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Knowledge Graphs as the Foundation for Interoperable Intelligent Systems

Fabien Gandon

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Submitted on 14 Dec 2024

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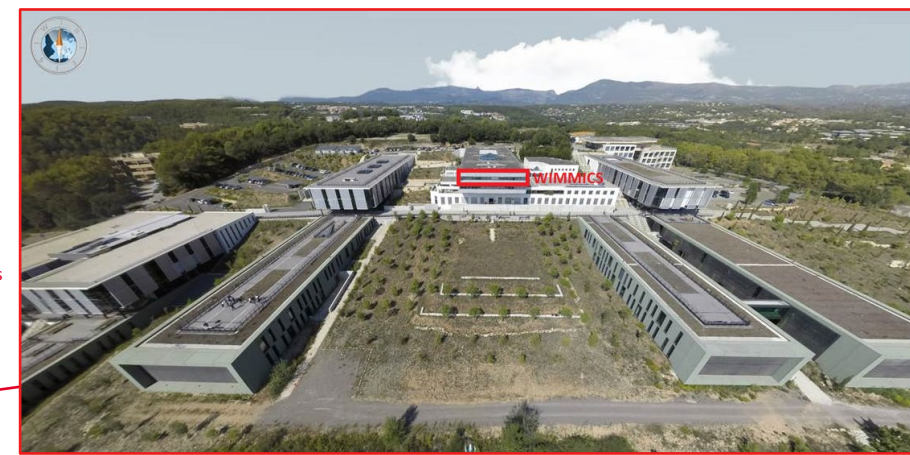
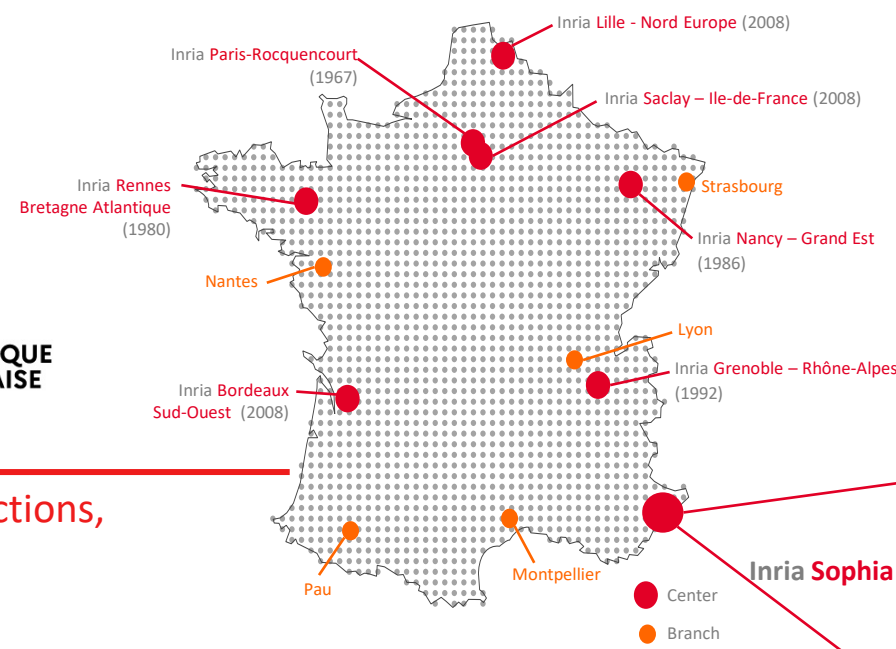


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Knowledge Graphs as the Foundation for Interoperable Intelligent Systems



WIMMICS TEAM



Inria Sophia Antipolis Méditerranée (1983) & UCA, I3S, CNRS – Nice, FRANCE

Web-Instrumented Man-Machine Interactions, Communities and Semantics

■ Inria *Inria*

■ CNRS 

■ University Côte D'Azur (UniCA) 

UNIVERSITÉ CÔTE D'AZUR 



MULTI-DISCIPLINARY TEAM

- 40~60 members
- ~15 nationalities
- 2 DR, 5 Professors
- 1CR, 1 Assistant professors



DR / Tenured Senior Researchers / Professors:

- Michel BUFFA, UCA, Web, Social Media, Web Audio/Music, K. Graphs
- Elena CABRIO, UCA, NLP, KR, Linguistics, Q&A, Text Mining, K. Graphs
- Catherine FARON, UCA, KR, AI, Semantic Web, K. Graphs
- Fabien GANDON, Inria, AI, KRR, Semantic Web, Social Web, K. Graphs
- Andrea TETTAMANZI, UCA, AI, Logics, Evo, Learning, Agents, K. Graphs
- Serena VILLATA, CNRS, AI, Argumentation, Licenses, Rights, K. Graphs
- Marco WINCKLER, UCA, Human-Computer Interaction, Web, K. Graphs

CR / ISFP / Tenured Junior Researchers / Assistant Professors:

- Victor DAVID, INRIA, AI, KRR, Argumentation, K. Graphs
- Aline MENIN, UCA, Human-Computer Interaction, Web, K. Graphs

Research engineer:

- Rémi CERES, Inria, Linked Data, Semantic Web, Triple Store, K. Graphs
- Franck MICHEL, CNRS, Linked Data, Integration, DB, K. Graphs

3IA Associate Professors:

- Pierre MONNIN, UCA, AI, Neuro-symbolic, KRR, K. Graphs
- Anais OLLAGNIER, UCA, NLP, Linguistics, Text analysis

Retired / Emeritus:

- Olivier CORBY, Inria, CR, KR, AI, Sem. Web, Programming, K. Graphs
- Alain GIBOIN, Inria, CR, Interaction Design, KE, User & Task, K. Graphs

External Collaborators:

- Andrei Ciortea (University of St. Gallen) Agents, WoT, Sem. Web, K. Graphs
- Nicolas DELAFORGE (Probabl) Sem. Web, KM, Integration, K. Graphs
- Freddy LECUE (JP Morgan, NY) AI, Logics, Mining, Big Data, S. Web, K. Graphs
- Ştefan SARKADI (King's College, London) Agent Simulation, Deceptive AI, K. Sharing

knowledge graphs

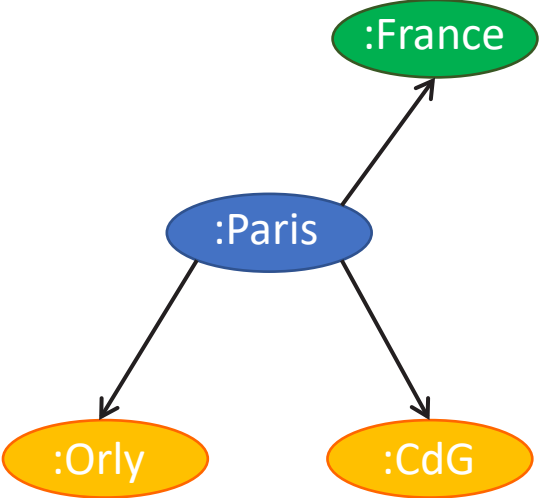
(Directed, Labels, Multi-Graphs)

« Paris »

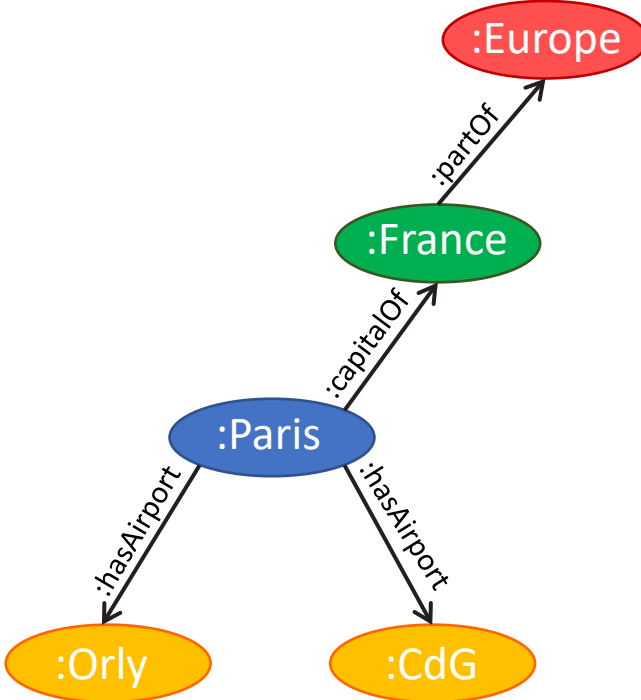


string

+ named entity



+ linked entity

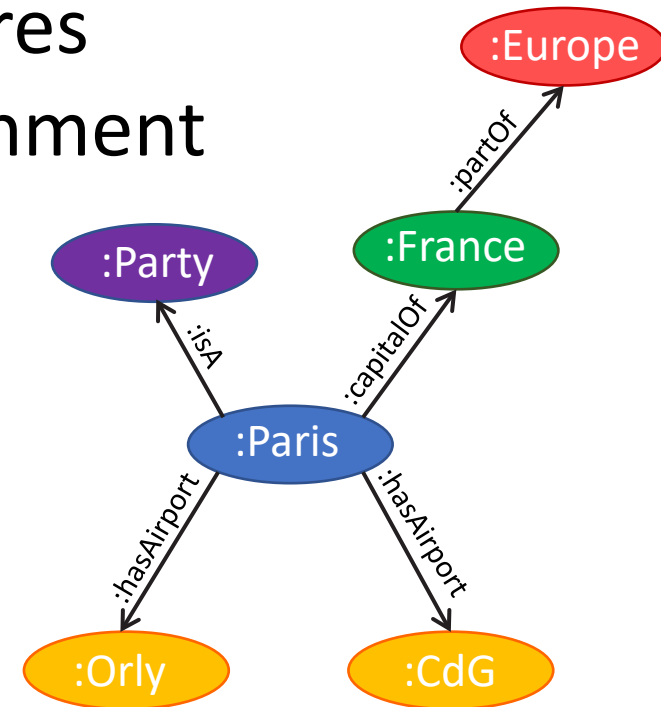


+ named relations

knowledge graphs

typically support

- **associative** data (sets) and object-oriented structures
- **flexible** extensions, changes, integration and enrichment in data and schemas (loosely coupled to schema)
- **complex** queries on relations
- **validation** and **inferential** schemata



Knowledge Graphs @ ORACLE®

Graph database topics

- [Graph database defined](#)
- [Graph database types](#)
- [How graphs and graph databases work](#)
- [Advantages of graph databases](#)**
- [How graph databases and graph analytics work](#)
- [Graph database use case: money laundering](#)
- [Graph database use case: social media analysis](#)
- [Graph database use case: credit card fraud](#)
- [The future of graph databases](#)

Advantages of graph databases

The graph format provides a more flexible platform for finding distant connections or analyzing data based on things like strength or quality of relationship. Graphs let you explore and discover connections and patterns in social networks, IoT, big data, data warehouses, and also complex transaction data for multiple business use cases including fraud detection in banking, discovering connections in social networks, and customer 360. Today, graph databases are increasingly being used as a part of data science as a way to make connections in relationships clearer.

Because graph databases explicitly store the relationships, queries and algorithms utilizing the connectivity between vertices can be run in subseconds rather than hours or days. Users don't need to execute countless joins and the data can more easily be used for analysis and machine learning to discover more about the world around us.

Graph databases are an extremely flexible, extremely powerful tool. Because of the graph format, complex relationships can be determined for deeper insights with much less effort. Graph databases generally run queries in languages such as Property Graph Query Language (PGQL). The example below shows the same query in PGQL and SQL.

PGQL:

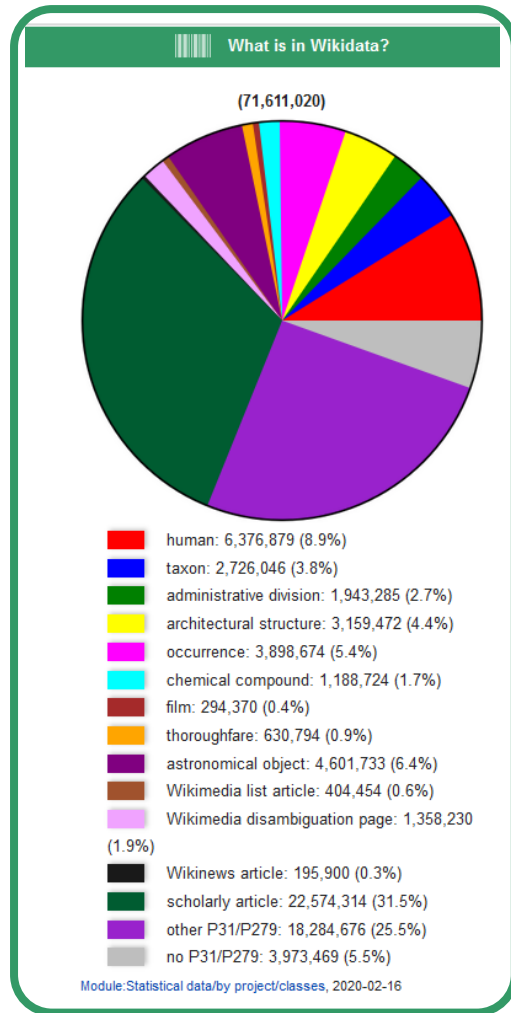
```
PATH shares_movie_with AS (from) <- (acted_in) -> (to)
SELECT y.name
MATCH (x:Actor) -/:shares_movie*/->(y:Actor)
WHERE x.name = 'Iron Man'
AND x <> y
```

SQL Equivalent:

```
WITH temp(actor_id, actor_name) AS (
  —Anchor member:
  SELECT actor_id, name
  FROM Devices
  WHERE name = 'Iron Man'
  UNION ALL
  —Recursive member:
  SELECT Actors.actor_id, Actors.name
  FROM temp, Actors, Connections conn1,
    Connections conn2, Movies
  WHERE temp.actor_id = conn1.to_actor_id
    AND conn1.from_acted_in_id = Connectors.movies_id
    AND Connectors.movie_id = conn2.from_movie_id
    AND conn2.to_actor_id = Devices.actor_id
    AND temp.actor_id != Actors.actor_id)
CYCLE actor_id SET cycle TO 1 DEFAULT 0
SELECT DISTINCT actor_name
FROM temp
WHERE cycle = 0
AND actor_name <> 'Iron Man'
```


KGs are adopted in every domain and are a key to access...

large datasets, private and public, every domain, general and specialized data, ML benchmarks, ...



RDF File

URL: <https://data.lacity.org/api/views/uqjn-rubw/trows.rdf?accessType=DOWNLOAD>

From the dataset abstract
Census 2010 population data approximated from block groups to LA Council Districts using Esri software
Source: Census Data by Council District

Resources
Comma Separated Values File
RDF File
JSON File
XML File
Share on Social Sites
Twitter
Facebook

About this Resource

Last updated	unknown
Created	unknown
Format	RDF File
License	other-license-specified

[Show more](#)

DATA.GOV
About | Open Government | Website Policies | Sitemap | PERFORMANCE.GOV | Login

KDnuggets

Blog Topics Datasets Education Resources

A Brief Introduction to Wikidata

Like Wikipedia, there are all kinds of data stored in Wikidata. As such, when you are looking for a specific dataset or if you want to answer a curious question, it can be a good start looking for that data at Wikidata first.

europeana pro

Linked Open Data FAQ

This page addresses the most important points of Linked Open Data in Europeana.

DBpedia

Since the emergence of the LOD Cloud in 2007 DBpedia constitutes the main resource of Linked Open Data on the Web containing more than 228 million entities to date. With the rapid growth of published LOD-datasets DBpedia evolved to the most interconnected freely available knowledge graph on the Web. Out of its popularity, numerous further resources emerged and have been created by and for research and industry for various purposes. As of today, a large community of Linked Data enthusiasts is continuously contributing

GENEONTOLOGY

Unifying Biology

Property	Value	Property	Value	Property	Value
Valid terms	42442 ($\Delta = -327$)	Number of annotations	7,655,937	Annotated gene products	1,537,348
Obsolete terms	5287 ($\Delta = 397$)	Annotations for biological process	2,833,885	Annotated species	5,387
Merged terms	2440 ($\Delta = 0$)	Annotations for molecular function	2,459,729	Annotated species with over 1,000 annotations	188
Biological process terms	27186	Annotations for cellular component	2,362,323		
Molecular function terms	11198	Annotations for evidence PHYLO	3,819,045		
Cellular component terms	4058	Annotations for evidence IEA	1,714,824		

GeoNames

The GeoNames geographical database covers all countries and contains over eleven million placenames that are available for download free of charge.

OceanGraph RDF dataset

Published: 16 March 2020 | Version 1 | DOI: 10.17632/9t5xkt9wwk.1
Contributors: Marcos Zárate, Carlos Buckle, Renato Mazzanti, Pablo Fillotrani, Claudio Delrieux, Mirtha Lewis

Description

RDF dataset generated by the OceanGraph project (DOI https://doi.org/10.1007/978-3-030-21395-4_3). It contains approximately 4.7M of triplets extracted from different data sets belonging to OBIS, GBIF, SN SciGraph. It also contains information on oceanographic campaigns of the Argentine initiative Pampa Azul extracted from Sistema Nacional de datos del Mar (SNDM).

Total number of entries in this release of UniProtKB

Section	Number of entries in total	Number of entries with an annotation update	Number of entries with a sequence update
UniProtKB	251,702,059	58,607,318	12,399

OKG FIBO

Financial Industry Business Ontology

Hall of fame of knowledge graphs



Google
KG

DBpedia

Wikidata

Bing KG

Yago

Freebase

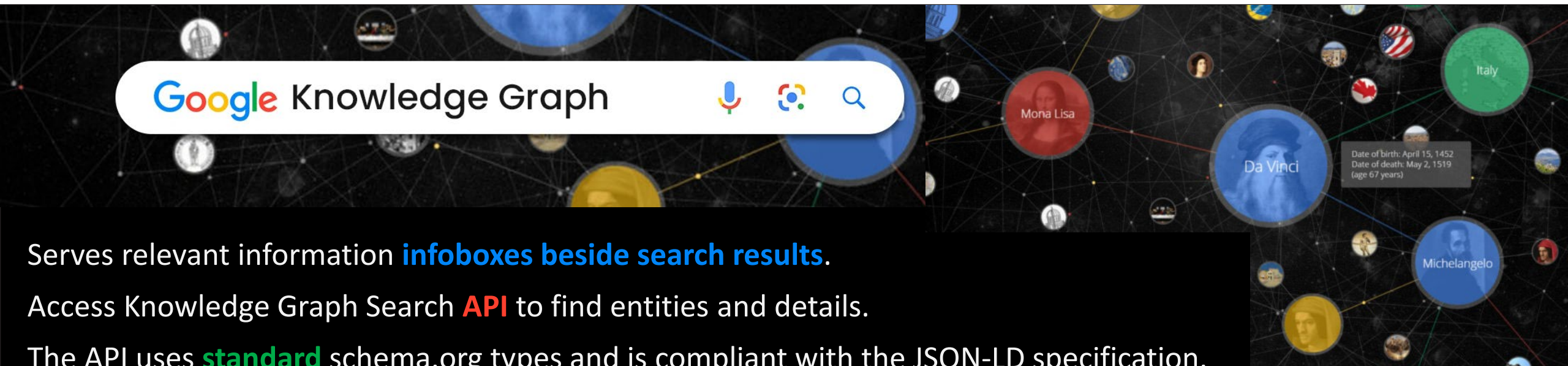
...

