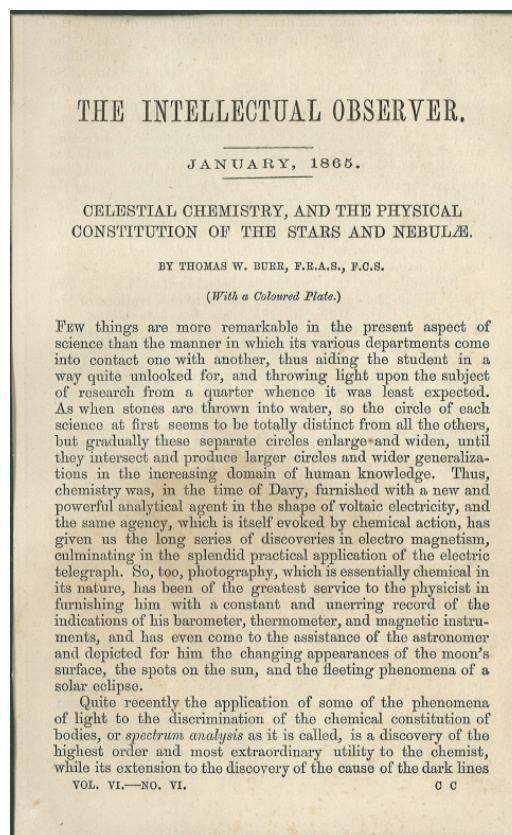
<sup>1</sup> Data gathered from <http://www.worldwidewebsize.com/> on January 4th, 2014.

# Scholarly Communication has not changed (much)

## 17<sup>th</sup> century



## 19<sup>th</sup> century



## 20<sup>th</sup> century



## 21<sup>st</sup> century



Meanwhile other information intense domains were completely disrupted: mail order catalogs, street maps, phone books, ...



# We need to rethink the way how research is represented and communicated

## Challenges we are facing:

### Digitalisation of Science

- Data integration and analysis
- Digital collaboration

### Monopolisation by commercial actors

- Publisher look-in effects
- Maximization of profits <sup>[1]</sup>

### Reproducibility Crisis

- Majority of experiments are hard or not reproducible <sup>[2]</sup>

### Proliferation of publications

- Publication output doubled within a decade
- continues to rise <sup>[3]</sup>

### Deficiency of Peer Review

- Deteriorating quality <sup>[4]</sup>
- Predatory publishing

[1] <http://thecostofknowledge.com>, <https://www.projekt-deal.de>

[2] M. Baker: *1,500 scientists lift the lid on reproducibility*, *Nature*, 2016.

[3] *Science and Engineering Publication Output Trends*, National Science Foundation, 2018.

[4] J. Couzin-Frankel: *Secretive and Subjective, Peer Review Proves Resistant to Study*, *Science*, 2013.

# Proliferation of scientific literature

## Science and engineering articles by region, country: 2004 and 2014

Rank	Region, country, or economy	2004	2014	Average annual growth rate (%)	2014 world total (%)	2014 cumulative world total (%)
na	World	1,272,362	2,290,294	6.1	100.0	na
1	United States	336,194	431,623	2.5	18.8	18.8
2	China	110,388	395,588	13.6	17.3	36.1
3	Germany	72,177	107,747	4.1	4.7	40.8
4	India	28,752	106,574	14.0	4.7	45.5
5	Japan	95,999	103,793	0.8	4.5	50.0
6	United Kingdom	75,119	101,536	3.1	4.4	54.4
7	France	53,375	74,269	3.4	3.2	57.7
8	Italy	42,647	70,453	5.1	3.1	60.8
9	South Korea	27,029	63,748	9.0	2.8	63.5
10	Canada	40,624	60,916	4.1	2.7	66.2
11	Spain	30,977	56,604	6.2	2.5	68.7
12	Brazil	18,814	53,152	10.9	2.3	71.0
13	Australia	26,277	52,269	7.1	2.3	73.3
14	Russia	26,869	43,487	4.9	1.9	75.2
15	Iran	4,952	36,539	22.1	1.6	76.8



# Reproducibility Crisis

## 1,500 scientists lift the lid on reproducibility

Monya Baker in *Nature*, 2016. **533** (7604): 452–454.  
[doi:10.1038/533452a](https://doi.org/10.1038/533452a):

- 70% failed to reproduce at least one other scientist's experiment
- 50% failed to reproduce one of their own experiments

## Failure to reproduce results among disciplines (in brackets own results)

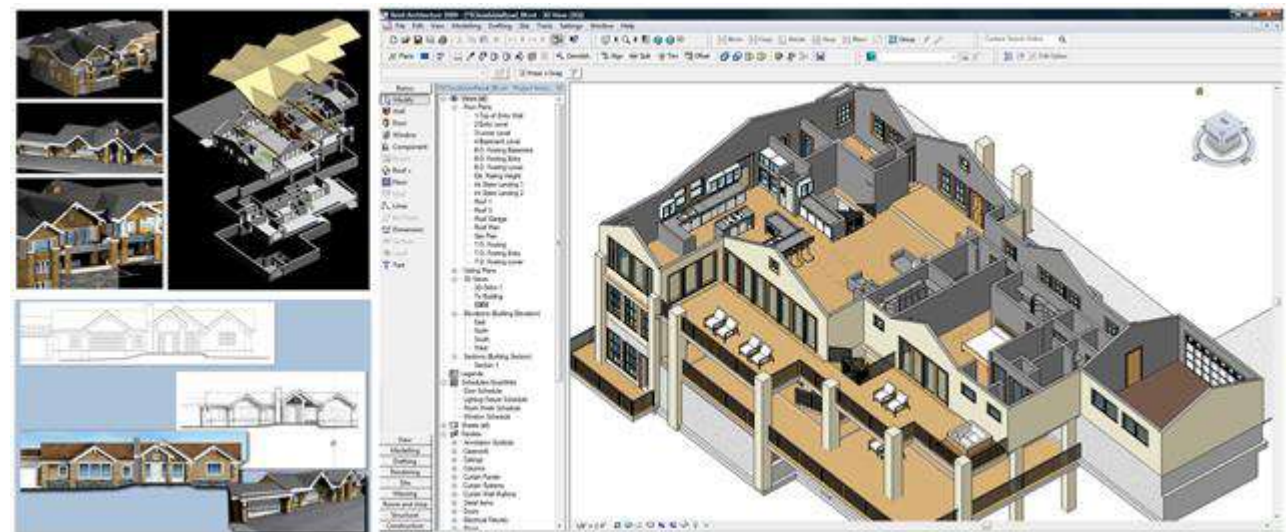
chemistry	87%	(64%)
biology	77%	(60%)
physics and engineering	69%	(51%)
Earth sciences	64%	(41%)



# Duplication and Inefficiency

How can we avoid duplication if the terminology, research problems, approaches, methods, characteristics, evaluations, ... are not properly defined and identified?

How would you build an engine / building without properly defining their parts, relationships, materials, characteristics ...?



## Root Cause – Deficiency of Scholarly Communication?

### Lack of...

#### Transparency

information is hidden  
in text

#### Integratability

fitting different  
research results  
together

#### Machine assistance

unstructured content  
is hard to process

#### Identifiability

of concepts beyond  
metadata

#### Collaboration

one brain barrier

#### Overview

Schientists look for  
the needle in the  
haystack



CRISPR

☐ Nur im Bibliothekskatalog der TIB suchen

**Search for CRISPR:  
> 9.000 Results**

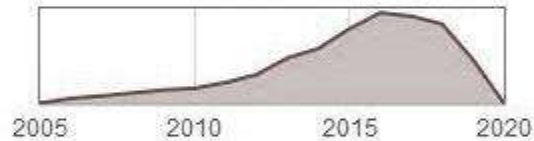
[Hier geht es zum klassischen Katalog ↗](#)

Seite 1 von 9.881 Ergebnissen

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## Treffer filtern

## Erscheinungsjahr

 -  

## Medientyp

- ☐ Aufsatz (Zeitschrift) (6.870)
- ☐ Patent (2.619)
- ☐ Hochschulschrift (127)
- ☐ Sonstige (82)
- ☐ Aufsatz (Konferenz) (58)

[+ Mehr anzeigen](#)Für folgende Begriffe wurden Synonyme verwendet: [CRISPR](#)▼Suche ohne Synonyme: [CRISPR](#)[«](#) [<](#) **1** [2](#) [3](#) [4](#) [5](#) [6](#) [7](#) [>](#)**CRISPR human trial.(clustered regularly interspaced short palindromic repeats)**

Online Contents | 2016

cited: 0 | score: 310.36673

**Advances in clustered regularly interspaced short palindromic repeats - A review**

Wang, L. / He, J. / Wang, J. | British Library Online Contents | 2011

cited: 0 | score: 297.1446

**1 regularly interspaced**

Ungefähr 238.000 Ergebnisse (0,04 Sek.)

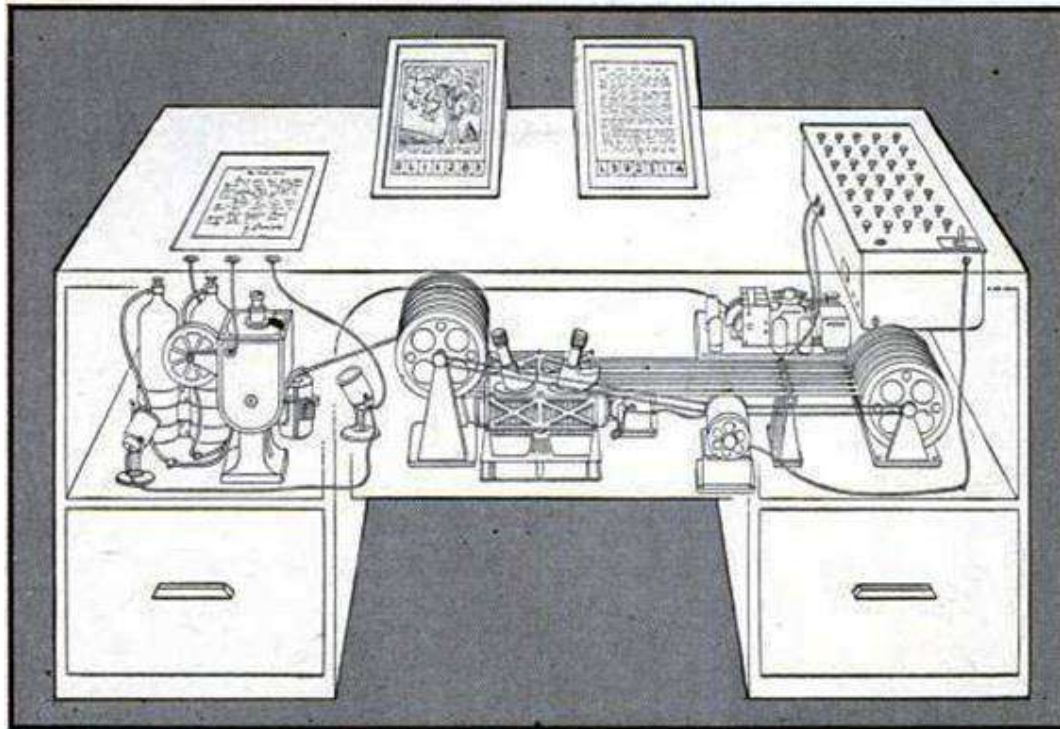
Zeitraum wä

☆ 99 Zitiert von: 3650 Ähnliche Artikel Alle 19 Versionen Web of Science: 2423

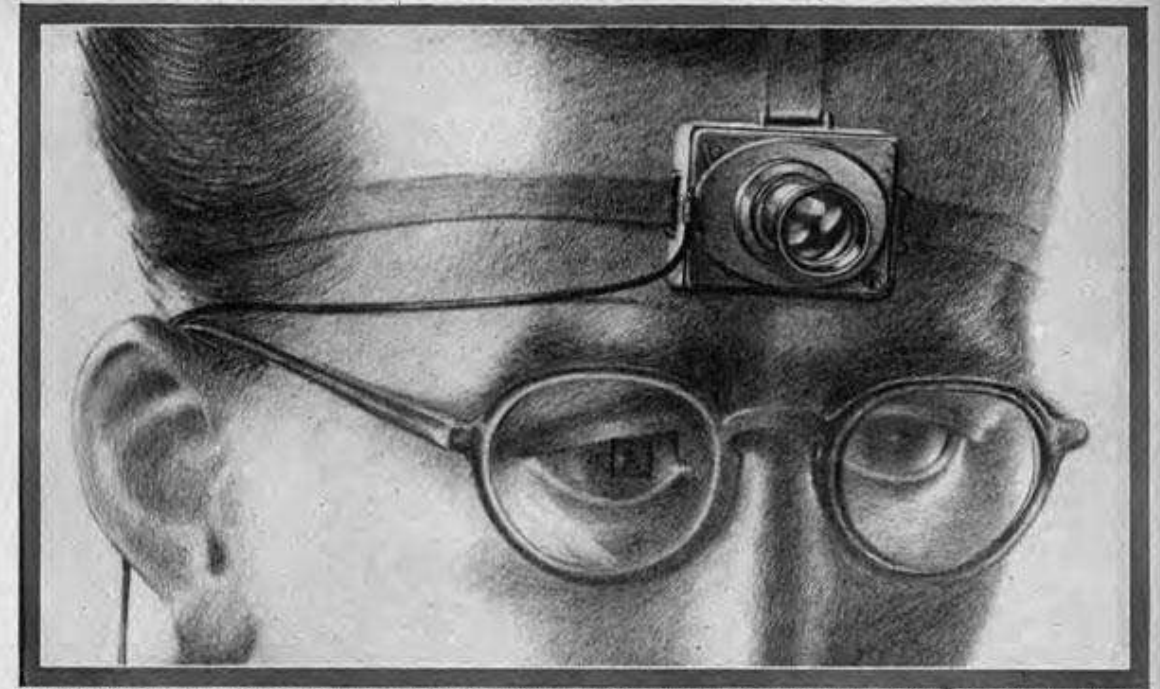
**How can  
we fix it?**



## Realizing Vannevar Bush's vision of Memex



Source: <http://photos1.blogger.com/blogger/5874/1071/1600/Memex.jpg>



A SCIENTIST OF THE FUTURE RECORDS EXPERIMENTS WITH A TINY CAMERA FITTED WITH UNIVERSAL-FOCUS LENS. THE SMALL SQUARE IN THE EYEGASS AT THE LEFT SIGHTS THE OBJECT

## AS WE MAY THINK

A TOP U. S. SCIENTIST FORESEES A POSSIBLE FUTURE WORLD  
IN WHICH MAN-MADE MACHINES WILL START TO THINK

by VANNEVAR BUSH

DIRECTOR OF THE OFFICE OF SCIENTIFIC RESEARCH AND DEVELOPMENT  
Condensed from the Atlantic Monthly, July 1945

This has not been a scientists' war; it has been a war in which all have had a part. The scientists, burying their old professional competition in the demand of a common cause, have shared greatly and learned much. It has been exhilarating to work in effective partnership. What are the scientists to do next?

For the biologists, and particularly for the medical scientists, there can be little indecision, for their war work has hardly required them to leave the old paths. Many indeed have been able to carry on their war research in their familiar peacetime laboratories. Their objectives remain much the same.

It is the physicists who have been thrown most violently off stride, who have left academic pursuits for the making of strange destructive gadgets, who have had to devise new methods for their unanticipated assignments.

These have done their work on the desert, they have been able to see both

ness, and the effort to bridge between disciplines is correspondingly superficial. Professionally our methods of transmitting and reviewing the results of research are generations old and by now are totally inadequate for their purpose. If the aggregate time spent in writing scholarly works and in reading them could be evaluated, the ratio between these amounts of time might well be startling. Those who conscientiously attempt to keep abreast of current thought, even in restricted fields, by close and continuous reading might well shy away from an examination calculated to show how much of the previous month's efforts could be produced on call.