Knowledge Graphs @ Microsoft Bing

Billions of real world entities : people, places, things, businesses, etc.

Used to power Bing **Knowledge Panels as well as traditional search** results

Access through Bing Entity Search **API** to get primary **details and sources** about any entity.



Serves relevant information **infoboxes beside search results**.

Access Knowledge Graph Search **API** to find entities and details.

The API uses **standard** schema.org types and is compliant with the JSON-LD specification.

Knowledge Graphs (KGs) everyday










Google daft punk

All Images News Videos Books Web Finance Tools

Daft Punk

Electronic duo

Overview Songs Albums Members Videos Listen




daftpunk.com
https://www.daftpunk.com

Daft Punk
Daft Punk (1993 - 2021) - Official website, music, merch, videos and more.


Wikipedia
https://en.wikipedia.org/wiki/Daft_Punk

Daft Punk
Daft Punk ; Thomas Bangalter · Guy-Manuel de Homem-Christo · daftpunk.com ...
Discography · Discovery (Daft Punk album) · Get Lucky (Daft Punk song) · Electroma

Members



Thomas Bangalter
Guitar



Guy-Manuel de Homem-Christo
Drum

Listen

About

daftpunk.com

Daft Punk were a French electronic music duo formed in 1993 in Paris by Thomas Bangalter and Guy-Manuel de Homem-Christo. They achieved early popularity in the late 1990s as part of the French house movement, combining elements of house music with funk, disco, techno, rock and synth-pop. [Wikipedia](#)

Origin: Paris

Genres: French house; dance; electronic; disco

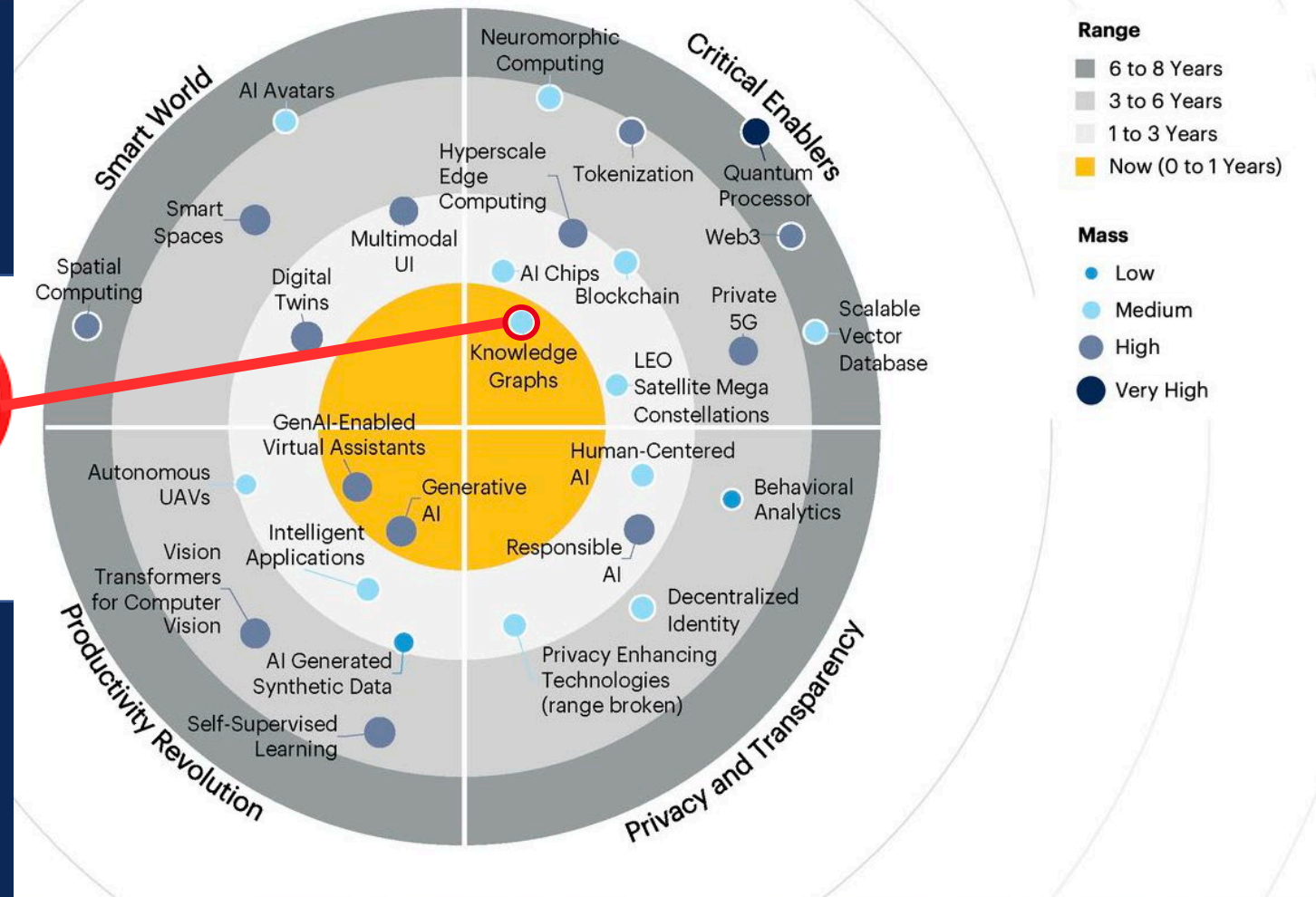
Active from: 1993

Labels: Daft Life; Columbia; Virgin; Soma; Parlophone; Warner; Walt Disney; ADA France

Gartner Emerging Tech Impact Radar 2024

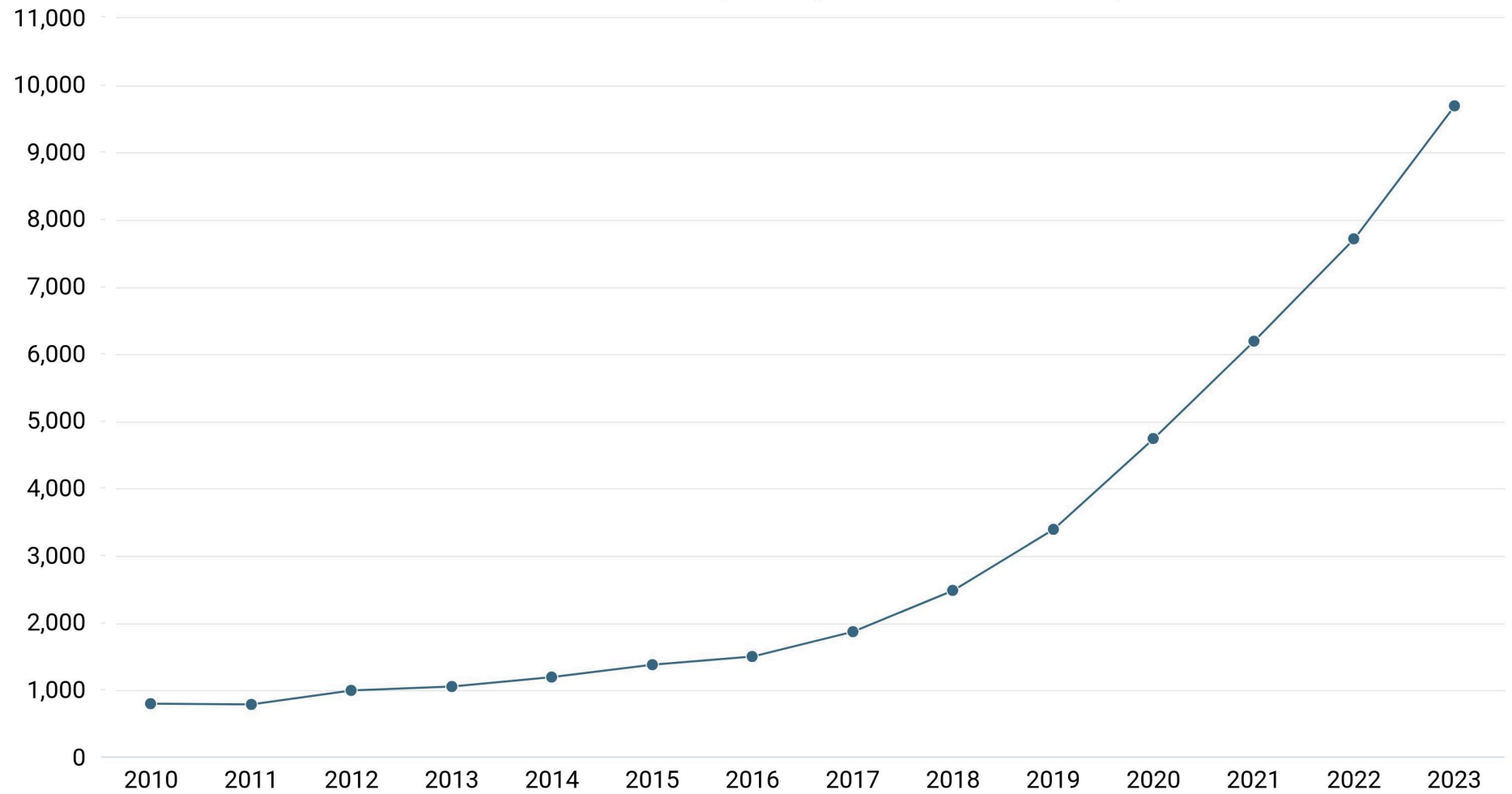


Knowledge graphs, were named a **Critical Enabler** on Gartner's 2024 Emerging Tech Radar.



The Gartner Emerging Tech Impact Radar highlights more than 650 emerging technologies and trends with the most potential to disrupt a broad cross-section of markets.

academic publications about knowledge graphs



● Publications (total)



Dimensions

Source: <https://app.dimensions.ai>
Exported: August 21, 2024
Criteria: 'knowledge graph' in title and abstract.

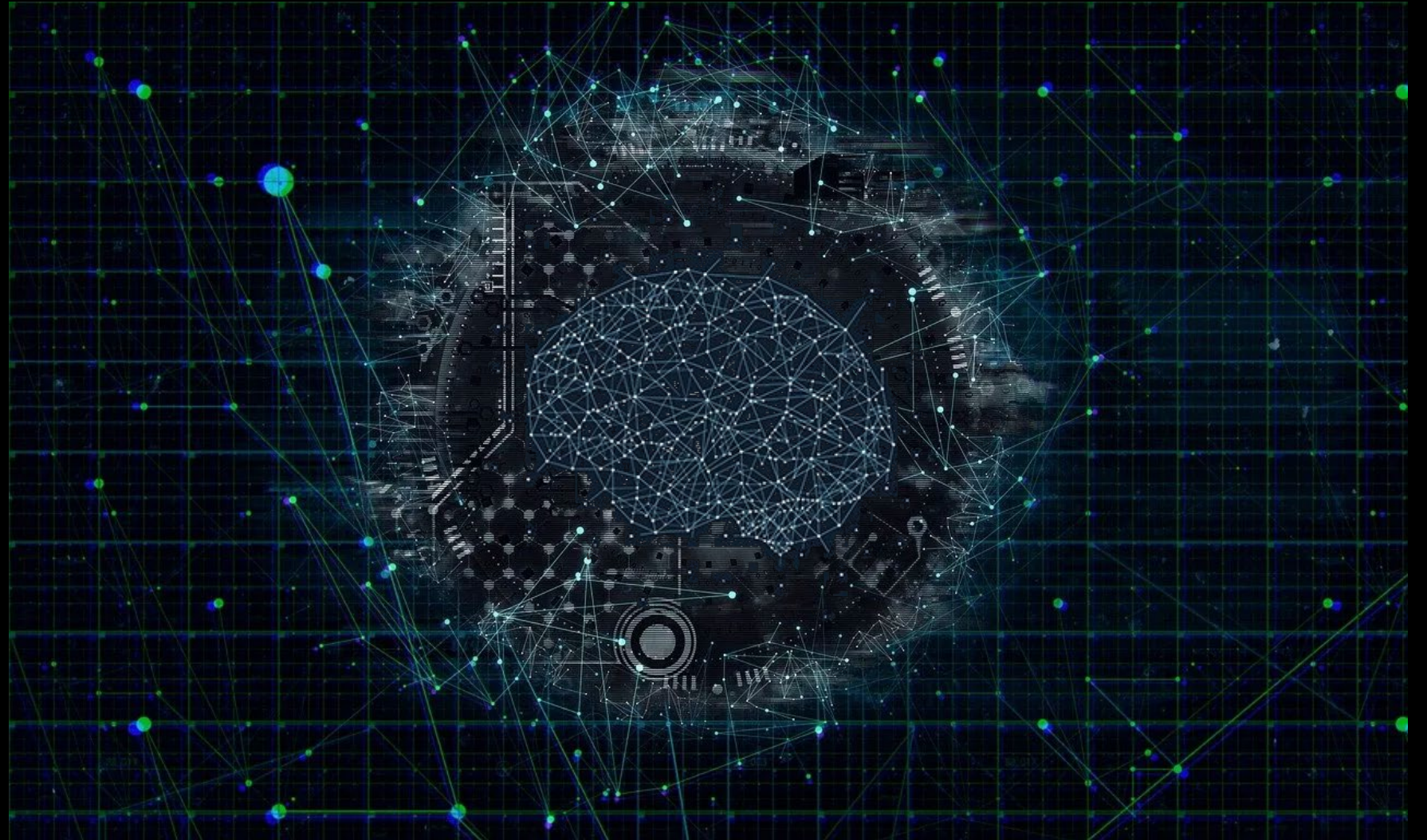
© 2024 Digital Science and Research Solutions Inc. All rights reserved. Non-commercial redistribution / external re-use of this work is permitted subject to appropriate acknowledgement. This work is sourced from Dimensions® at www.dimensions.ai.

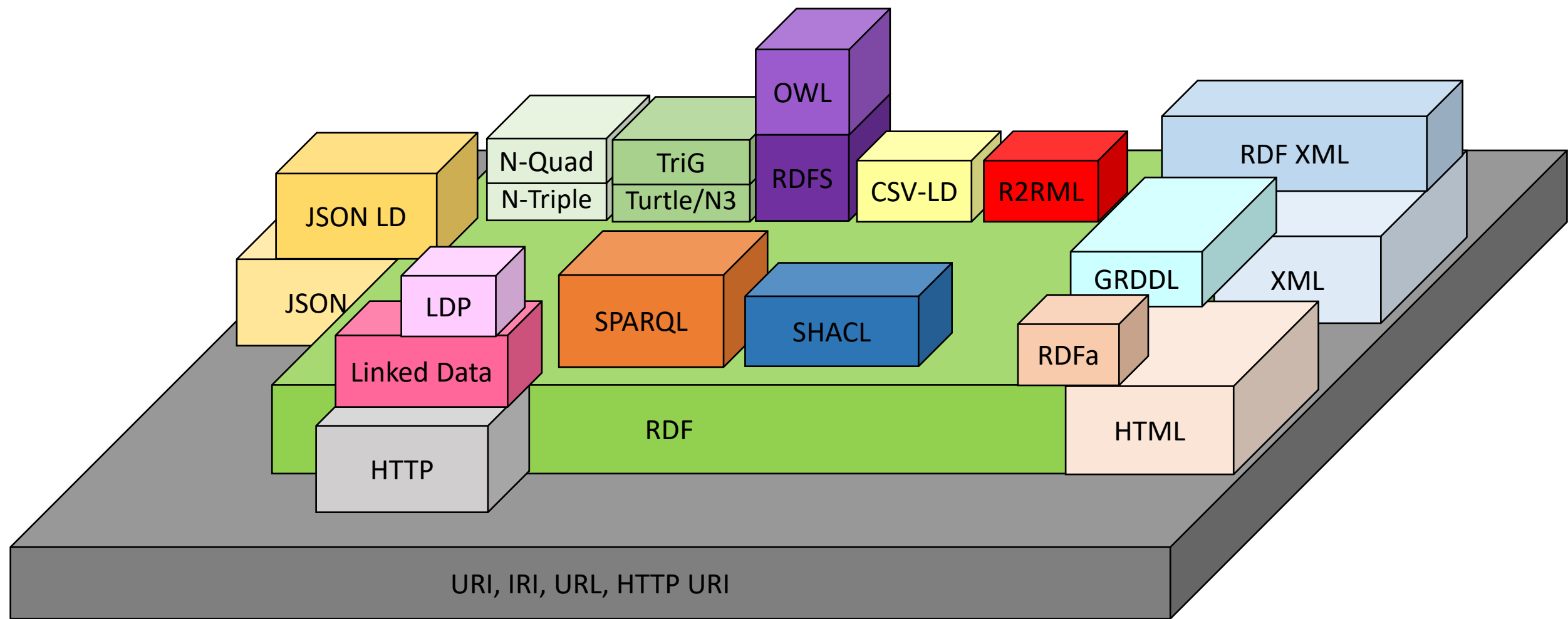
KGs' Research Questions

- Formal models and representation
- Efficient storage, indexing, access
- Validation, verification, quality
- Enrichment, augmentation, reasoning
- Extraction from heterogenous data
- Security, privacy, access control
- Traceability, provenance,
- Decentralization, distribution
- Analytics, mining, learning
- Interaction design, visualization
etc.