Mendel's concept of the laws of genetics was lost to the world for a generation because his publication did not reach the few who were capable of understanding it. The sort of catastrophe is undoubtedly being significant attainments become lost in the mass

Source: <http://tntindex.blogspot.com/2014/10/tabletalk-vannevar-bushs-memex.html>

been part of a great team. Now one asks where they will find objectives

Publication has been extended far beyond our present ability to make real

# Concepts

## Overarching Concepts

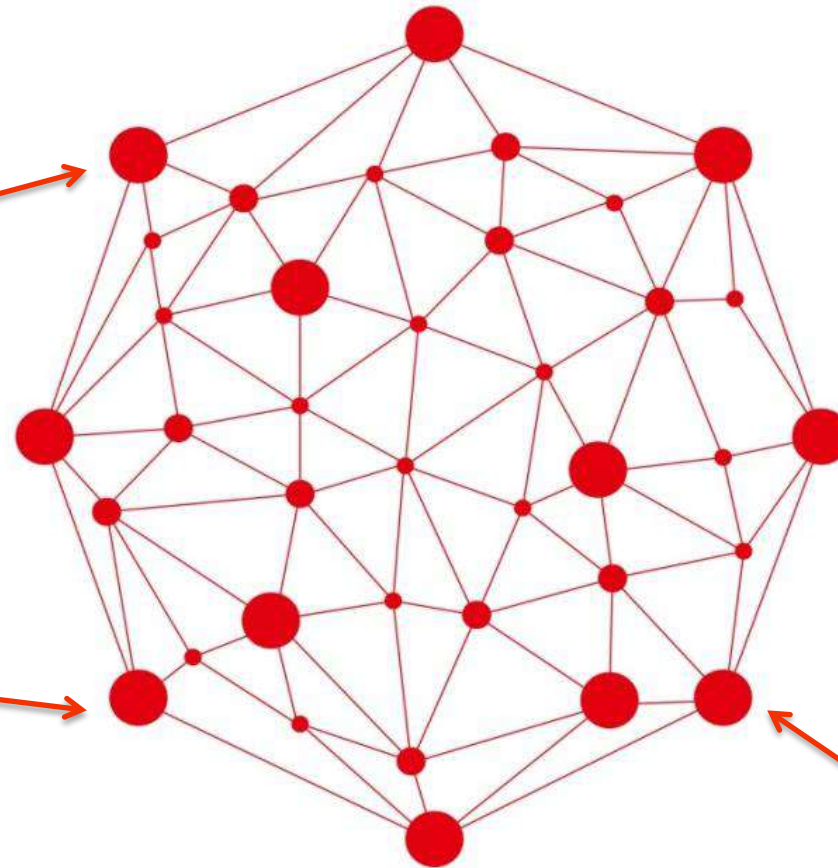
- Research problems
- Definitions
- Research approaches
- Methods

## Artefacts

- Publications
- Data
- Software
- Image/Audio/Video
- Knowledge Graphs / Ontologies

## Domain specific Concepts

Mathematics	Physics	Chemistry	Computer Science	Technology	Architecture
<ul style="list-style-type: none"> <li>• Definitions</li> <li>• Theorems</li> <li>• Proofs</li> <li>• Methods</li> <li>• ...</li> </ul>	<ul style="list-style-type: none"> <li>• Experiments</li> <li>• Data</li> <li>• Models</li> <li>• ...</li> </ul>	<ul style="list-style-type: none"> <li>• Substances</li> <li>• Structures</li> <li>• Reactions</li> <li>• ...</li> </ul>	<ul style="list-style-type: none"> <li>• Concepts</li> <li>• Implementations</li> <li>• Evaluations</li> <li>• ...</li> </ul>	<ul style="list-style-type: none"> <li>• Standards</li> <li>• Processes</li> <li>• Elements</li> <li>• Units, Sensor data</li> </ul>	<ul style="list-style-type: none"> <li>• Regulations</li> <li>• Elements</li> <li>• Models</li> <li>• ...</li> </ul>





# Chemistry Example: CRISPR Genome Editing





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**A practical guide to CRISPR/Cas9 genome editing in Lepidoptera**

Linlin Zhang,  Robert Reed

doi: <https://doi.org/10.1101/130344>

Now published in *Diversity and Evolution of Butterfly Wing Patterns* doi: [10.1007/978-981-10-4956-9\\_8](https://doi.org/10.1007/978-981-10-4956-9_8)

Abstract

Info/History

Metrics

Preview PDF

**Abstract**

CRISPR/Cas9 genome editing has revolutionized functional genetic work in many organisms and is having an especially strong impact in emerging model systems. Here we summarize recent advances in applying CRISPR/Cas9 methods in Lepidoptera, with a focus on providing practical advice on the entire process of genome editing from experimental design through to genotyping. We also describe successful targeted GFP

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Genetics

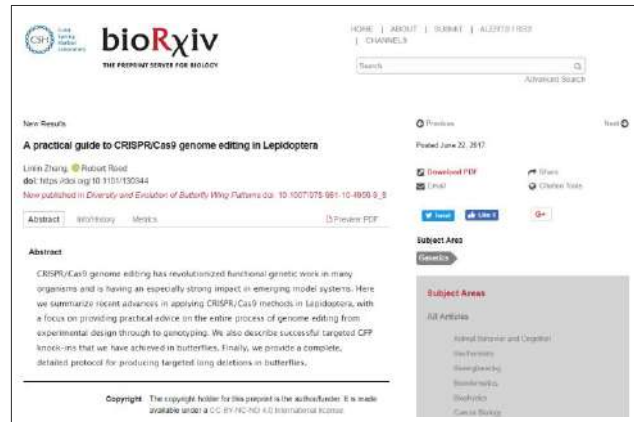
**Subject Areas**

All Articles



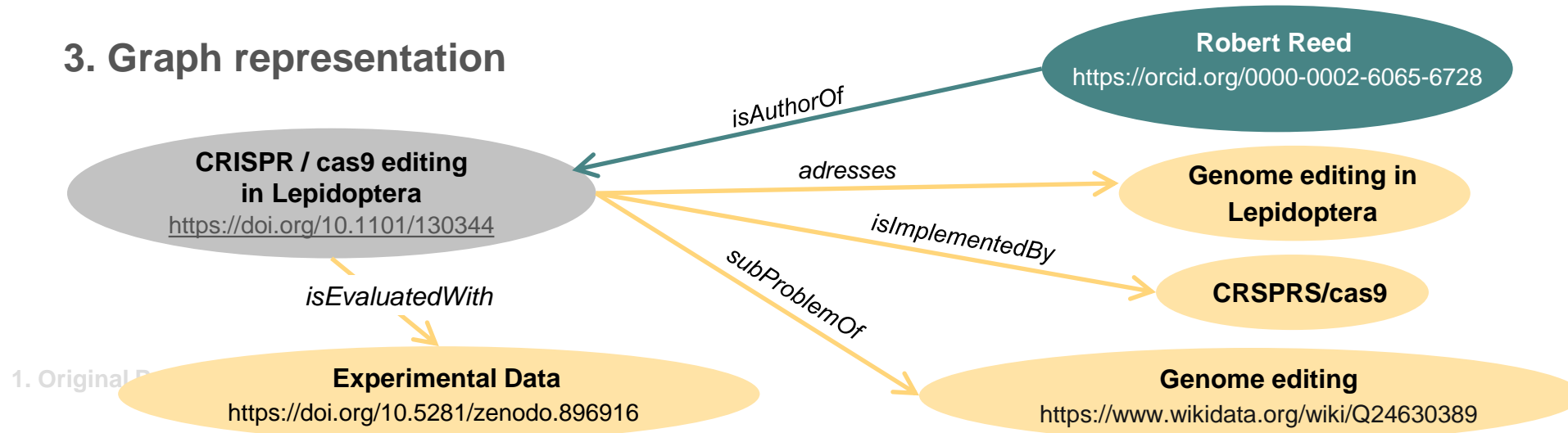
# Chemistry Example: Populating the Graph

## 2. Adaptive Graph Curation & Completion



Author	Robert Reed
Research Problem	Genome editing in Lepidoptera
Methods	CRISPR / cas9
Applied on	Lepidoptera
Experimental Data	<a href="https://doi.org/10.5281/zenodo.896916">https://doi.org/10.5281/zenodo.896916</a>

## 3. Graph representation



# Cognitive Knowledge Graphs for scholarly knowledge

KGs are *proven to capture factual knowledge* [1]

**Research Challenge:** Manage

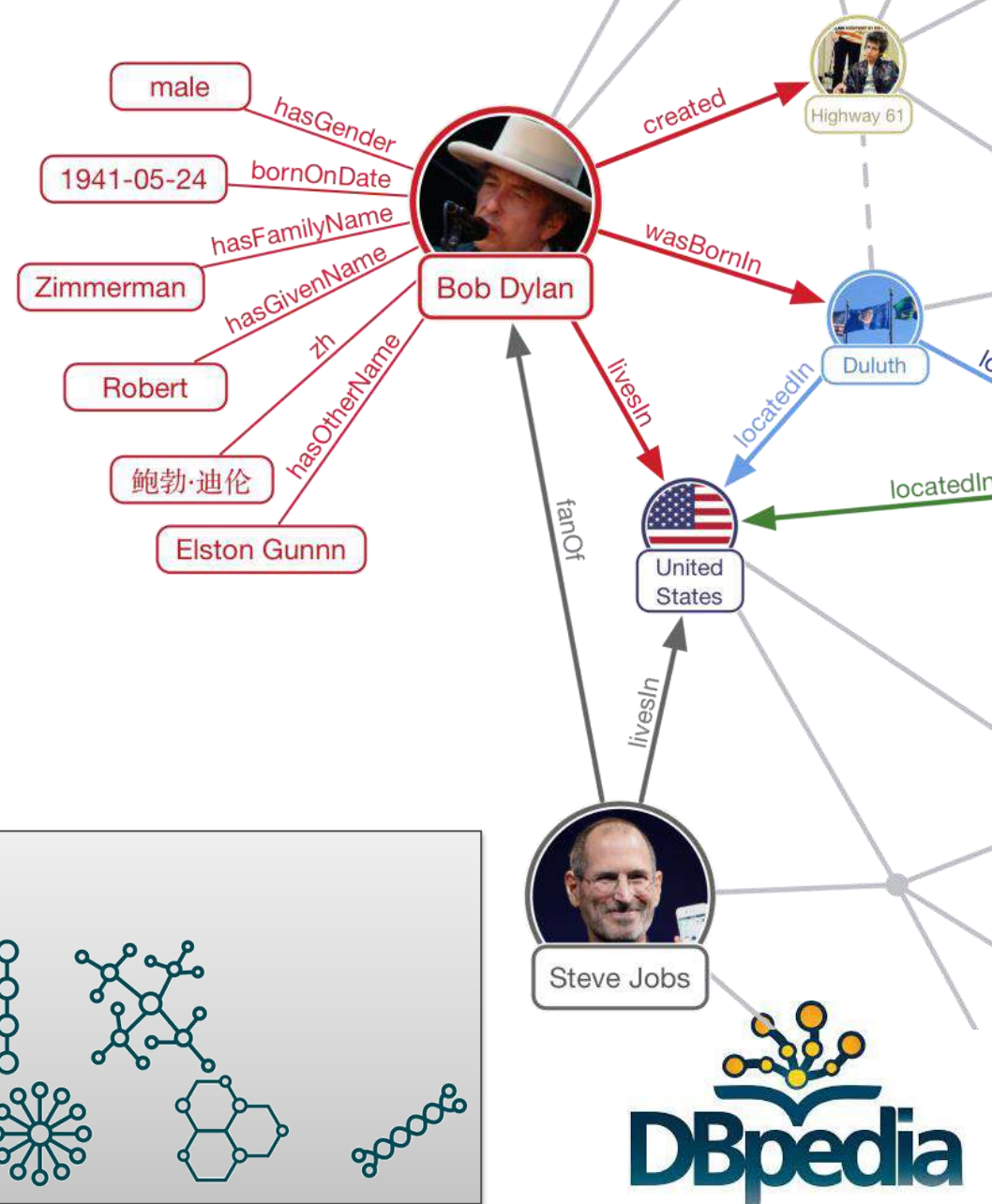
- Uncertainty & disagreement
- Varying semantic granularity
- Emergence, evolution & provenance
- Integrating existing domain models

But maintain *flexibility and simplicity*

**ScienceGRAPH approach:**

**Cognitive Knowledge Graphs**

- **Fabric of knowledge molecules** – compact, relatively simple, structured units of knowledge
- Can be **incrementally** enriched, annotated, interlinked ...



[1] S Auer et al.: *DBpedia: A nucleus for a web of open data*. 6th Int. Semantic Web Conf. (ISWC) – 10-year best paper award.  
cf. also knowledge graphs from: WikiData, BBC, Google, Bing, Thomson Reuters, AirBnB, BNY Mellon ...

# From Factual Knowledge Graphs

Today

	Factual
Base entities	Real world
Granularity	Atomic Entities
Evolution	Addition/deletion of facts
Collaboration	Fact enrichment



# From Factual to **Cognitive Knowledge Graphs**

Today

ScienceGRAPH

	Factual	Cognitive
<b>Base entities</b>	Real world	Conceptual
<b>Granularity</b>	Atomic Entities	Interlinked descriptions (molecules) with annotations (provenance)
<b>Evolution</b>	Addition/deletion of facts	Concept drift, varying aggregation levels
<b>Collaboration</b>	Fact enrichment	Emergent semantics

# Exploration and Question Answering

## Research Challenge:

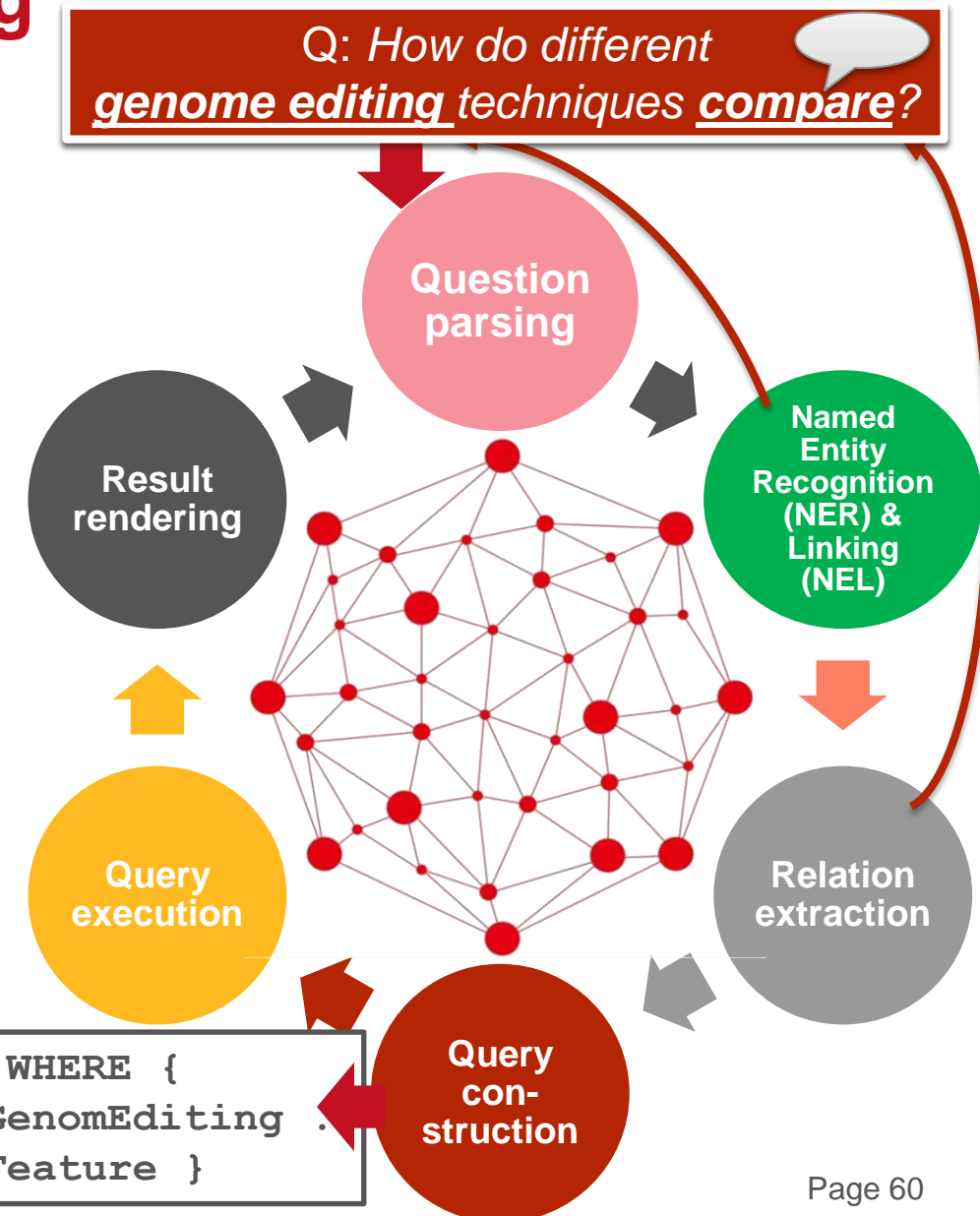
- Intuitive exploration leveraging the rich semantic representations
- Answer natural language questions