open standards for knowledge graphs





W3C[®] OPEN STANDARDS FOR PUBLIC & PRIVATE KGs

RDF

is a model for directed labeled multigraphs

<http://ns.inria.fr/fabien.gandon#me>

<http://inria.fr/schema#author>

<http://inria.fr/rr/doc.html>

<http://inria.fr/rr/doc.html>

<http://inria.fr/schema#topic>

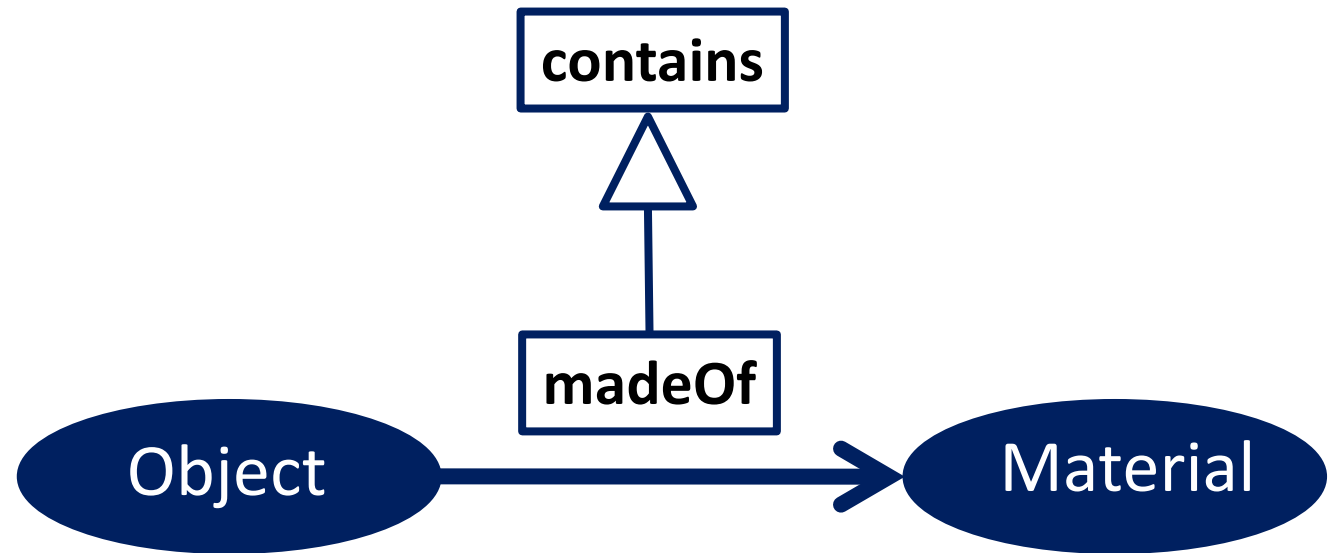
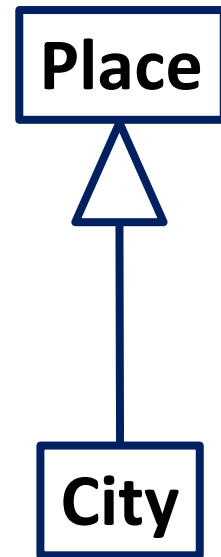
<http://inria.fr/schema#keyword>

"Music"



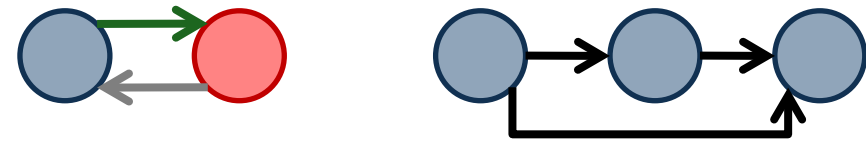
- Publications
- Life Sciences
- Cross-Domain
- Social Networking
- Geographic
- Government
- Media
- User Generated Content
- Linguistic

RDFS to declare classes of resources and properties, of your knowledge graph and organize their hierarchy



OWL in one...

 algebraic properties



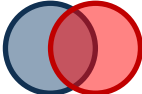
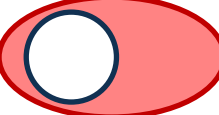
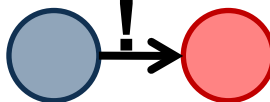
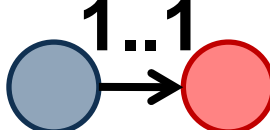


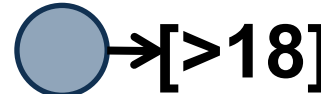

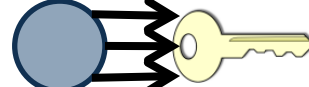


 disjoint properties

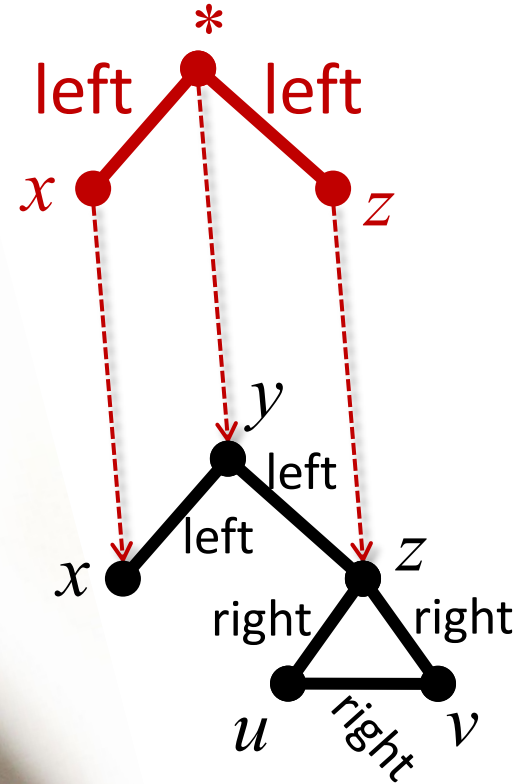
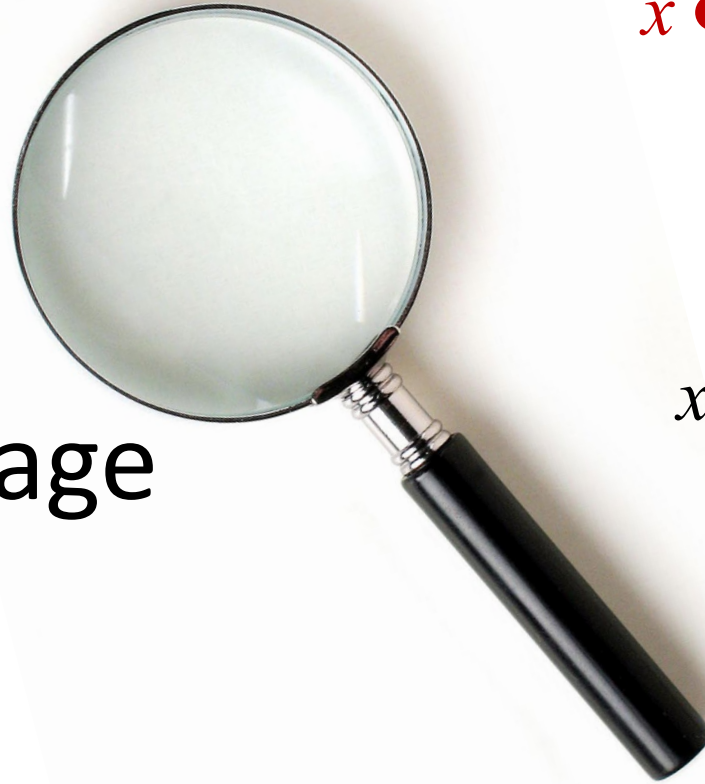
 qualified cardinality

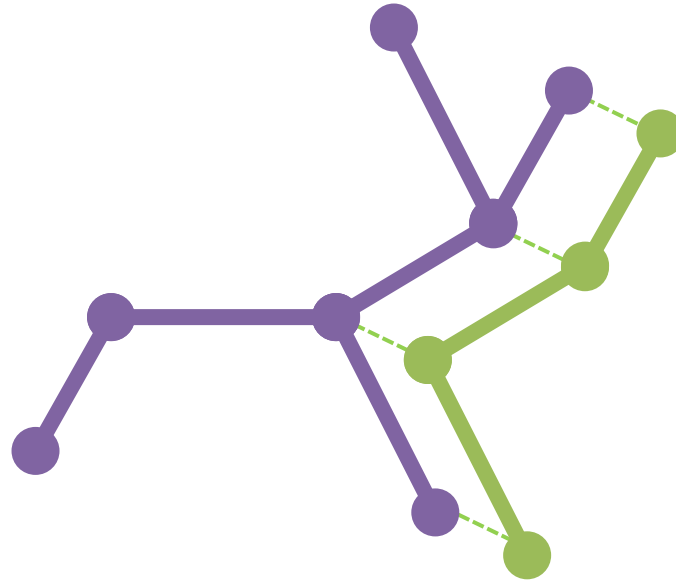
 individual prop. neg

 chained prop.

-  union
-  disjunction
-  intersection
-  complement
-  restriction
-  cardinality
-  equivalence
-  enumeration
-  value restriction
-  disjoint union
-  keys

SPARQL
Protocol
And
RDF
Query
Language





SHACL

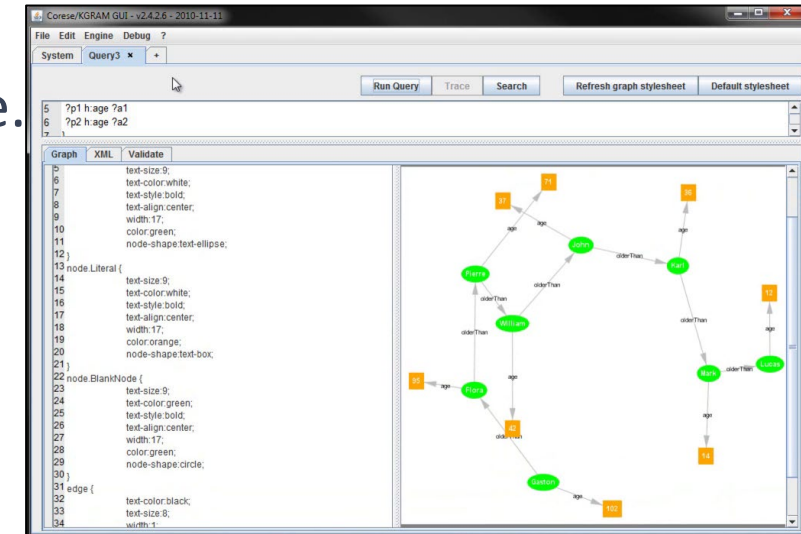
shape = **targets** + **constraints**

Targets: nodes in the graph that must be validated

Constraints : rules on how to validate a node

open source software implementing & extending W3C standards for data on the Web: to create, manipulate, parse, serialize, query, reason and validate RDF data and knowledge graphs

- **Corese-Library**: library to process RDF and use it in your software.
- **Corese-Server**: create, configure and manage endpoints.
- **Corese-GUI**: graphical interface for visual/manual use
- **Corese-Command**: command line version for scripts, etc.
- **Corese-Python**: Python API to CORESE library



Keywords : Knowledge Graphs, Artificial Intelligence, Querying, Reasoning, Web Open Standards, Semantic Web, Linked Data, Ontologies

Standards : RDF, SPARQL, SHACL, RDFS, OWL, etc.

Git: <https://github.com/Wimmics/corese/>



Knowledge Graphs @ :Probabl.

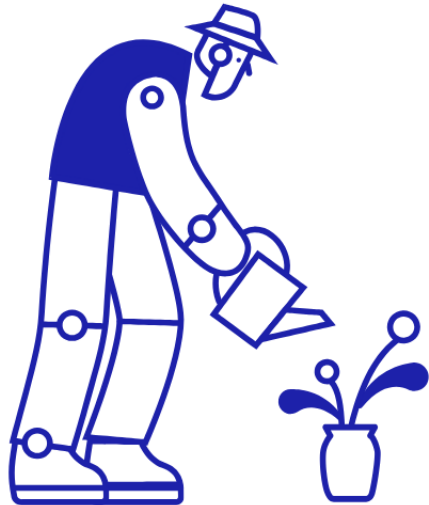
Open Source for
common good



Creating impact together



Develop, maintain, and sustain open source projects and communities in data science.



our-philosophy

We believe technology serves as a catalyst for societal progress, adopting various models, mostly open source, sometimes closed source, fully managed or on-premises solutions, each playing its role in a complex system.

Our approach and commitment is to provide a fully open source, reversible, and transparent contribution, catering to the needs of the data science and machine learning community.

corese

Software platform implementing and extending the standards of the Semantic Web. It allows to create, manipulate, parse, serialize, query, reason and validate RDF data.



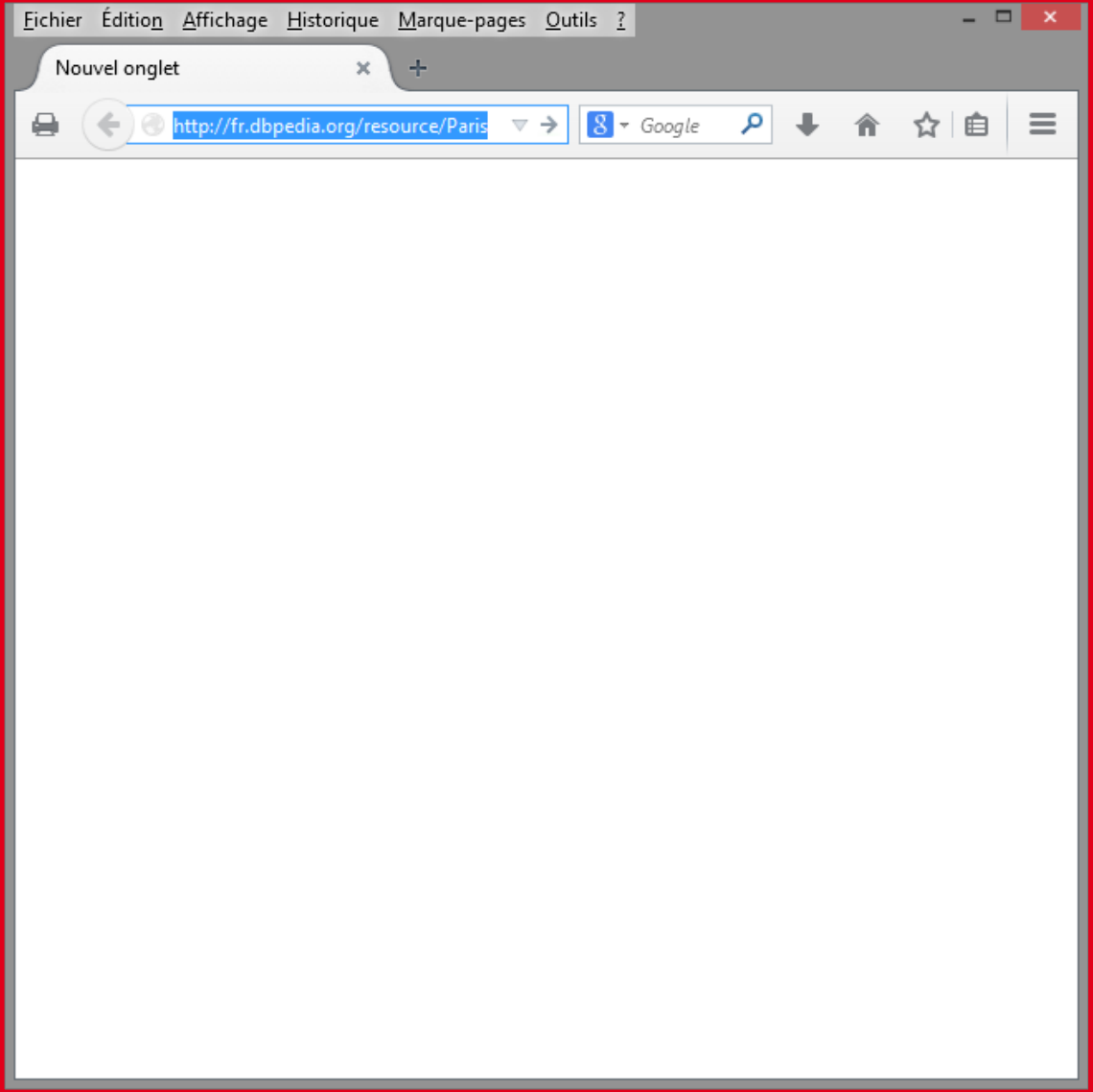
a Web approach to data publication

« <http://fr.dbpedia.org/resource/Paris> »

???