## ScienceGRAPH Approach:

- KG-based QA component integration for dynamic and automated composition of QA pipelines for cognitive knowledge graphs (e.g. following [1])
- Round-trip refinement and integration of search, faceted exploration, question answering and conversational interfaces

[1] K. Singh, S. Auer et al: *Why Reinvent the Wheel? Let's Build Question Answering Systems Together.* The Web Conference (WWW 2018).

```
SELECT Approach, Feature WHERE {  
  Approach addresses GenomEditing .  
  Approach hasFeature Feature }
```



# Result:

## Automatic Generation of Comparisons / Surveys

Q: How do different **genome editing** techniques **compare**?

Engineered Nucleases	Site-specificity	Safety	Ease-of-use / costs/ speed
zinc finger nucleases (ZFN)	++ 9-18nt	+	-- \$\$\$: screening, testing to define efficiency
transcription activator-like effector nucleases (TALENs)	+++ 9-16nt	++	++ Easy to engineer 1 week / few hundred dollar
engineered meganucleases	+++ 12-40 nt	0	-- \$\$\$ Protein engineering, high-throughput screening
CRISPR system/cas9	++ 5-12 nt	-	+++ Easy to engineer few days / less 200 dollar





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**i** The **Open Research Knowledge Graph** - or - ORKG aims to describe research papers and contributions in a structured manner. With ORKG research contributions become findable and comparable. In order to add your own research, or to contribute, [learn more](#) ↗

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Sciences

Engineering

Physical Sciences &  
Mathematics

Life Sciences

### + Recently added papers

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Katrin Leinweber

Open Research Knowledge Graph: Towards Machine Actionability in Scholarly Communication

Mohamad Yaser Jaradeh

Capsules of the diatom *Achnanthes minutissima* arise from fibrillar precursors and foster attachment of bacteria

Katrin Leinweber

# Add paper



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Paper DOI

10.1147/rd.225.0509

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Social and Behavioral Sciences	Physics	Software Engineering
Engineering	Oceanography and Atmospheric Sciences and Meteorology	OS/Networks
<b>Physical Sciences &amp; Mathematics</b>	Mathematics	Programming Languages/Compilers
Life Sciences	Earth Sciences	Numerical Analysis/Scientific Computing
	<b>Computer Sciences</b>	



## General paper data

By DOI

Manually

Paper DOI ?

10.1147/rd.225.0509

Lookup

## Lookup result

**Paper title:** Algorithm and Hardware for a Merge Sort Using Multiple Processors

**Authors:** S. Todd

**Publication date:** April 2010

Next step





## Specify research contributions

Contribution 1



+ Add another contribution

Research problems ?

Sorting algorithms ✕

Contribution data ?

← Back

Main

Merge sort

Programming language: C++



Stable: Yes



Best complexity:  $n \log n$



Worst complexity:  $n \log n$



+ Add property

Previous step

Next step

# Algorithm and Hardware for a Merge Sort Using Multiple Processors

📅 April 2010

☰ Theory/Algorithms

👤 S. Todd

## Contribution 1

### Research problems

Sorting algorithms

### Contribution data

← Back

Mair Merge sort

Worst complexity:  $n \log n$



Best complexity:  $n \log n$



Programming language: C++



Stable: Yes



### Similar contributions [Show full comparison](#)

**80**  
% A variant of heapsort with almost optimal number of comparisons

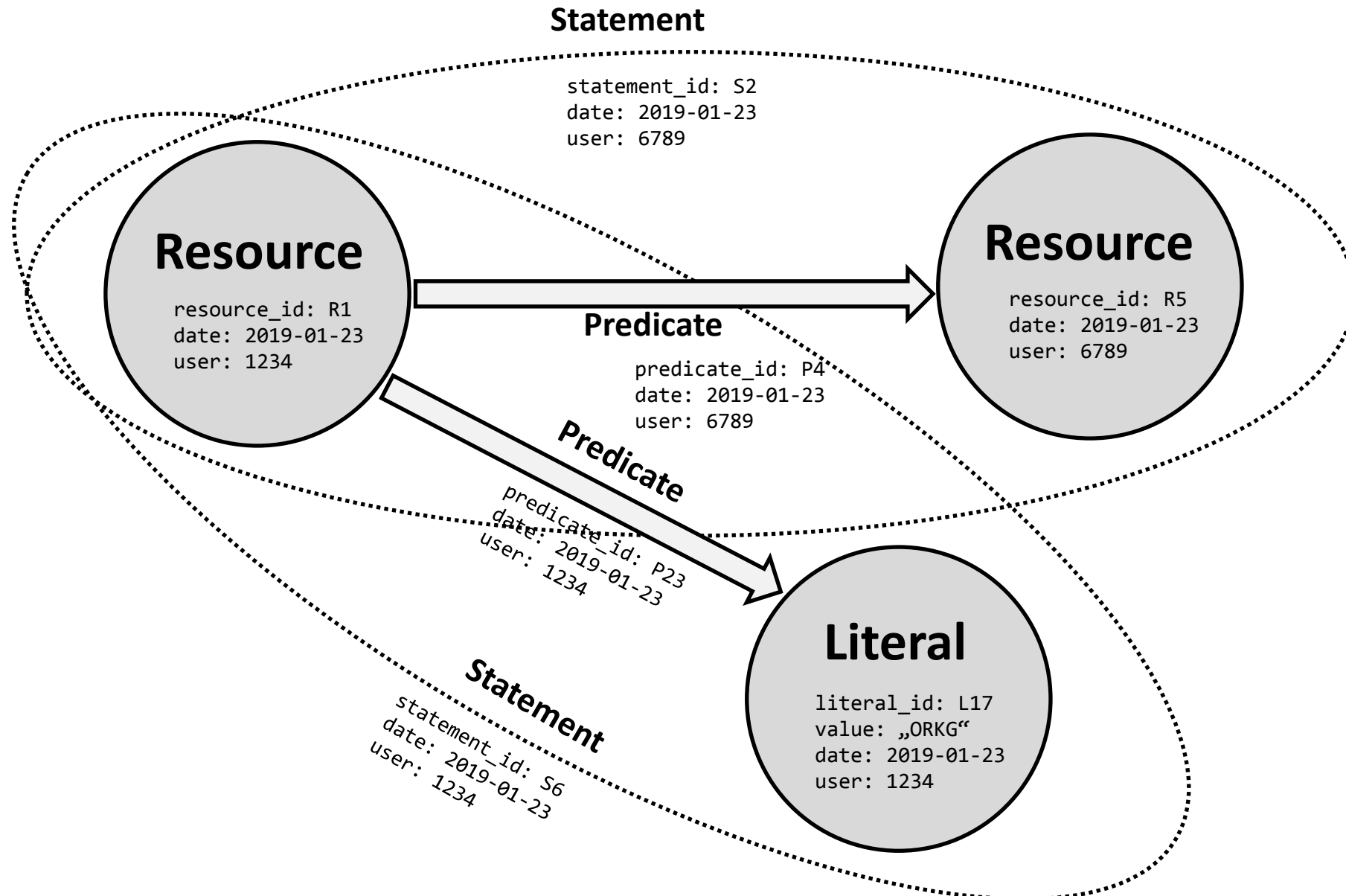
**54**  
% Bubble sort: an archaeological algorithmic analysis

Compare

Add to comparison

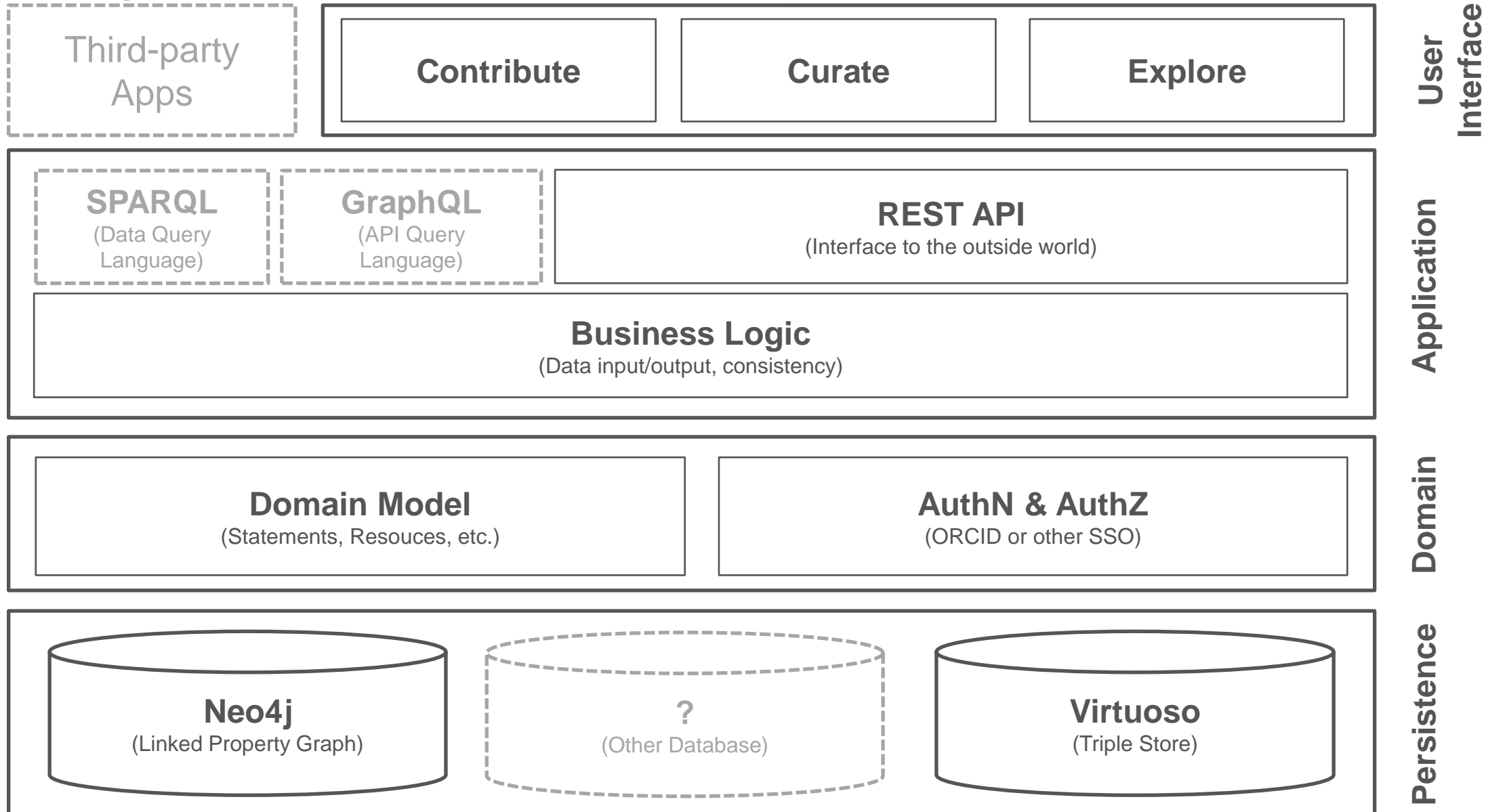
Properties	Algorithm and hardware for a merge sort using multiple processors Contribution #2	A variant of heapsort with almost optimal number of comparisons Contribution #1	Bubble sort: an archaeological algorithmic analysis Contribution #1
Algorithm	Merge sort	Heap sort	Bubble sort
Problem	Efficient sorting	Efficient sorting	Sorting
Programming language	C++	Empty	Python
Stable	Y	N	N
Best complexity	$n \log n$	$n$	$n$
Worst complexity	$n \log n$	$n \log n$	$n \log n$

# High-level Data Model: RDF + Metadata





# High-Level Architecture: Neo4j Graph Application



# Iron-regulatory proteins secure iron availability in cardiomyocytes to prevent heart failure

**Saba Haddad<sup>1,2</sup>, Yong Wang<sup>1,2</sup>, Bruno Galy<sup>3,4</sup>, Mortimer Korf-Klingebiel<sup>1,2</sup>,  
Valentin Hirsch<sup>1,2</sup>, Abdul M. Baru<sup>1,2</sup>, Fatemeh Rostami<sup>1,2</sup>, Marc R. Reboll<sup>1,2</sup>,  
Jörg Heineke<sup>2</sup>, Ulrich Flögel<sup>5</sup>, Stephanie Groos<sup>6</sup>, André Renner<sup>7</sup>, Karl Toischer<sup>8</sup>,  
Fabian Zimmermann<sup>9</sup>, Stefan Engeli<sup>10</sup>, Jens Jordan<sup>10</sup>, Johann Bauersachs<sup>2</sup>,  
Matthias W. Hentze<sup>3</sup>, Kai C. Wollert<sup>1,2</sup>, and Tibor Kempf<sup>1,2\*</sup>**

<sup>1</sup>Division of Molecular and Translational Cardiology, Hannover Medical School, Carl-Neuberg-Straße 1, 30625 Hannover, Germany; <sup>2</sup>Department of Cardiology and Angiology, Hannover Medical School, Carl-Neuberg-Straße 1, 30625 Hannover, Germany; <sup>3</sup>European Molecular Biology Laboratory, Meyerhofstraße 1, 69117 Heidelberg, Germany; <sup>4</sup>Division of Virus-associated Carcinogenesis, German Cancer Research Centre, Im Neuenheimer Feld 280, 69120 Heidelberg, Germany; <sup>5</sup>Department of Molecular Cardiology, University of Düsseldorf, Universitätsstraße 1, 40225 Düsseldorf, Germany; <sup>6</sup>Institute of Cell Biology, Hannover Medical School, Carl-Neuberg-Straße 1, 30625 Hannover, Germany; <sup>7</sup>Department of Thoracic and Cardiovascular Surgery, University of Bochum, Georgstraße 11, 32545 Bad Oeynhausen, Germany; <sup>8</sup>Department of Cardiology and Pneumology, University of Göttingen, Robert-Koch-Straße 40, 37075 Göttingen, Germany; <sup>9</sup>Department of Analytical Chemistry, Leibniz University Hannover, Callinstraße 1, 30167 Hannover, Germany; and <sup>10</sup>Institute of Clinical Pharmacology, Hannover Medical School, Carl-Neuberg-Straße 1, 30625 Hannover, Germany