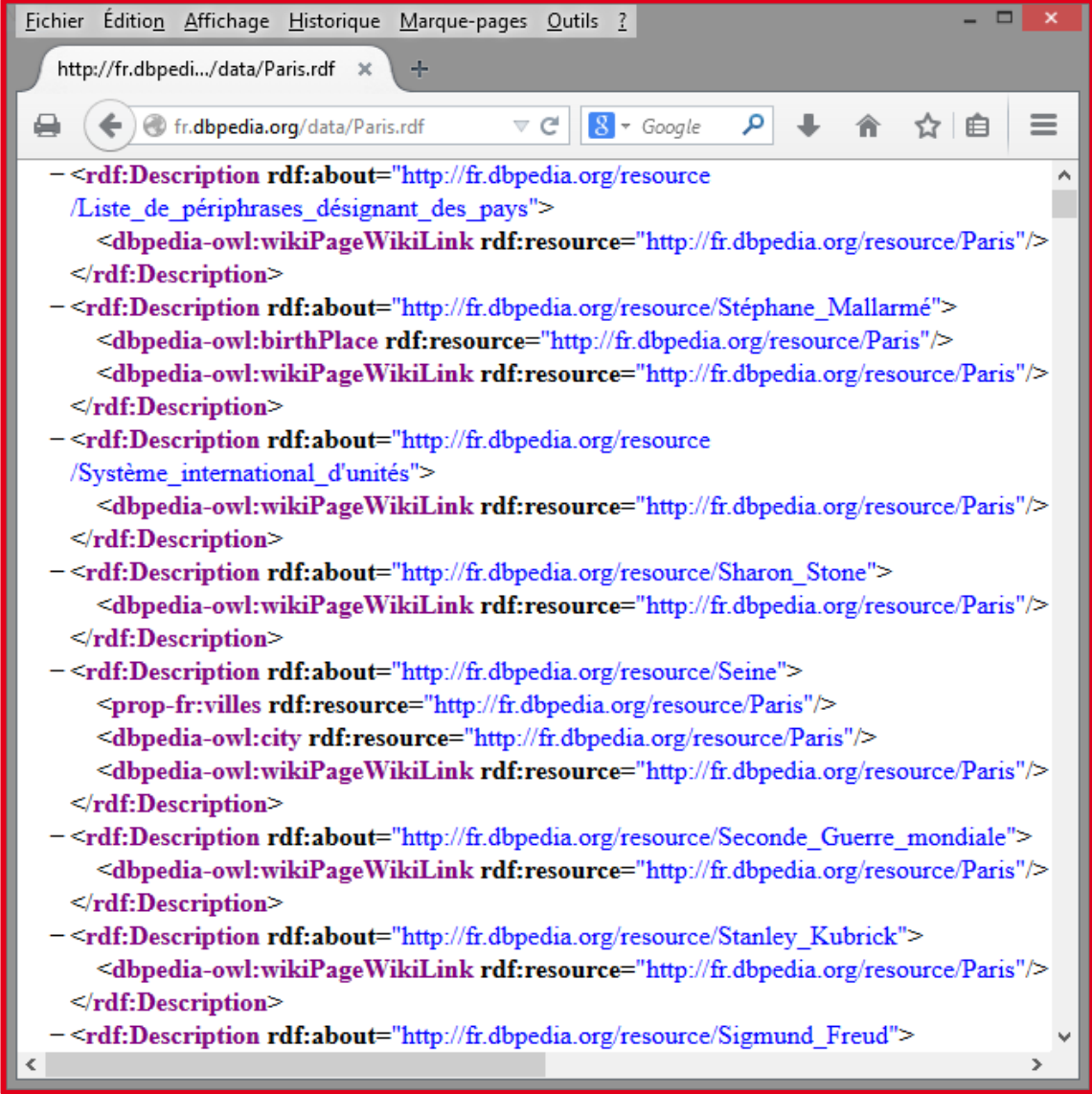
a Web approach to data publication



a Web approach to data publication



a Web approach to data publication

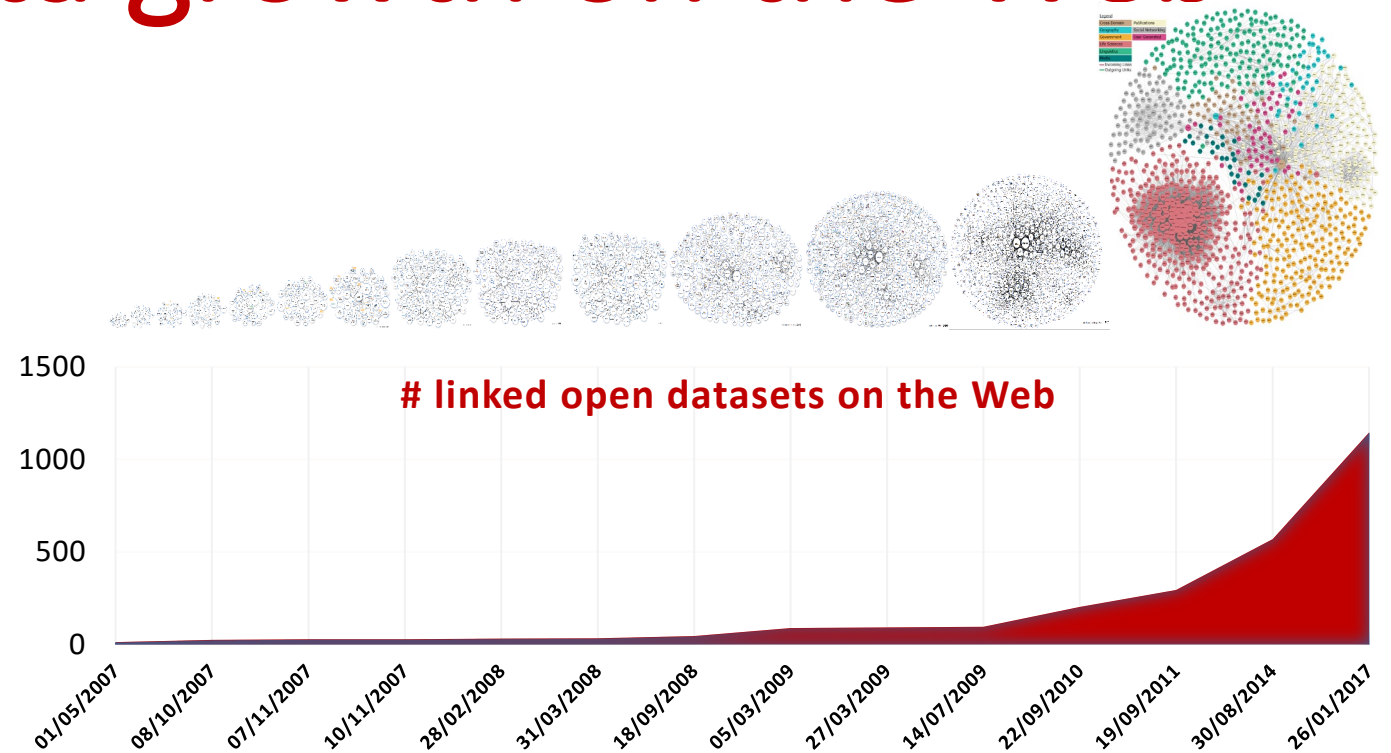
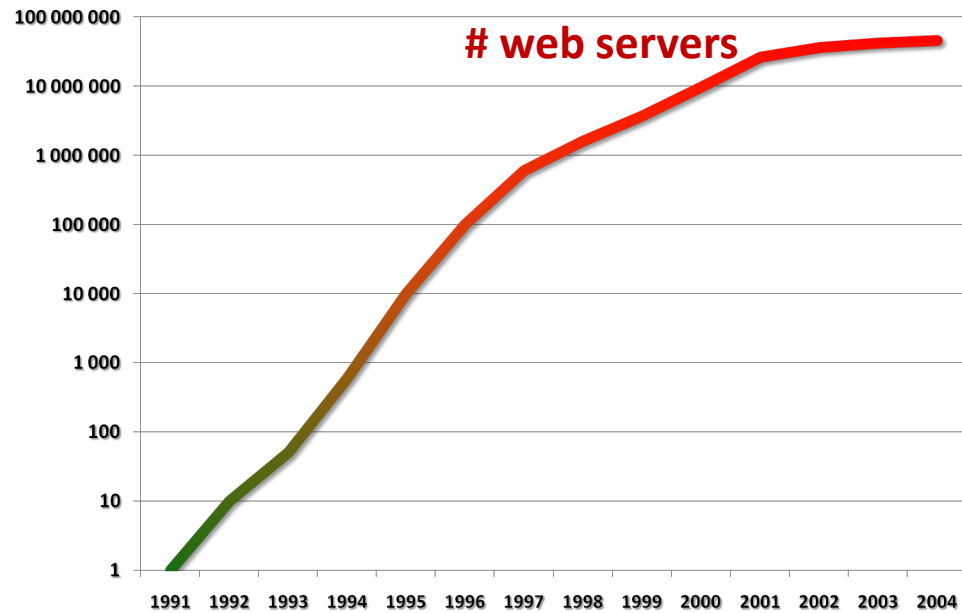


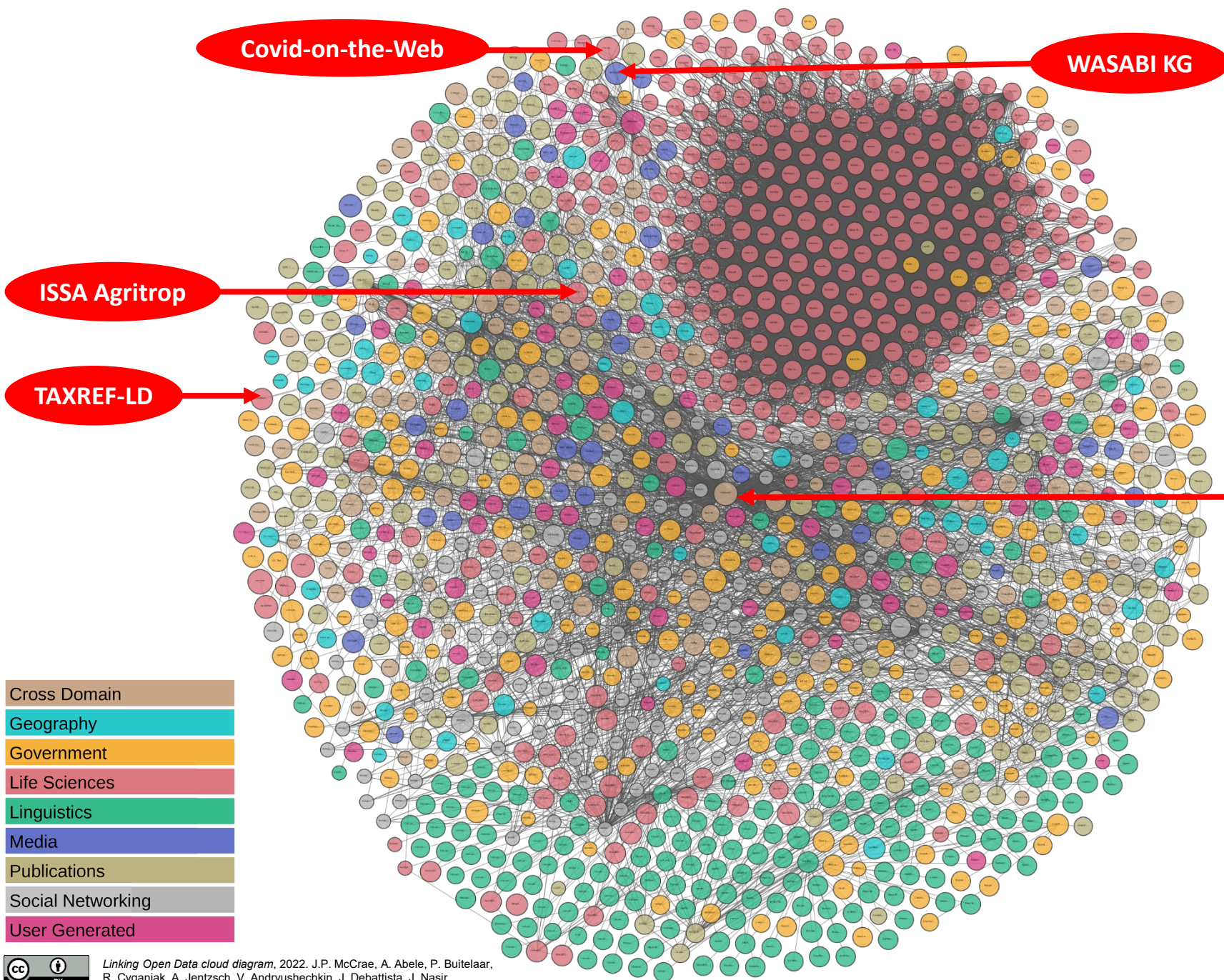
The screenshot shows a web browser window with the address bar containing `http://fr.dbpedia.org/data/Paris.rdf`. The main content area displays an RDF document with the following structure:

```
-<rdf:Description rdf:about="http://fr.dbpedia.org/resource/Liste_de_périphrases_désignant_des_pays">  
  <dbpedia-owl:wikiPageWikiLink rdf:resource="http://fr.dbpedia.org/resource/Paris"/>  
</rdf:Description>  
-<rdf:Description rdf:about="http://fr.dbpedia.org/resource/Stéphane_Mallarmé">  
  <dbpedia-owl:birthPlace rdf:resource="http://fr.dbpedia.org/resource/Paris"/>  
  <dbpedia-owl:wikiPageWikiLink rdf:resource="http://fr.dbpedia.org/resource/Paris"/>  
</rdf:Description>  
-<rdf:Description rdf:about="http://fr.dbpedia.org/resource/Système_international_d'unités">  
  <dbpedia-owl:wikiPageWikiLink rdf:resource="http://fr.dbpedia.org/resource/Paris"/>  
</rdf:Description>  
-<rdf:Description rdf:about="http://fr.dbpedia.org/resource/Sharon_Stone">  
  <dbpedia-owl:wikiPageWikiLink rdf:resource="http://fr.dbpedia.org/resource/Paris"/>  
</rdf:Description>  
-<rdf:Description rdf:about="http://fr.dbpedia.org/resource/Seine">  
  <prop-fr:villes rdf:resource="http://fr.dbpedia.org/resource/Paris"/>  
  <dbpedia-owl:city rdf:resource="http://fr.dbpedia.org/resource/Paris"/>  
  <dbpedia-owl:wikiPageWikiLink rdf:resource="http://fr.dbpedia.org/resource/Paris"/>  
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</rdf:Description>  
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  <dbpedia-owl:wikiPageWikiLink rdf:resource="http://fr.dbpedia.org/resource/Paris"/>  
</rdf:Description>  
-<rdf:Description rdf:about="http://fr.dbpedia.org/resource/Sigmund_Freud">
```



document and data growth on the Web





- Cross Domain
- Geography
- Government
- Life Sciences
- Linguistics
- Media
- Publications
- Social Networking
- User Generated



Linking Open Data cloud diagram, 2022. J.P. McCrae, A. Abele, P. Buitelaar, R. Cyganiak, A. Jentzsch, V. Andryushechkin, J. Debattista, J. Nasir. <http://lod-cloud.net/>

DBPEDIA.FR @ Inria
(extraction, end-point since 2012)

300 million of extracted triples; second chapter in size ; processed 1.8+ billion queries over the year ; 3.86 million daily average 32.5 million daily max.



[Ringwald, Cojan, Boyer et al.]



Daft Punk

Sommaire masquer

Article Discussion

Lire Modifier Modifier le code Voir l'historique Outils

Début

Biographie

- Débuts (1987-1997)
- Années *Homework* (1997-1999)
- Discovery et gain de notoriété (1999-2003)
- Human After All* (2004-2007)
- Tron : L'Héritage* (2008-2010)
- Random Access Memories* (2013-2014)
- Autres projets et séparation (2015-2021)
- Sorties post-séparation (depuis 2022)

Concerts

- Tournée en 2006-2007
- Apparitions sur scène après 2007

Honneur

Membres

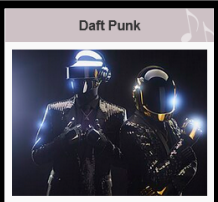
Discographie

Filmographie

Notes et références

Voir aussi

- Bibliographie
- Articles connexes
- Liens externes
- Bases de données et dictionnaires



Informations générales	
Pays d'origine	 France
Genre musical	House , musique électronique ?, dance ?, disco ?
Instruments	Roland TB-303, Roland TR-909, Roland SVC 350, EMS 2000, Roland VP-330, Roland Juno 106, Moog Minimoog Voyager, BOSS Metal Zone MT-2, Roland TR-808
Années actives	1993-2021
Labels	Daft Life Ltd., Virgin, EMI (1996-2013), Columbia, Sony Music (2013-2021), Warner Music Group (2022), daftpunk.com ?
Composition du groupe	
Anciens membres	Thomas Bangalter Guy-Manuel de Homem-Christo

Biographie

Débuts (1987-1997)

La rencontre de **Thomas Bangalter** et **Guy-Manuel de Homem-Christo** a lieu en 1986 à la section collégiale du lycée Carnot dans le 17^e arrondissement de Paris⁴. En 1992, les deux hommes fondent avec **Laurent Brancowitz**, futur guitariste du groupe **Phoenix**, un groupe de rock nommé **Darlin'**, en hommage à la chanson des **Beach Boys**.

Ils enregistrent leur premier **single** homonyme, *Darlin'* sur le label discographique indépendant anglais Duophonic. Ce 45 tours contient deux titres : *Darlin'* et *Cindy so Loud*. Le succès n'est pas au rendez-vous, le titre se vend à un millier d'exemplaires, et le groupe n'a quasiment aucune incidence sur la scène française. En mai 1993, une critique du magazine britannique *Melody Maker* qualifie la musique du groupe de « *daft punky thrash* »^{5,6}, ce qui donnera à Thomas et Guy-Manuel l'idée de nommer leur futur duo « Daft Punk », littéralement « punk idiot »⁷.

En 1993, Thomas Bangalter et Guy-Manuel de Homem-Christo fondent à Paris le duo Daft Punk⁸. Lors d'une *rave party* sur le toit du **Centre Beaubourg**, Daft Punk rencontre les responsables du label écossais Soma⁹. En parallèle, Thomas Bangalter et Guy-Manuel de Homem-Christo commencent à travailler sur du matériel électronique tel que l'échantillonneur. Le duo sort un an plus tard, sous le nom Daft Punk, le maxi trois titres *The New Wave*. À défaut de succès retentissant, la « techno adolescente française » de Daft Punk retient l'attention de quelques journalistes et critiques anglais. L'année 1995 est celle de leur premier succès, le groupe sort le maxi electro-rock *Da Funk / Rollin' and Scratchin'*. Le titre rencontre le succès et se répand petit à petit dans les clubs d'Europe¹⁰. Toujours en 1995, Thomas Bangalter crée son label, *Roulé*, sur lequel il sort le titre *Trax On Da Rocks*. Daft Punk fait alors la première partie des **Chemical Brothers** à Londres. En France, le groupe participe à la 17^e édition des **Trans Musicales** de Rennes¹¹, l'une de ses très rares apparitions à visages découverts¹², et est repéré par la maison de disques **Virgin**, c'est ainsi qu'il fait une apparition sur la compilation *Souciérolé* vol.2 du label **Soucié** (qui fait partie de Virgin) avec le titre *Musical*, en 1996. Source est dès lors le premier label à diffuser Daft Punk en France.

Années *Homework* (1997-1999)

Le 7 janvier 1997, à la suite de la sortie du single *Da Funk*, Daft Punk sort son premier album *Homework*, caractérisé par la **house** et les rythmes **techno** inspirés de la scène de **Chicago**. Celui-ci rencontre le succès : deux millions d'exemplaires se vendent dans trente-cinq pays différents en l'espace de deux mois¹³. La presse généraliste et spécialisée fait fêlage de l'album, qui conquiert la jeunesse internationale. Le titre *Around the World* entre dans les charts européens et nord-américains. La réalisation du clip, dans lequel on voit plusieurs groupes de personnages danser au rythme des différents instruments, est signée par le réalisateur **Michel Gondry**, et la chorégraphie par **Bianca Li**¹⁴.

Le groupe acquiert dès lors une notoriété internationale, et entame sa première tournée mondiale de quarante dates d'**octobre** à décembre 1997. Le spectacle y est aléatoire, le concert durant parfois jusqu'à cinq heures. L'album de **musique électronique** *Homework* emblématique de la **French touch** démocratisa la « house filtrée », et ses conditions de mixage parfois aléatoires influèrent sur ce que les critiques appelleront le « son Daft Punk ». Le succès de cet album constitue un tremplin qui permit à d'autres groupes de la scène électronique française et mondiale de se révéler. C'est aussi en 1997 que Guy-Manuel de Homem-Christo lance son propre label **Clydeamanu**¹⁵.

Discovery et gain de notoriété (1999-2003)

En 2001, Daft Punk sort son premier album live intitulé *Alive 1997* enregistré à Birmingham en Angleterre¹⁶, contenant une piste longue de 15 min sans pause, on y retrouve quelques tubes comme *Da Funk*, *Daftendirekt*, *Rollin' and Scratchin'* et *Alive*

Apparence masquer

Taille de texte

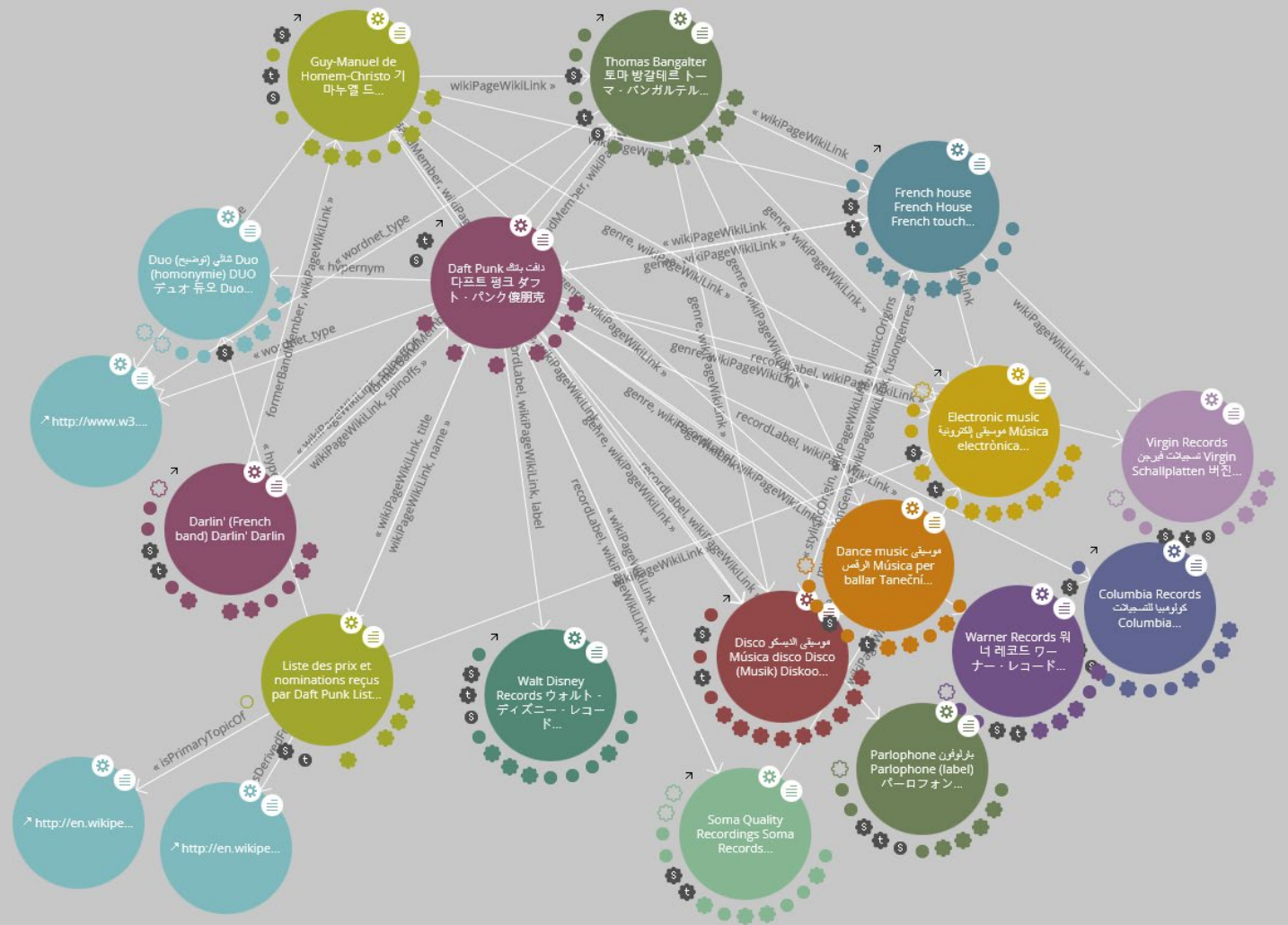
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- Standard
- Grande

Largeur

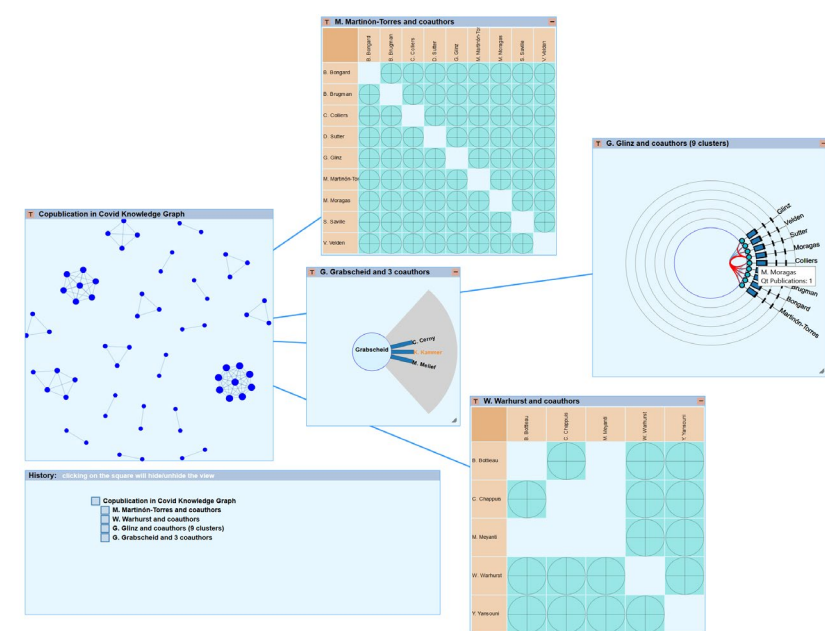
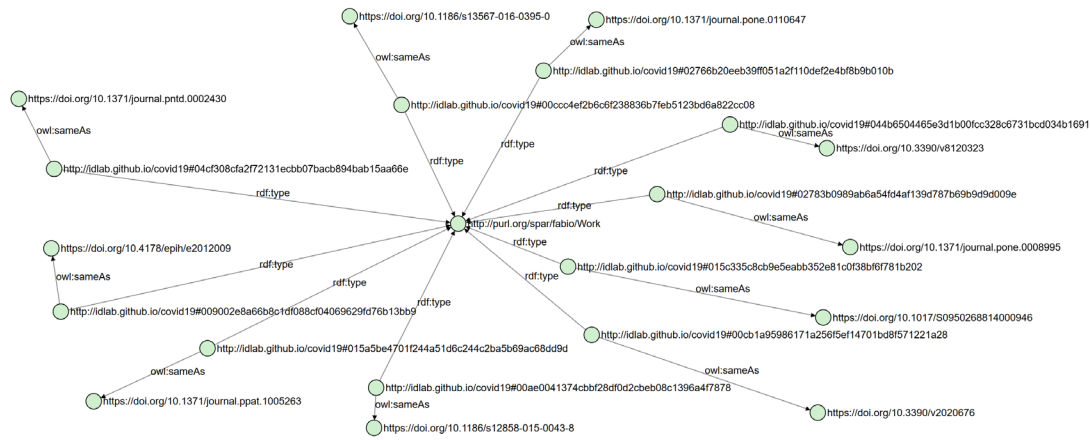
- Standard
- Large

Couleur (bêta)

- Automatique
- Clair
- Sombre



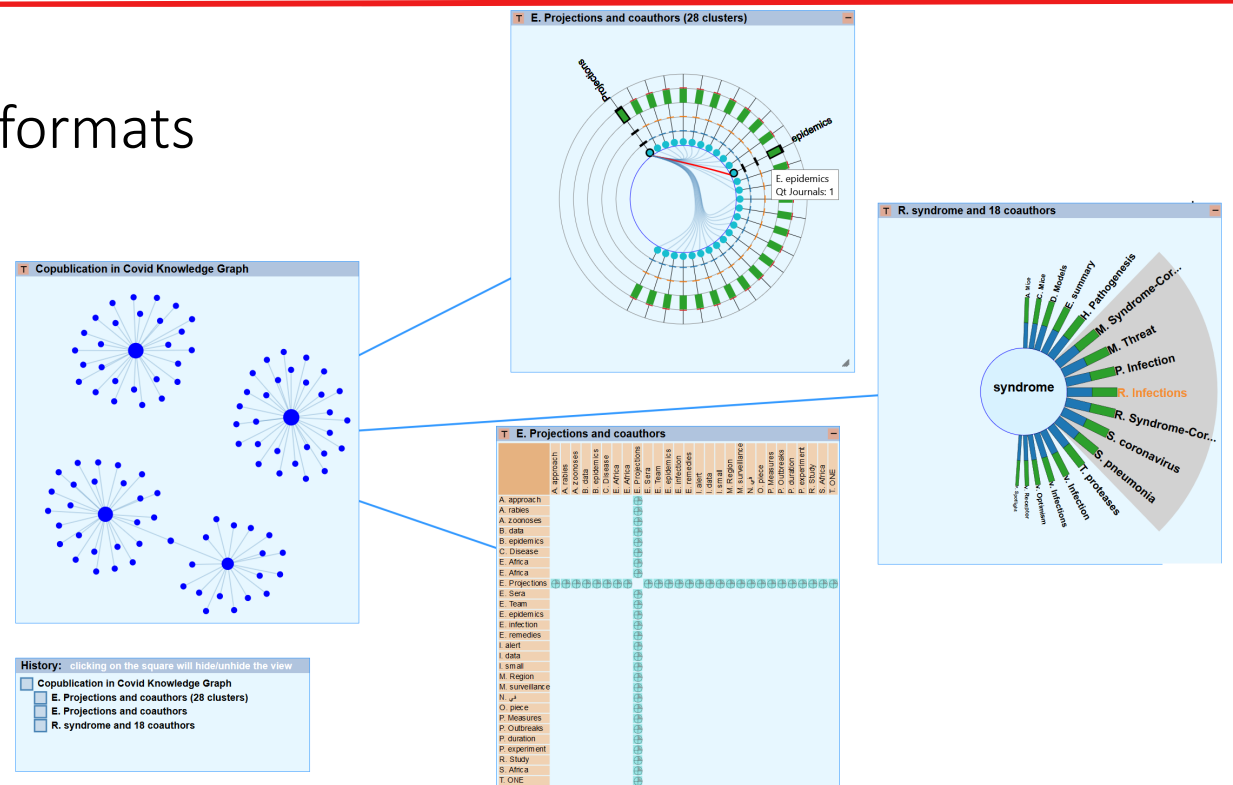
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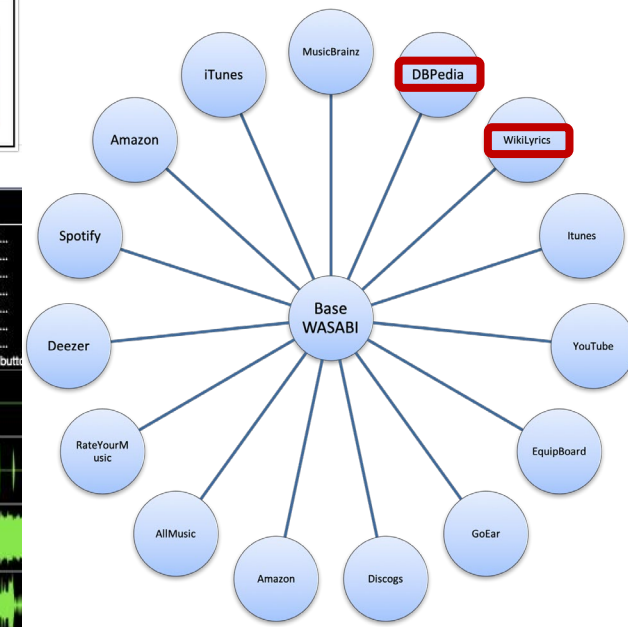
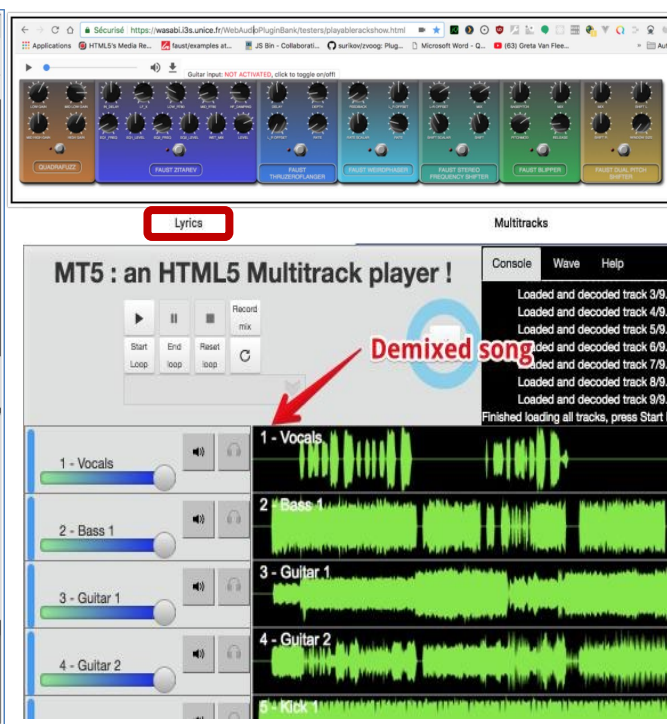
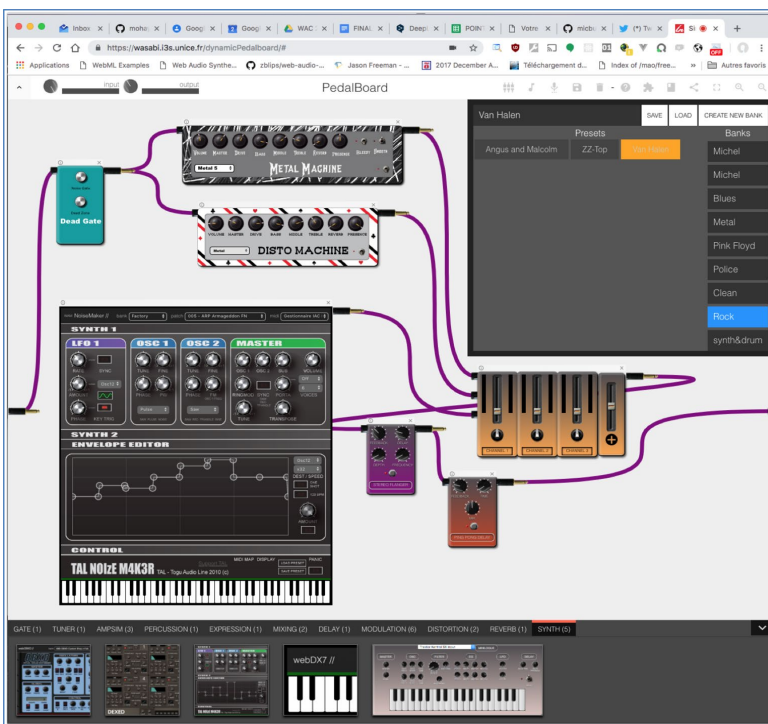


COVID ON THE WEB

[Corby, Michel, Gazzotti, Winckler, et al. 2019]

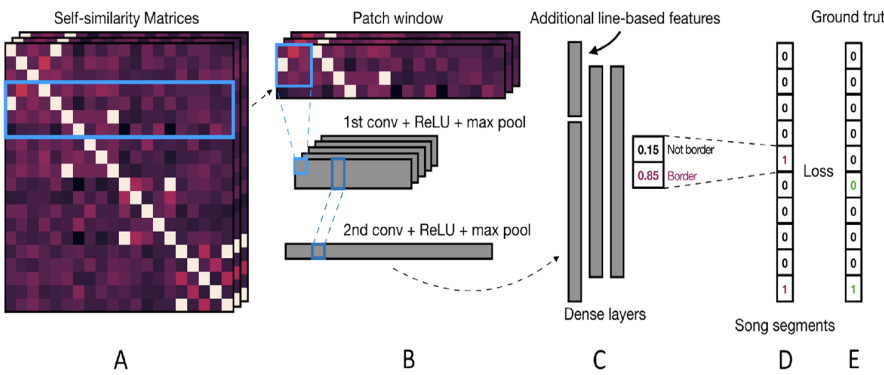
- integrate **multiple datasets** in heterogeneous formats
- perform **information extraction** to enrich
- perform **inferences and validation** to improve
- provide a **public end-point** for reuse
- provide **querying and visualization** services





WASABI

Web-augmented music interactions



V_1 you took me by surprise
 just like a rainbow in the night
 when i looked in your eyes
 i could see diamonds shining bright
 V_2 i never realized
 youd be the one to make it right
 you got me hypnotized
 before my life was black and white
 B_1 you and me make a team
 i want you near me every day
 last night i had a dream
 you went away
 C_1 dont break my heart
 dont let me down
 dont break my heart
 dont make me frown
 V_3 were getting serious
 life by your side can be so nice
 youre so mysterious
 yesterday you were cold as ice
 B_2 i wnder how you feel
 if all your feelings are the same
 when are your smiles for real
 or is it a game
 C_2 dont break my heart
 dont let me down
 dont break my heart
 dont make me frown
 C_3 dont break my heart
 dont let me down
 dont break my heart
 dont make me frown
 C_4 dont break my heart
 dont let me down
 dont break my heart
 dont make me frown
 O dont break my heart
 dont let me down

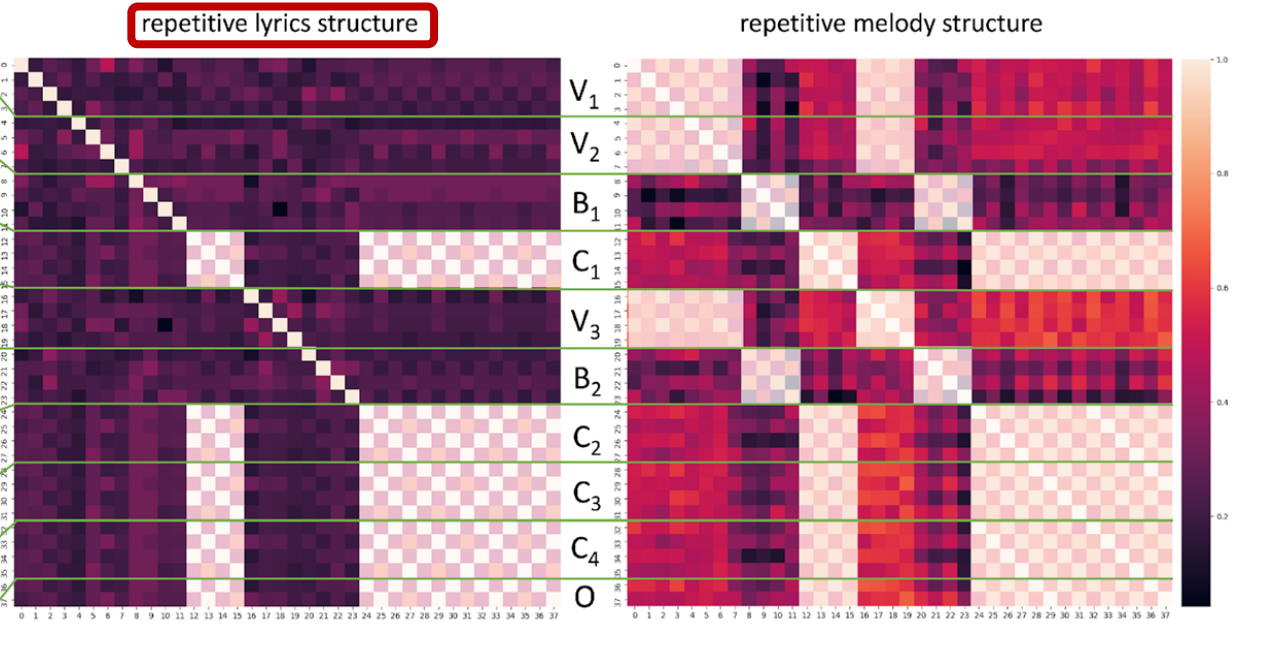
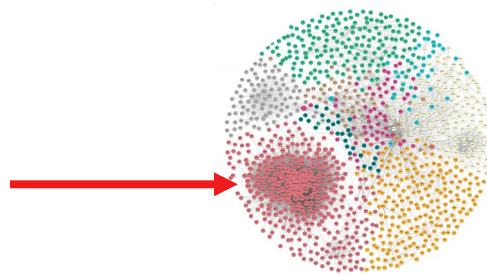


Figure 2: Convolutional Neural Network-based model inferring lyrics segmentation (Fell et al. 2018).