Received 30 November 2015; revised 27 June 2016; accepted 12 July 2016; online publish-ahead-of-print 21 August 2016

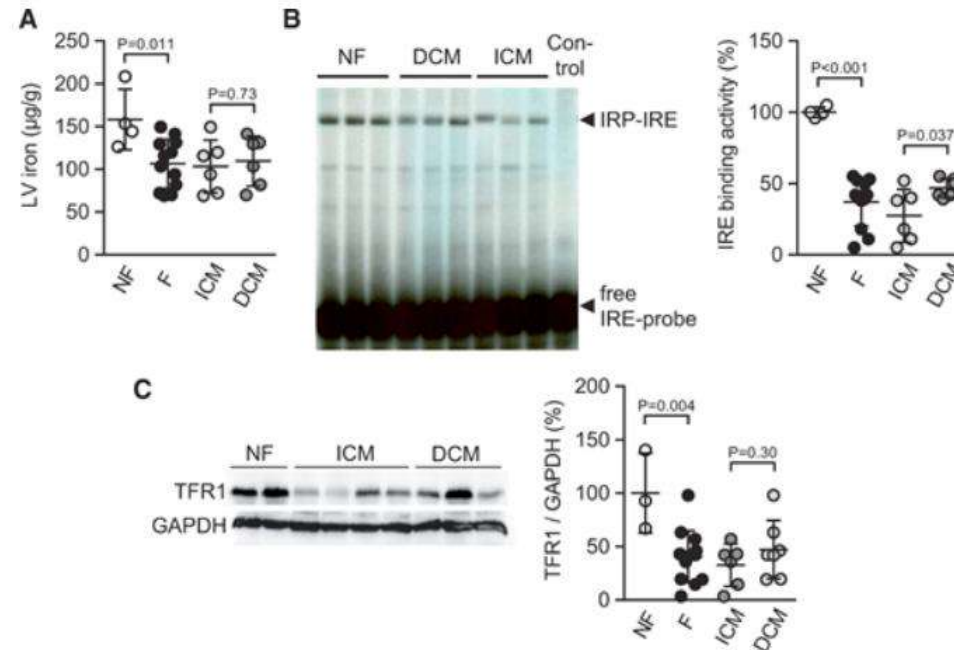
See page 373 for the editorial comment on this article (doi: 10.1093/eurheartj/ehw386)

## Results

### Reduced iron content, IRE binding activity, and transferrin receptor expression in the failing human heart

Consistent with previous reports,<sup>5,6</sup> iron concentration was significantly lower in LV tissue samples from patients with advanced heart failure than in LV tissue samples from unused donor hearts (Figure 1A). As shown by electrophoretic mobility shift assays, IRE binding activity was significantly reduced in failing hearts (most pronounced in patients with ischemic cardiomyopathy) (Figure 1B). Protein expression levels of the transferrin receptor were significantly lower in failing hearts than in the controls (Figure 1C).

**Figure 1**





File Edit View Run Kernel Tabs Settings Help

Files

orkg.ipynb



Code



Running

Commands

Cell Tools

Tabs

```
In [2]: labels = ['non-failing heart', 'failing heart']
data = [(99, 52),
        (96, 40),
        (100, 38),
        (105, 18),
        (np.nan, 11),
        (np.nan, 5),
        (np.nan, 42),
        (np.nan, 55),
        (np.nan, 53),
        (np.nan, 39),
        (np.nan, 42),
        (np.nan, 50)]

d = pd.DataFrame.from_records(data, columns=labels)
t = ttest_ind(d['non-failing heart'],
              d['failing heart'],
              equal_var=False, nan_policy='omit')

store(represent(d, t))

t.pvalue
```

```
Out[2]: 1.3111247517411591e-08
```





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1

General

2

Research field

3

Contributions

4

Finish

### General paper data

☒ By DOI☐ ManuallyPaper DOI [Lookup](#)[Next step](#)

## General paper data

By DOI Manually

Paper DOI ?

10.1093/eurheartj/ehw333

Lookup

## Lookup result

**Paper title:** Iron-regulatory proteins secure iron availability in cardiomyocytes to prevent heart failure

**Authors:** Saba Haddad, Yong Wang, Bruno Galy, Mortimer Korf-Klingebiel, Valentin Hirsch, Abdul M. Baru, Fatemeh Rostami, Marc R. Reboll, Jörg Heineke, Ulrich Flögel, Stephanie Groos, André Renner, Karl Toischer, Fabian Zimmermann, Stefan Engeli, Jens Jordan, Johann Bauersachs, Matthias W. Hentze, Kai C. Wollert, Tibor Kempf

**Publication date:** August 2016

Next step



## Select the research field

Arts and Humanities	Nutrition	Systems and Integrative Physiology
Social and Behavioral Sciences	Forestry and Forest Sciences	Exercise Physiology
Engineering	Entomology Food Science	Endocrinology
Physical Sciences & Mathematics	Animal Sciences	Comparative and Evolutionary Physiology
<b>Life Sciences</b>	<b>Physiology</b>	<b>Cellular and Molecular Physiology</b>
	Nursing Pharmacology, Toxicology and Environmental Health	

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## Specify research contributions

Contribution 1



+ Add another contribution

Research problems ?

Iron deficiency in heart failure patients

Contribution data ?

No values

+ Add property

Previous step

Next step



Contribution 1



+ Add another contribution

Research problems ?

Iron deficiency in heart failure patients ✕

Contribution data ?

Yields

🗑 Delete ▼

Object ▼ IRE

Cancel

Done

+ Add property

Statistically significant hypothesis test with IRE  
binding dependent variable on failing and non-  
failing hearts

Previous step

Next step

Contribution 1



+ Add another contribution

Research problems ?

Iron deficiency in heart failure patients ✕

Contribution data ?

Yields

Delete



Statistically significant hypothesis test with IRE binding dependent variable on failing and non-failing hearts

+ Add value

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#### Cellular and Molecular Physiology papers

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Iron-regulatory proteins secure iron availability in cardiomyocytes to prevent heart failure























Saba Haddad

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## View paper

### Iron-regulatory proteins secure iron availability in cardiomyocytes to prevent heart failure

 August 2016
  Cellular and Molecular Physiology
  Saba Haddad
  Yong Wang
  Bruno Galy
  Mortimer Korf-Klingebiel
  Valentin Hirsch
  Abdul M. Baru
  Fatemeh Rostami
  Marc R. Reboil
  Jörg Heineke
  Ulrich Flügel
  Stephanie Groos
  André Renner
  Karl Toischer
  Fabian Zimmermann
  Stefan Engeli
  Jens Jordan
  Johann Bauersachs
  Matthias W. Hentze
  Kai C. Wollert
  Tibor Kempf

#### Contribution 1

#### Research problems

Iron deficiency in heart failure patients

#### Contribution data

Yields: Statistically significant hypothesis test with IRE binding dependent variable on failing and non-failing hearts



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80 % Wiles's proof of Fermat's last theorem

54 % Gruber's design of ontologies

14 % Design criteria for ontologies

## Research problems

Iron deficiency in heart failure patients

## Contribution data

[← Back](#)

Ma Statistically significant hypothesis test with IRE binding dependent variable on failin

Has specified output: *the p-value of the statistical hypothesis test*



Type: *two sample t-test with unequal variance*



Has specified input: *3 values*



Label: *Statistically significant hypothesis test with IRE binding dependent variable on failing and non-failing hearts*



## Research problems

Iron deficiency in heart failure patients

## Contribution data

[← Back](#)

Main

Stat

the p-value of the statistical hypothesis test

Has value specification: *the value specification of the p-value*



Type: *p-value*



Label: *the p-value of the statistical hypothesis test*



# Research problems

Iron deficiency in heart failure patients

## Contribution data

[← Back](#)   [Main](#)   [Stat](#)   [the p](#)   [the value specification of the p-value](#)

Type: scalar value specification	▼
Has specified numeric value: 1.3111247517411591e-08	▼
Label: the value specification of the p-value	▼



## Research problems

Iron deficiency in heart failure patients

## Contribution data

[← Back](#)

Ma Statistically significant hypothesis test with IRE binding dependent variable on failin

Has specified output: *the p-value of the statistical hypothesis test*



Type: *two sample t-test with unequal variance*



Has specified input



failing heart

the study design dependent variable

non-failing heart

Label: *Statistically significant hypothesis test with IRE binding dependent variable on failing and non-failing hearts*



## Research problems

Iron deficiency in heart failure patients

## Contribution data

← Back

Main

Status

the study design dependent variable

Type

study design dependent variable

iron-responsive element binding

Label: *the study design dependent variable*

Term of the Gene Ontology, namely [GO:0030350](#)

## Research problems

Iron deficiency in heart failure patients

## Contribution data

[← Back](#)

Main

Stat

non-failing heart

### Has part



[the scalar measurement datum #3](#)

[the scalar measurement datum #1](#)

[the scalar measurement datum #4](#)

[the scalar measurement datum #2](#)

Type: *continuous variable*



Label: *non-failing heart*



## Research problems

Iron deficiency in heart failure patients

## Contribution data

[← Back](#)

Main | Statistics | non-statistical | the value specification #4

Type: *scalar value specification*



Has specified numeric value: *105.0*



Label: *the value specification #4*





## Research problems

Iron deficiency in heart failure patients

## Contribution data

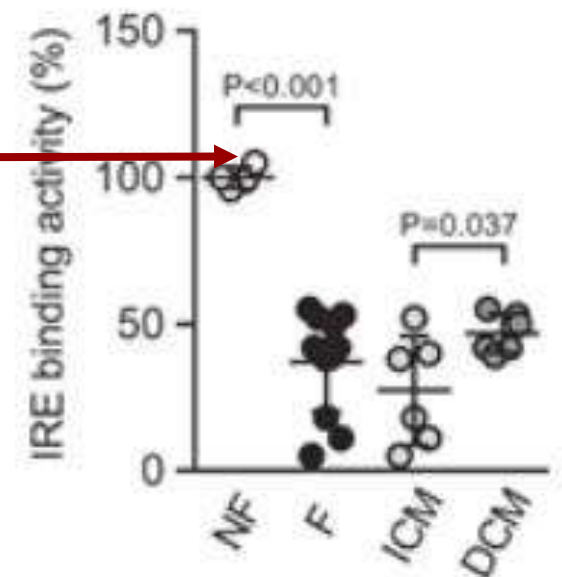
← Back

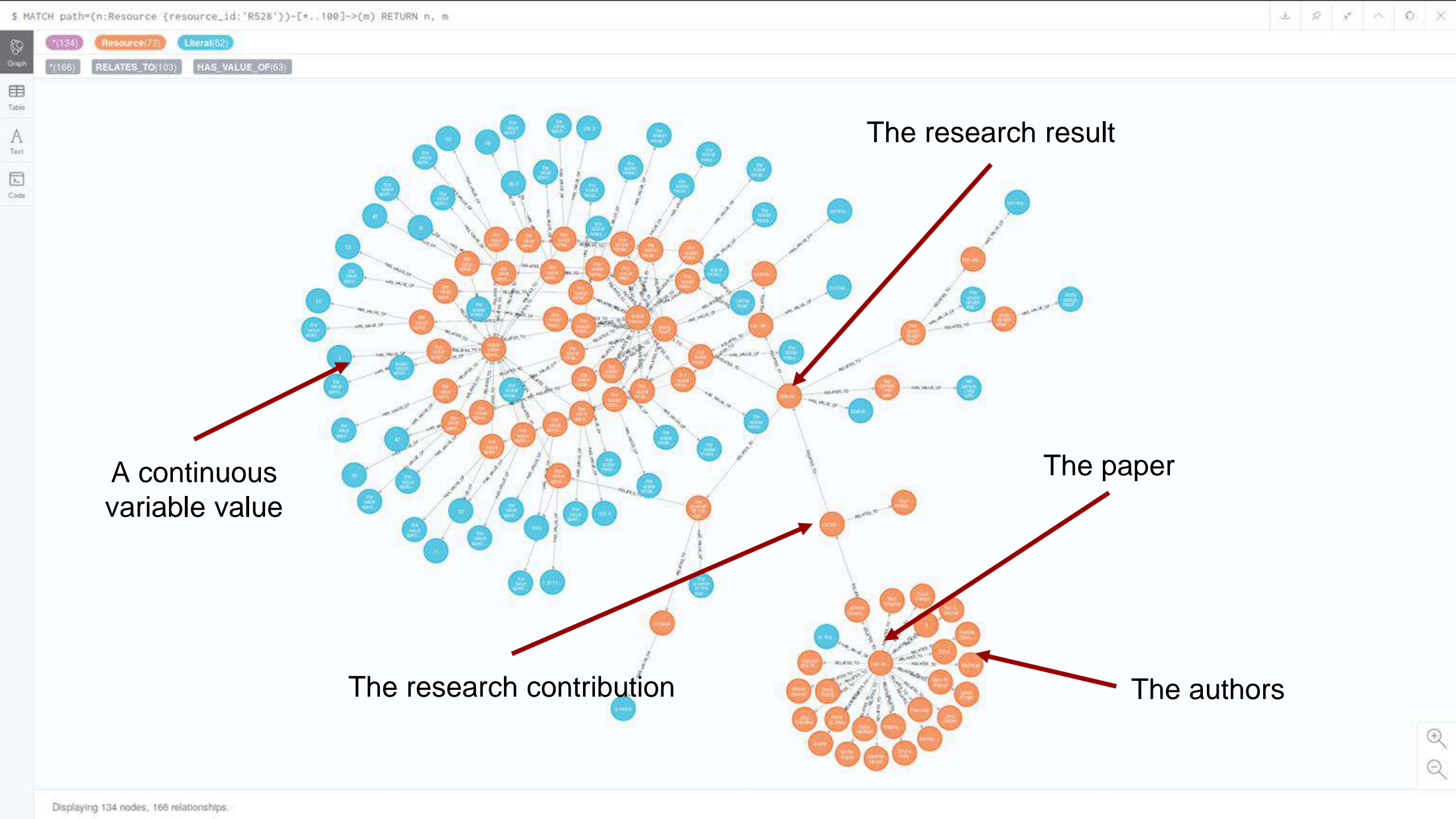
Main | Statistics | non- | the s | the value specification #4

Type: *scalar value specification*

Has specified numeric value: 105.0

Label: *the value specification #4*





## More projects



Nursing AI



### Stay tuned

- <https://tib.eu>
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<https://groups.google.com/forum/#!forum/orkg>
- Open Research Knowledge Graph:  
<https://orkg.org>
- ERC Consolidator Grant ScienceGRAPH started in May
- Transfer event on International Data Space on June 19:  
<https://events.tib.eu/transfer/>



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# The Team



## Group Leaders



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Dr. Gábor Kismihók

## PostDocs



Dr. Javad Chamanara



Dr. Jennifer D'Souza

## Software Development



Manuel Prinz



Wazed Ali

## Doctoral Researchers



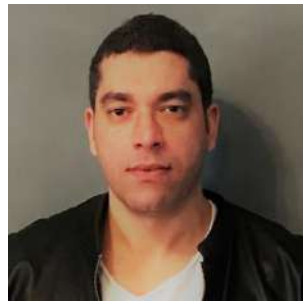
Olga Lezhnina



Allard Oelen



Yaser Jaradeh



Shereif Eid



Sarven Capadisli



Vitalis Wiens



## Collaborators TIB/L3S Scientific Data Management



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Dr. Maria Esther Vidal



Kemele Endris



Farah Karim

## Collaborators InfAI Leipzig / AKSW



Dr. Michael Martin



Natanael Arndt

## Project Management



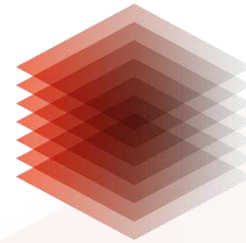
Alex Garatzogianni



Laura Granzow



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