DeKO



ALOOF: RDF dataset about objects

- common sense knowledge about objects: classification, prototypical locations and actions
- knowledge extracted from natural language parsing, crowdsourcing, distributional semantics, keyword linking, ...

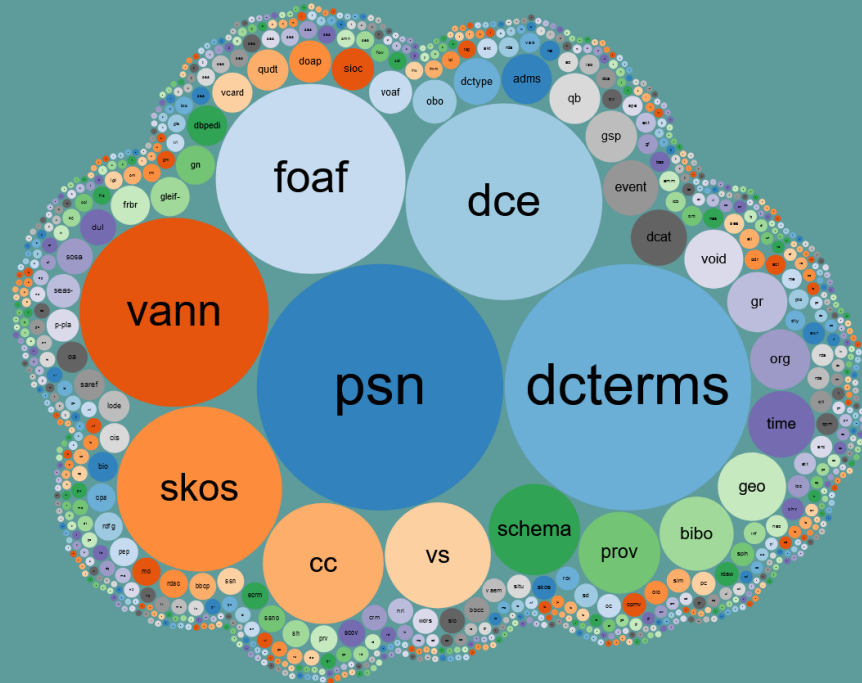
[Cabrio, Basile et al.]



Linked Open Vocabularies (LOV)

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864 Vocabularies in LOV



Category Tags

- Methods
- Metadata
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- RDF
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- Quality
- General & Upper
- Vocabularies
- Geometry
- Events
- Multimedia
- Biology
- Time
- Government
- W3C Rec
- Academy
- Tag
- FRBR
- eBusiness
- Contracts
- Travel
- Health

Latest insertion

- gtm** - Gouda Time Machine Ontology
2024-12-10
- intro** - INTRO: the intertextual, interpictureal, and intermedial relations ontology
2024-11-17
- psn** - Product Supply Network Vocabulary
2024-10-02
- vair** - Vocabulary of AI Risks
2024-09-17
- foo** - Forest Observatory Ontology (FOO)
2024-07-18

Latest Updates

- gtm** - Gouda Time Machine Ontology
2024-12-10
- intro** - INTRO: the intertextual, interpictureal, and intermedial relations ontology
2024-11-18
- IIoT** - Ontology for Industrial Internet of Things systems
2024-10-23
- psn** - Product Supply Network Vocabulary
2024-10-02
- m4i** - Metadata4ing: An ontology for describing the generation of research data within a scientific activity.
2024-10-02

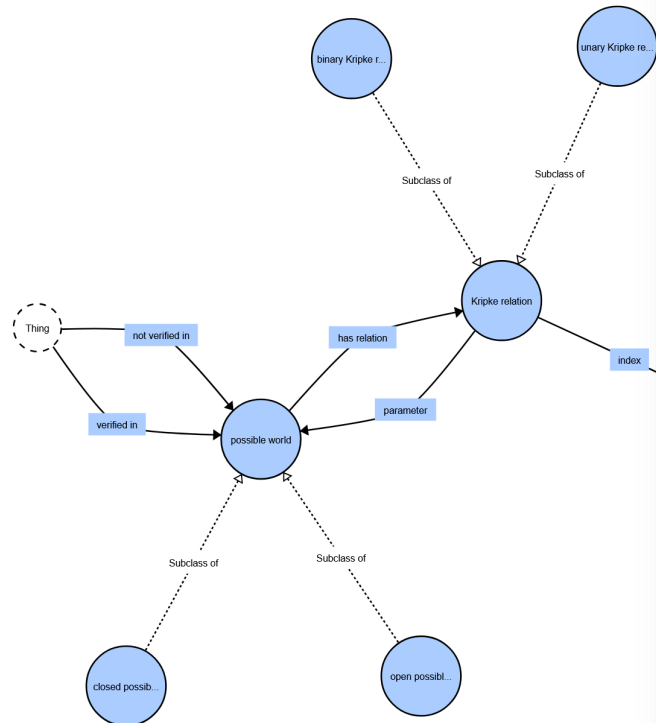
LOV, LOV, LOV... all you need is LOV

PWKSO - Possible Worlds and Kripke Structures Ontology

IRI: <http://ns.inria.fr/pwks/>
Formats: [Turtle/N3](#), [XML](#), [N-Triples](#), [JSON](#)

Table of Contents

- 1. [Classes](#)
- 2. [Object properties](#)
- 3. [Namespaces](#)



Normative Requirements Vocabulary

Powered by

IRI: <http://ns.inria.fr/nrv/>
Authors: Fabien Gandon (<http://ns.inria.fr/fabien.gandon/foaf.html#me>)
Contributors: Fabien Gandon, Guido Governatori
Publisher: Inria
Other visualisation: [Turtle/N3](#), [RDF/XML](#), [Onto-Doc](#)

Abstract

An OWL vocabulary for describing normative requirements.

Table of Content

- 1. [Classes](#)
- 2. [Object Properties](#)
- 3. [Named Individuals](#)
- 4. [Namespace Declarations](#)

Classes

[achievement](#) [atomic formula](#) [co-occurrent punctual requirement](#) [compensable requirement](#) [compensated requirement](#) [compensation](#) [compliance](#) [compliant requirement](#) [deontic modality](#) [deontic specification](#) [logical formula](#) [maintenan](#) [modality](#) [non co-occurrent punctual requirement](#) [non compensable requirement](#) [non perdurant requirement](#) [non preemptive achievement requirement](#) [non violable requirement](#) [Normative Requirement](#) [obligation](#) [penalty statement](#) [perdurant achievement requirement](#) [permission](#) [persistent requirement](#) [preemptive achievement requirement](#) [prescriptive statement](#) [prohibition](#) [punctual](#) [reparation](#) [right](#) [suborder list](#) [term](#) [violable requirement](#) [violated requirement](#) [violation](#)

achievement^c

IRI: <http://ns.inria.fr/nrv/#Achievement>
an obligation for which achieving the content at least once is enough to fulfil it.

has super-classes

[obligation^c](#)

has sub-classes

[non perdurant requirement^c](#), [non preemptive achievement requirement^c](#), [perdurant achievement requirement^c](#), [preemptive achievement requirement^c](#)

atomic formula^c

IRI: <http://docs.oasis-open.org/legalruleml/ns/v1.0/rule-metamodel/#AtomicFormula>

mUnc Vocabulary Specification

Namespace Document, 01 february 2019

This version: <http://ns.inria.fr/munc/v2/> (owl, ttl)
Latest version: <http://ns.inria.fr/munc/> (owl, ttl)

Status: **Work in progress**

Author: [OJEBRI Ahmed El Amine](#), University Côte d'Azur, CNRS, INRIA, I3S, France
Advisors: [Andrea G. B. Tettamanzi](#), University Côte d'Azur, CNRS, INRIA, I3S, France
[Fabien Gandon](#), INRIA, University Côte d'Azur, CNRS, I3S, France

IRI: <http://ns.inria.fr/munc/>

mUnc uses W3C's open and freely available Web standards: [RDF](#), [OWL](#). It also bases on [LDScript](#) language implemented in [Coress](#) to present uncertainty calculus.

Abstract

mUnc (Metadata with *UNCertainty*) is an OWL ontology for describing *UNCertainty* information. It aims to offer a standard representation for uncertainty theories and values with respect to the current Semantic Web standards. It also offers the possibility to represent and exchange calculation involved in the evaluation of uncertainty.

Table of Content

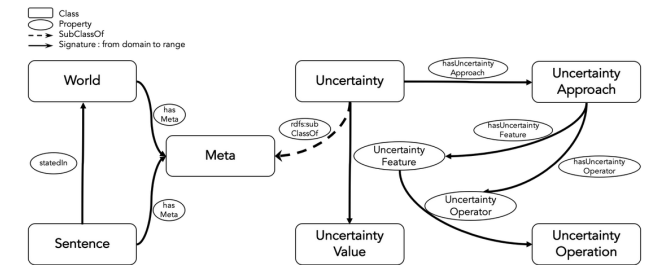
- 1. [An ontology for Uncertainty Representation: *mUnc*](#)
- 2. [Examples](#)
- 3. [Classes](#)
- 4. [Object Properties](#)
- 5. [Namespace Declarations](#)

An ontology for uncertainty representation: *mUnc*

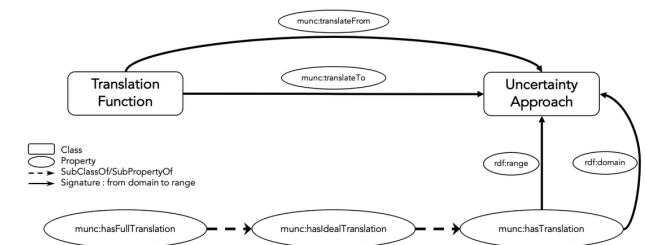
The open nature of the Web allow the existence of fuzzy, vague, or uncertain information for which exists no standard on the Semantic Web. The aim from *mUnc* is to offer a formal, publishable and reusable representation of uncertainty over the web of linked data, and allow the integration of many theories [1-4] about "uncertainty reasoning". Moreover, this vocabulary offer a way to link between the theories and their calculus.

The current version enables uncertainty representation at different levels of granularity. Uncertainty can be linked to a sentence or to a world (context).

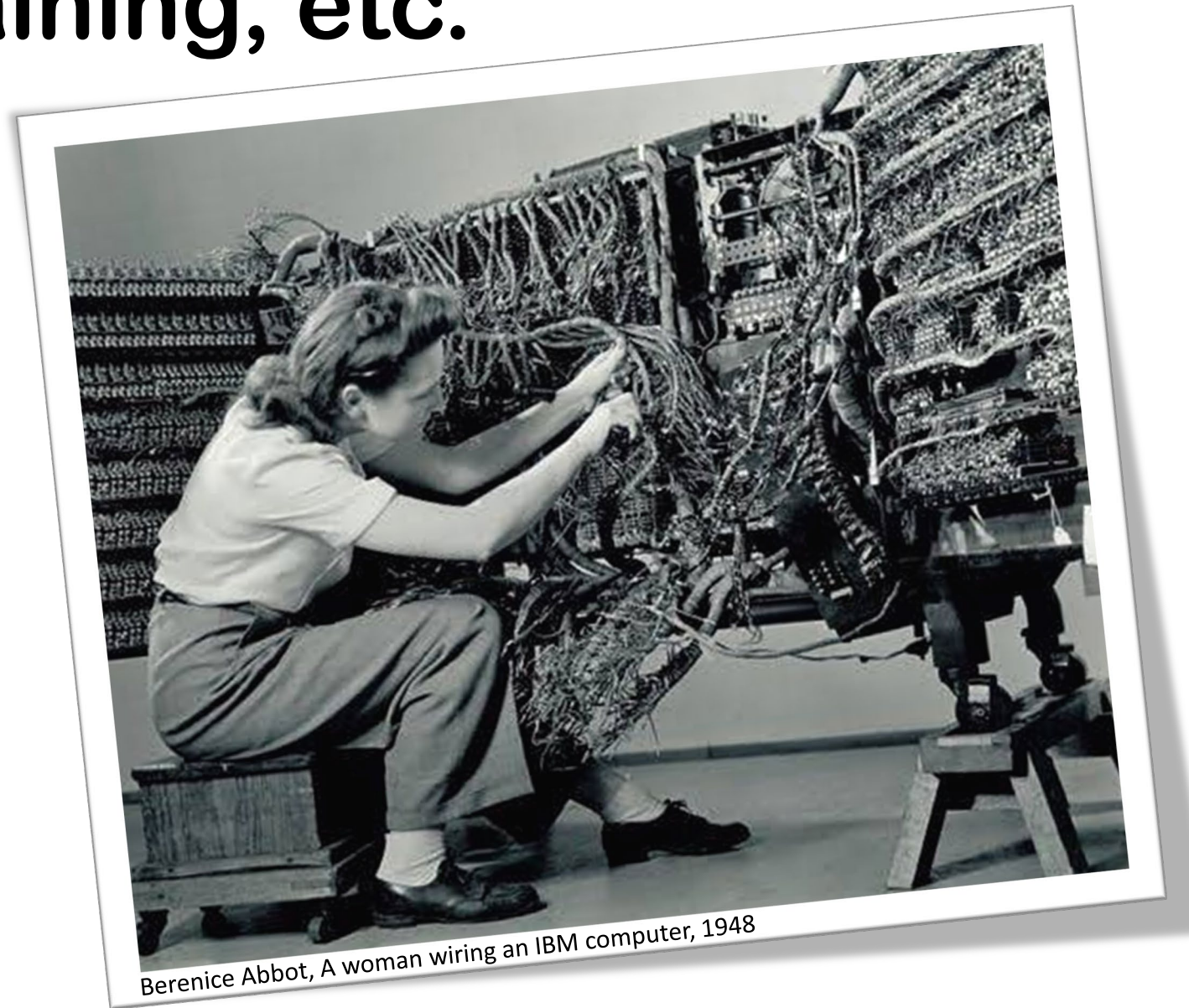
The figure below shows the core classes and properties of *mUnc*:



In the version 2 of *mUnc*, an extension allowing the representation of translatability of uncertainty theories, as shown in the figure below:



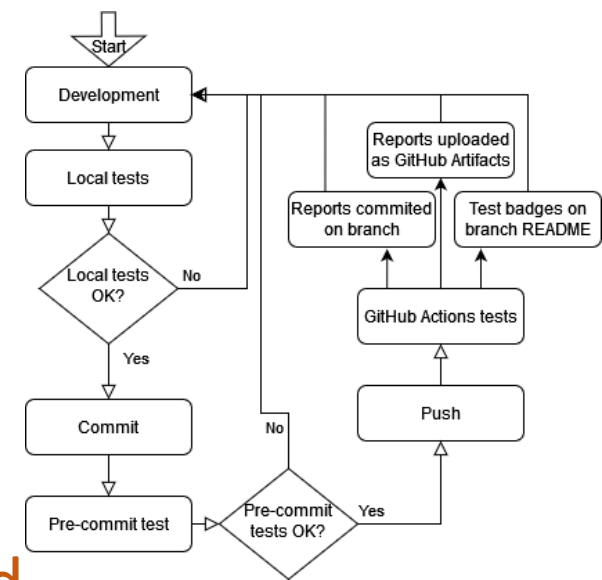
**complex networks: KG designing,
debugging, maintaining, etc.**



Berenice Abbot, A woman wiring an IBM computer, 1948

OLIVAW [Nicolas Robert et al.]

- Github repositories for ontologies, schemata, vocabularies...
- command line tool & github workflow for agile collaborative ontology development.
- composite actions that can directly be called in workflows
- pre-commit hook to prevent the biggest mistakes to be pushed
- SHACL & EARL & markdown for reporting



Statistic summary

Here is a short overview for this test report

214 Outcomes

❌ 3 MajorFail, 🟡 46 MinorFail, ⚠️ 0 CannotTell, 🕒 30 NotTested, ✅ 135 Pass



The different status types are an extension of the [EARL](#) vocabulary where the nextended terms can be found in the [olivaw-earl dataset](#), each outcome type means:

- ❌ MajorFail: This is an error that is critical and consider as blocking for production
- 🟡 MinorFail: This is an error that should be fixed, but it is cannot be considered as critical error
- ⚠️ CannotTell: It is unclear if the subject passed or failed the test. This happens when an automated test requires human judgement to make a definite decision.
- 🕒 NotTested: The test has not been carried out. Here this is because a previous test that was mandatory to be passed did not end up as Pass.
- ✅ Pass: The subject passed the test.

<https://github.com/Wimmics/olivaw>

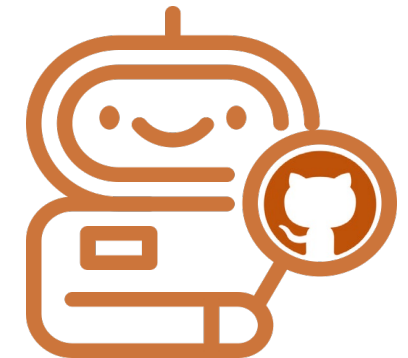
<https://github.com/Wimmics/Olivaw-Template>

Outcome Detail

Jump	Type	MajorFail
Section top	Identifier	syntax-error
Section top	Title	Test subject has syntax errors
Section top	Description	The subject has turtle syntax errors that makes it unprocessable by an engine
Section top	Pointer	Undefined prefix: dcterms:source
Section top	Pointer	Undefined prefix: doco:Glossary

Outcome Detail

Jump	Type	MinorFail
Section top	Identifier	no-reference-module
Section top	Title	Term not referenced to a module
Section top	Description	Subject terms not linked to a module by a rdfs:isDefinedBy property
Section top	Pointer	<pre>:perceiveResourceFormSpecification a shacl:NodeShape ; shacl:class hctl:Form ; shacl:property [shacl:hasValue "" ; shacl:maxCount 1 ; shacl:minCount 1 ; shacl:path hctl:hasTarget], <https://purl.org/hmas/interaction-http/GetMethod>, <https://purl.org/hmas/interaction-http/ReadAction>, <https://purl.org/hmas/interaction-http/forTextTurtle .</pre>



Cataloguing & Indexing data ... and the world



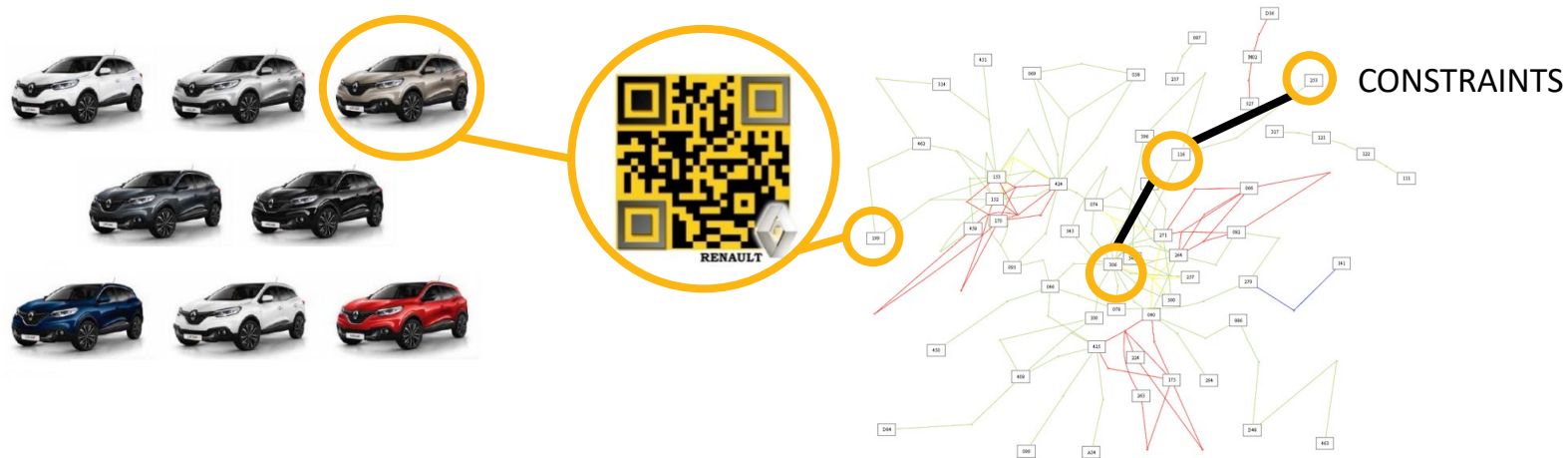


Car configurations as linked data

10^{25} car configurations but only 10^{20} coherent (1/100 000)

from [François-Paul Servant *et al.* ESWC 2012]

1 (partial) Configuration = 1 URI



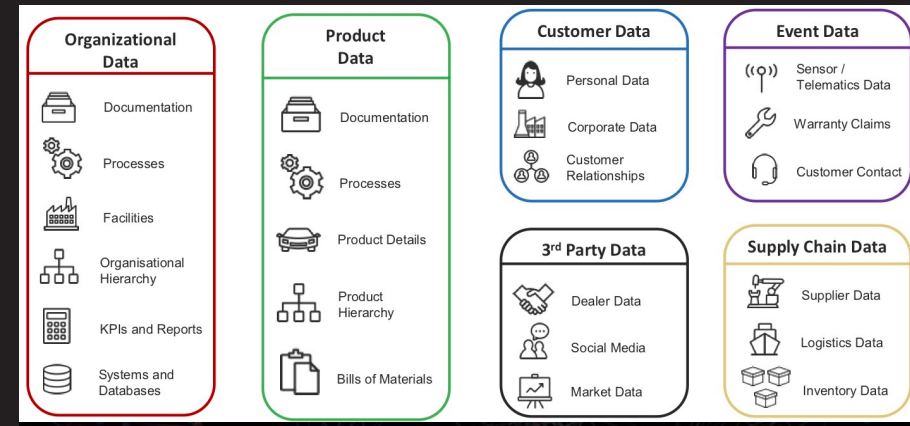
publish data and computations

Knowledge Graphs @

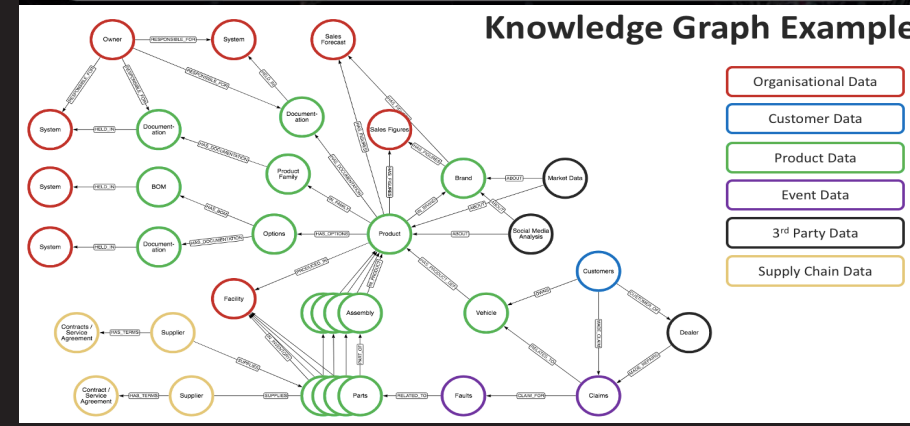
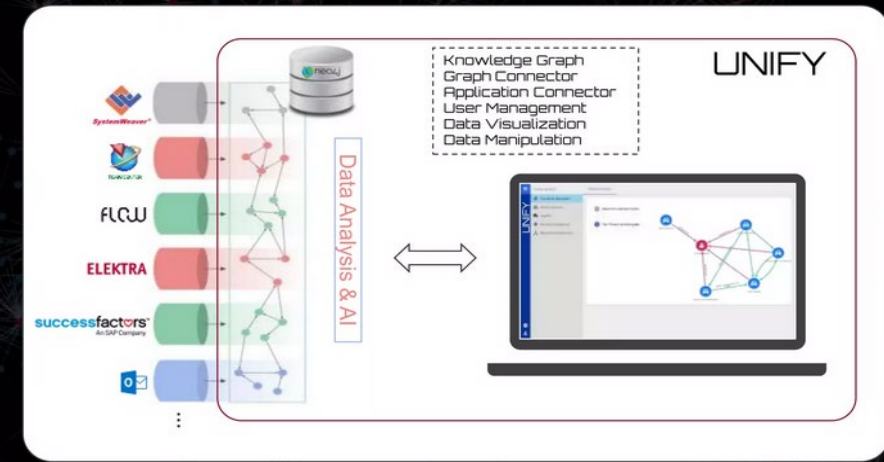
- Vehicles, configurations, customizations, offers, demands,... are getting more and more complex
- More and more dependencies between, features, functions, actors, ...

Integrated graph & services improving collaboration

- To **manage connected data**
- To transform **complex data** in a unified graph
- To **analyze** data for useful and actionable insights
- To **unlock** new value from manufacturing data



VOLVO CARS GRAPH INTELLIGENCE PLATFORM



Sources: "Build a car with Graphs", Fabien Batejat, Graph Technology Specialist, Volvo Cars, Neo4j GraphTour 2019, Customer Presentation;
 "Graphs in Automotive and Manufacturing: Unlock New Value from Your Data";
 "Volvo Cars", Graph Tour 2019 ;
 "Volvo Cars: transforming complex data with a unified graph platform";
 "Connecting Systems Engineering and Human Factors through MBSE"
 Nilsson Robert, Bligård Lars-Ola; Neo4J UseCases



Open KGs for usable knowledge during the entire lifecycle of a product

For business partners and consumers about all aspects of a product

To support **multiple sources** (manufacturer, transporter, customers, ...) and a large percentage of the recoverable materials at the end of its life

“Data economy enabling Circular economy”

The screenshot shows the GS1 website page for the Digital Link Standard. The navigation bar includes 'About', 'Standards', 'Services', 'Industries', and 'News & Events'. The breadcrumb trail is 'Home > Standards > GS1 Digital Link Standard'. The main heading is 'GS1 Digital Link'. The introductory text states: 'The GS1 Digital Link standard extends the power and flexibility of GS1 identifiers by making them part of the web. That means that GS1 identifiers, such as the GTIN, are now a gateway to consumer information that strengthens brand loyalty, improved supply chain traceability information, business partner APIs, patient safety information and more.' It further explains that a URL typically points to a single website, but GS1 Digital Link enables connections to all types of business-to-business and business-to-consumer information. It notes that adding a QR code or NFC tag to a product, using the GS1 standard, means you're not only providing a URL for people to scan, you're also carrying GS1 identifiers - the same identifiers relied upon throughout industry - and following a non-proprietary, no vendor-lock system. This means the brand owner remains in complete control of the number of information sources, all from one symbol, saving space and improving efficiency. More specifically, in Healthcare, the GS1 Digital Link standard helps reinforce the One-barcode initiative, as distributors and hospitals will still use the ubiquitous barcode for years to come, for many different purposes, such as off-care scanning. Yet, now with GS1 Digital Link, they have the opportunity of using a **single barcode** about the product.

The page is divided into three columns:

- Current Version:**
 - GS1 Digital Link Standard 1.2:**
 - [URI syntax](#) (Jan 2021)
 - Resolution (coming soon)
 - Compression and decompression (coming soon)
 - Semantics (coming soon)
 - See previous [version 1.1](#) for anything not covered in the published URI syntax
- Future Versions:**
 - With the publication of Release 1.2, GS1 Digital Link is expected to move to a [GSMP Standard Maintenance Group](#) which will update and improve the standard at a yet to be determined schedule.
- Legal:**
 - [GS1 Digital Link Standard 1.2](#) (2020)
 - [GS1 Digital Link Standard 1.1](#) (2018)

At the bottom, there is a 'Find out more' section with links to:

- [GS1 Digital Link Implementation Guideline \(Global Edition\)](#) (Feb 2020)
- [GS1 Digital Link Flyer: Connect your customers to the product info they want and need \(2-pager\)](#)
- [GS1 Digital Link Flyer: Connect your customers to the product info they want and need \(4-pager\)](#)

GS1 Digital Link:
A New Standard Integration with a Decentralized Knowledge Graph

GS1 in Europe | **W3C WORLD WIDE WEB consortium**

A standards-based knowledge system for the circular economy

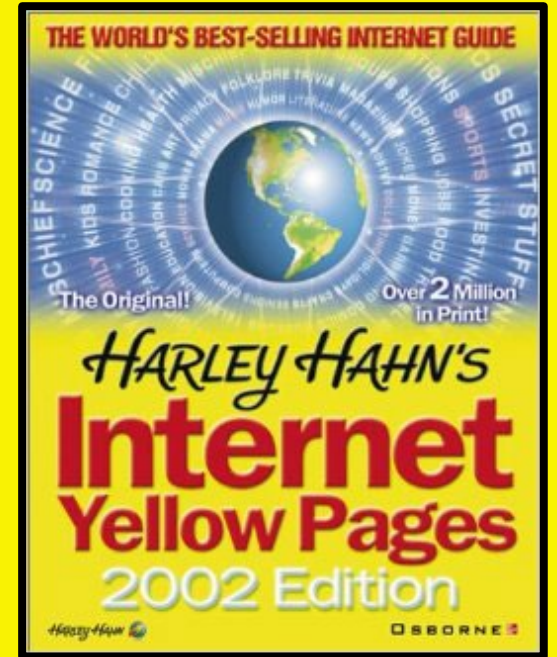
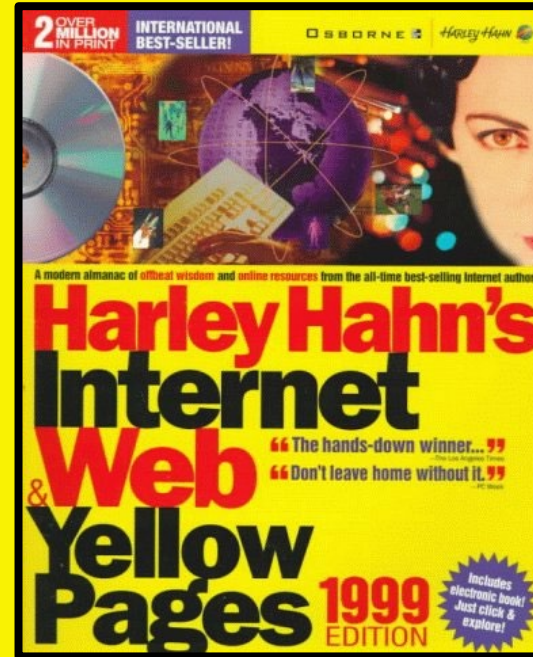
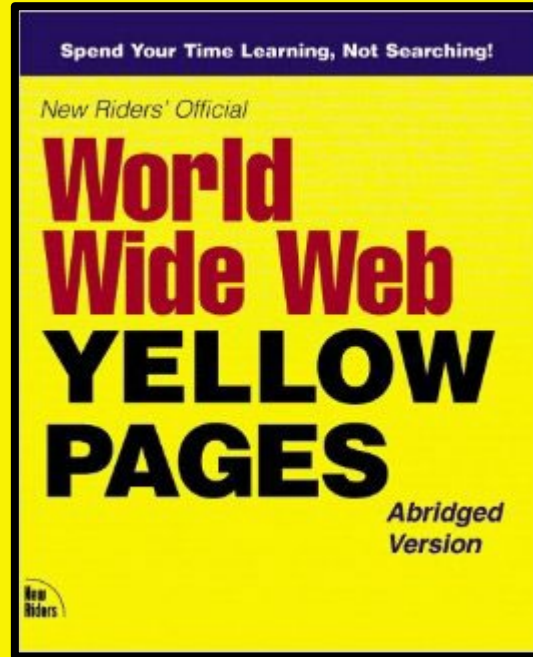
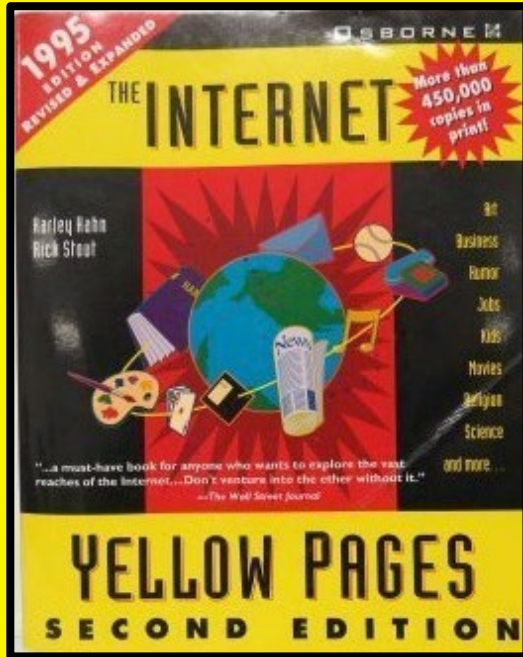
The business case and the challenge for the circular economy
All products are designed, manufactured and sold under market constraints that evolve over time. Today, consumers are increasingly mindful of ethical considerations and the use of recycled materials and a low environmental impact are now selling points.

Providing data to business partners and consumers about these aspects of a product is both essential and challenging. Information systems are needed, for example, to support decision-making in low energy production techniques and efficient transport options, balanced by the resilience of the product and the ease and recoverable percentage of the materials at the end of its life.

It's clear that data is necessary to realize the circular economy. But data is not sufficient. We are drowning in data but starved for knowledge. We need a system that can give us *usable knowledge* during the entire lifecycle of a product.

A standards-based solution
Two communities are willing to join forces. The business and supply chain community on the one hand, and the data exchange and engineering community on the other. These communities choose to create industry standards at GS1 and W3C respectively. Both organizations welcome the opportunity to share their ideas regarding how to meet the EU Data Strategy and Circular Economy Plan.

did you get your yellow pages?



to google: transitive verb that means using the Google search engine to obtain information on something or somebody on the World Wide Web.

Nominal Forms

Infinitive: to google
Participle: googled
Gerund: googling

Indicative

Present

I google
you google
he googles
we google
you google
they google

Perfect

I have googled
you have googled
he has googled
we have googled
you have googled
they have googled

Past

I googled
you googled
he googled
we googled
you googled
they googled

Pluperfect

I had googled
you had googled
he had googled
we had googled
you had googled
they had googled

Future

I will google
you will google
he will google
we will google
you will google
they will google

Future perfect

I will have googled
you will have googled
he will have googled
we will have googled
you will have googled
they will have googled

Subjunctive

Present

I google
you google
he google
we google
you google
they google

Perfect

I have googled
you have googled
he have googled
we have googled
you have googled
they have googled

Imperfect

I googled
you googled
he googled
we googled
you googled
they googled

Pluperfect

I had googled
you had googled
he had googled
we had googled
you had googled
they had googled

Conditional

Present

I would google
you would google
he would google
we would google
you would google
they would google

Perfect

I would have googled
you would have googled
he would have googled
we would have googled
you would have googled
they would have googled

Imperative

you google

we Let's google
you google

Progressive (Continuous) Forms

Indicative

Present

I am googling
you are googling
he is googling
we are googling
you are googling
they are googling

Perfect

I have been googling
you have been googling
he has been googling
we have been googling
you have been googling
they have been googling

Past

I was googling
you were googling
he was googling
we were googling
you were googling
they were googling

Pluperfect

I had been googling
you had been googling
he had been googling
we had been googling
you had been googling
they had been googling

Future

I will be googling
you will be googling
he will be googling
we will be googling
you will be googling
they will be googling

Future perfect

I will have been googling
you will have been googling
he will have been googling
we will have been googling
you will have been googling
they will have been googling

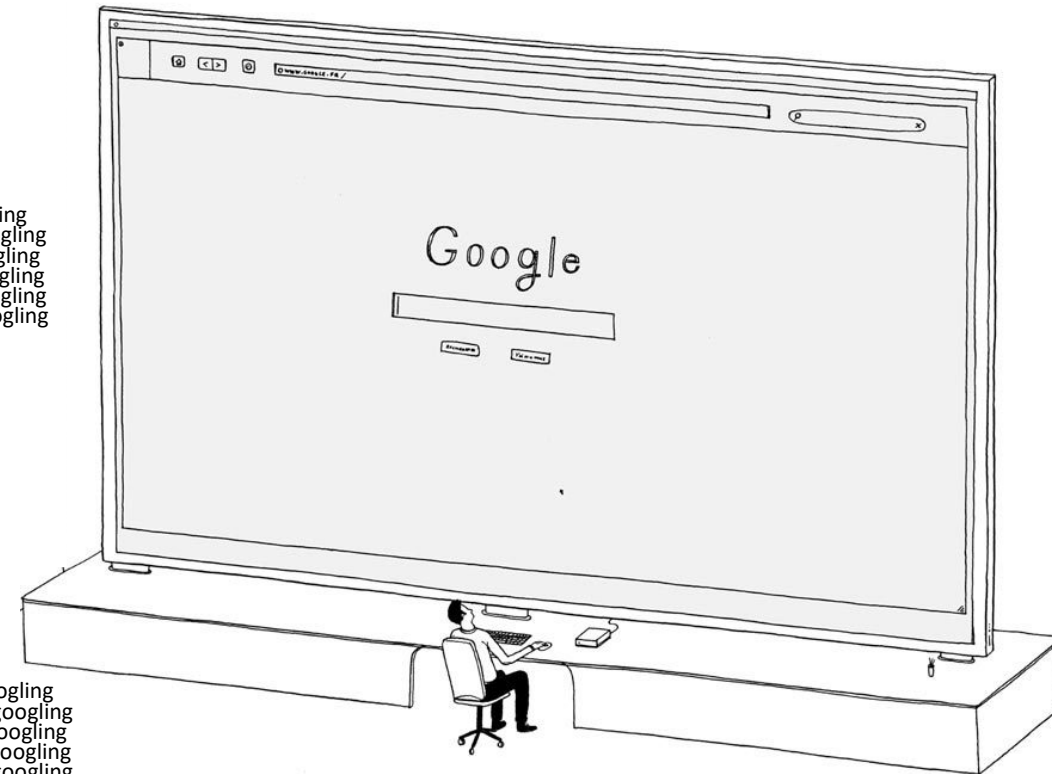
Conditional

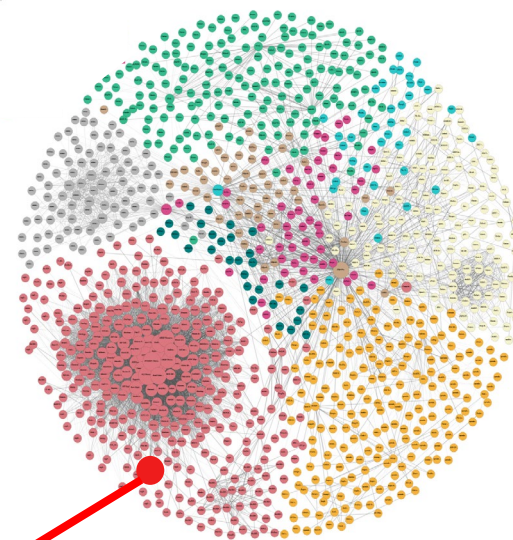
Present

I would be googling
you would be googling
he would be googling
we would be googling
you would be googling
they would be googling

Perfect

I would have been googling
you would have been googling
he would have been googling
we would have been googling
you would have been googling
they would have been googling





CRAWLING [Huang, Gandon 2019]

- Predict data availability
- Select features of URIs
- Learn crawling selection (KNN/NaiveBayes/SVM)
- Online learning w. crawling (FTRL-proximal algorithm)

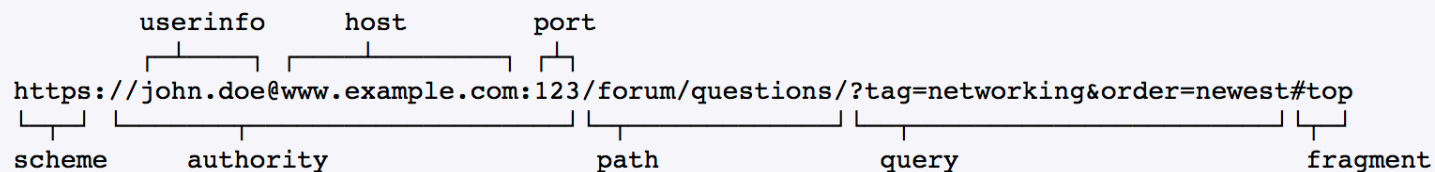


Table 1. Performance of the combinations of feature sets

Combination of Feature Sets	KNN		Naive Bayes		SVM	
	F-measure	Accuracy	F-measure	Accuracy	F-measure	Accuracy
$F_{+t+r+p+x}$	0.6951	0.7407	0.7154	0.7462	0.7944	0.7722
F_{+t+p+x}	0.6261	0.6832	0.7094	0.7413	0.7801	0.7643
F_{+t+r+x}	0.6773	0.7121	0.7111	0.7448	0.7829	0.7650
F_{+t+r+p}	0.7592	0.7731	0.7660	0.7701	0.8216	0.7902
F_{+r+p+x}	0.6015	0.7010	0.6328	0.7075	0.6839	0.7074
F_{+t+x}	0.5582	0.6912	0.6012	0.6172	0.6828	0.6277
F_{r+p}	0.3953	0.5810	0.4874	0.6097	0.6790	0.6424
F_{p+x}	0.4392	0.5739	0.6086	0.6238	0.6689	0.6269

Crawler	Percentage
BFS	0.302
crawler_NB (20K)	0.341
crawler_NB (40K)	0.345
crawler_SVM (20K)	0.402
crawler_SVM (40K)	0.413
crawler_KNN (20K)	0.331
crawler_KNN (40K)	0.324
LDCOC ($\tau = 0.5, \epsilon = 0.17$)	0.655

IndeGx: knowledge graphs about... knowledge graphs

[Maillot et al. 2022]

declarative framework with extractions rules managed on github to build a public RDF

index of RDF datasets <https://github.com/Wimmics/dekalog>

```
1 @prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
2 @prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
3 @prefix dcterms: <http://purl.org/dc/terms/> .
4 @prefix earl: <http://www.w3.org/ns/earl#> .
5 @prefix kgi: <http://ns.inria.fr/kg/index#> .
6 @prefix void: <http://rdfs.org/ns/void#> .
7 @prefix dcat: <http://www.w3.org/ns/dcat#> .
8 @prefix skos: <http://www.w3.org/2004/02/skos/core#> .
9 @prefix xsd: <http://www.w3.org/2001/XMLSchema#> .
10
11 <> rdf:type kgi:TestQuery ;
12     dcterms:isReferencedBy <manifest.ttl> ;
13     dcterms:title "Presence of language tags in the content." ;
14     dcterms:description "Check if there are language tags to make the content of the KB multilingual." ;
15     kgi:timeout "PT120S"^^xsd:duration ;
16     kgi:query """ASK {
17         SELECT DISTINCT (lang(?o) as ?lang) WHERE {
18             ?s ?p ?o . FILTER( isLiteral(?o) )
19         } LIMIT 1
20     }""" .
```

Exclusively based of W3C standards

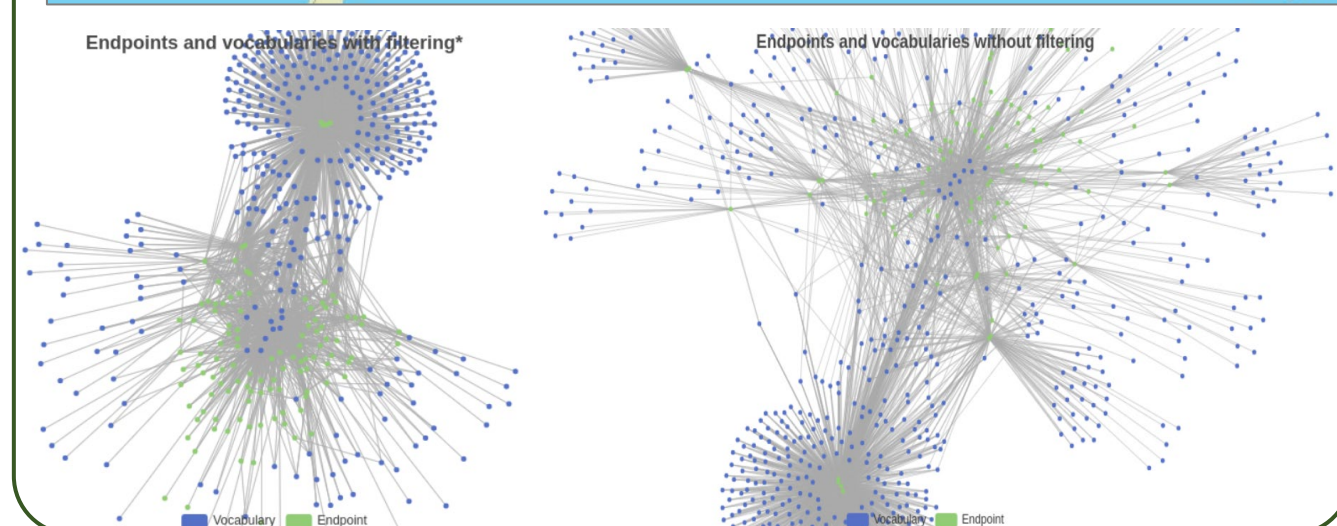
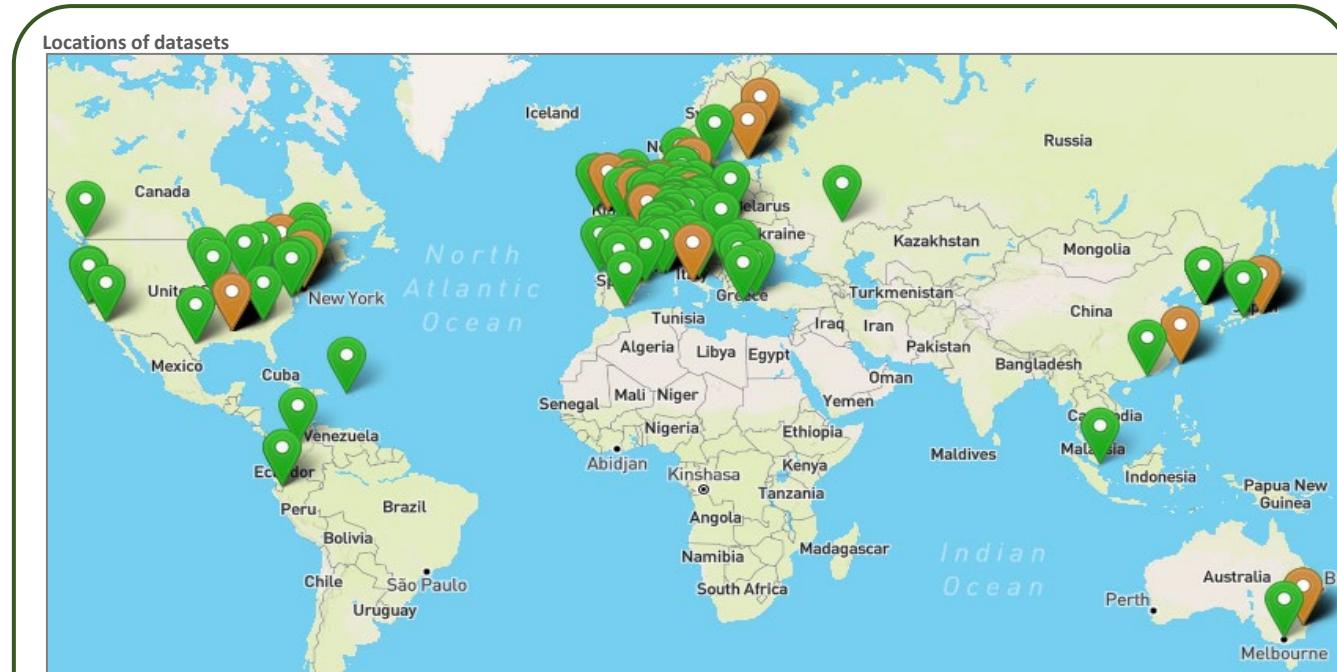
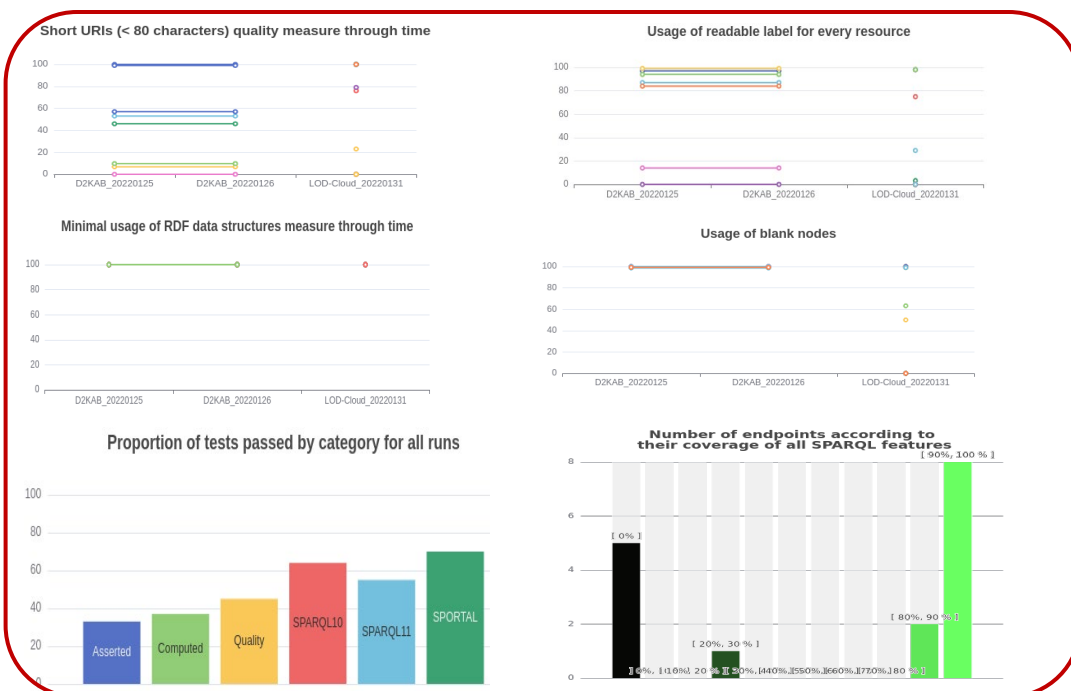
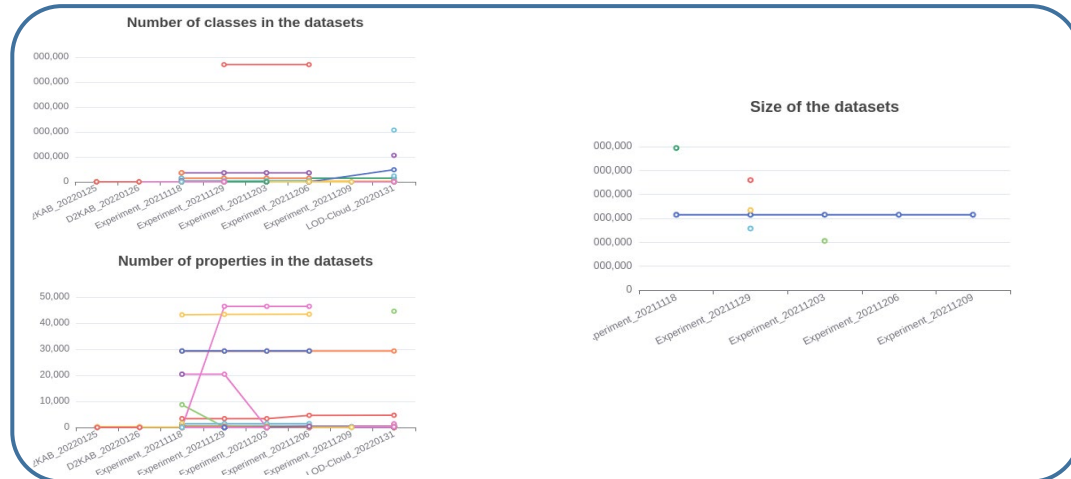


Used to index more than 300 SPARQL endpoints

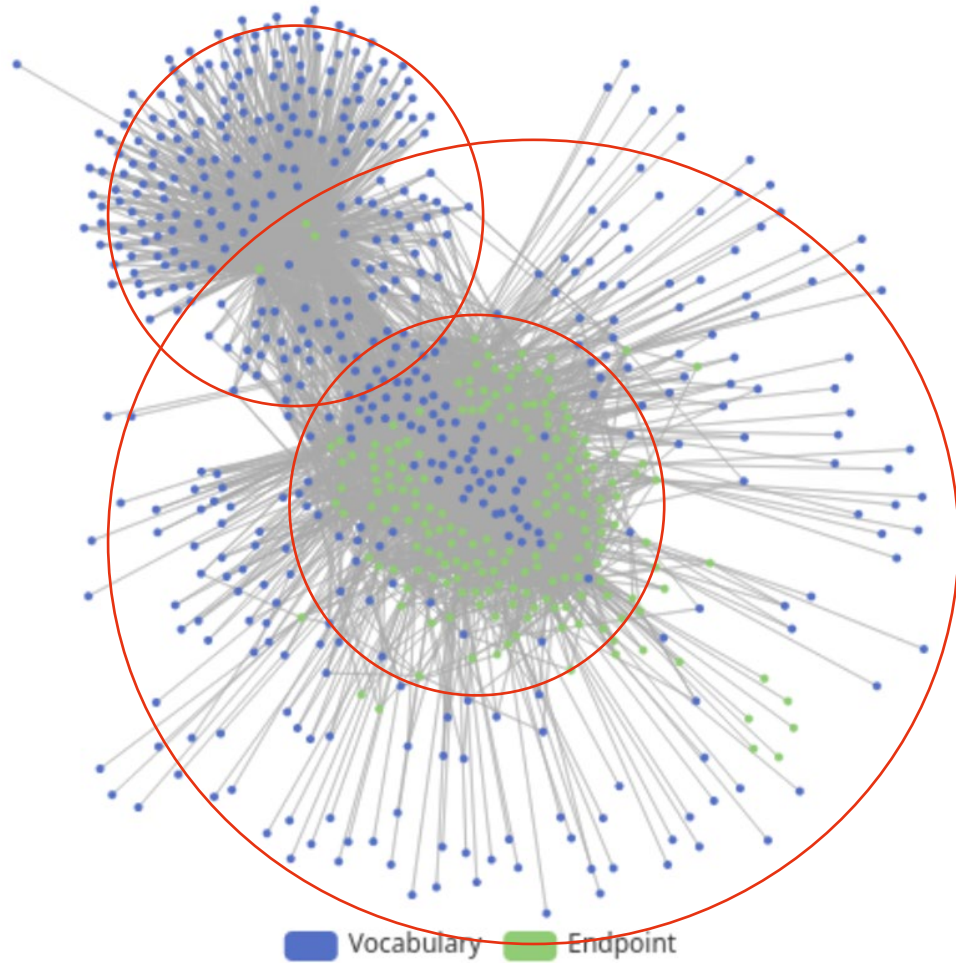
Easily extendable with new rule declarations

KartoGraph: visualize what can be accessed through the endpoint of IndeGx [Maillot et al. 2022]

<http://prod-dekalog.inria.fr/>



Popular Schemas, Ontologies, Vocabularies, Languages...



Empty diagonal...



Metadatamatic is a simple Web application that allows you to create the description of a dataset. It is being provided as a quick and easy way for you to create your own dataset description. Simply enter the form on this page and complete whichever details you'd like to add to your description. If you enter the URL of an endpoint, you will be able to extract some of the details of the dataset automatically. The final dataset description is displayed at the bottom of the page. It can be downloaded as a file or copied and pasted into an RDF file.

Title

Short title for the knowledge base and its content.

Short title for the knowledge base Language tag (optional)

Description

Long description of the knowledge base and its content.

Long description of the knowledge base Language tag (optional)

Endpoint URL

URL of the SPARQL endpoint.

Endpoint's URL

Creator

Represents the different actors involved in the creation of the dataset.

Creator's name or URI

Publication date

Publication date of the knowledge base. A standard [ISO 8601](#) date is expected, e.g. YYYY-MM, YYYY-MM-DD, YYYY-MM-DDThh:mm:ss, etc.

Publication date of the knowledge base

Keywords

Keywords describing the content of the knowledge base.

Keywords used to describe the knowledge base

Version

Current version number of the knowledge base.

Version number

Motivation

- < 10% of bases contain provenance metadata
- > 34 vocabularies to describe a dataset

Supporting dataset metadata generation

- No knowledge of RDF vocabularies necessary
- Usage of existing bases for auto-completion
 - Licenses, languages, etc.
- Automatic extraction of features from endpoints
 - Nb. of triples, classes, properties, list of graphs, etc.

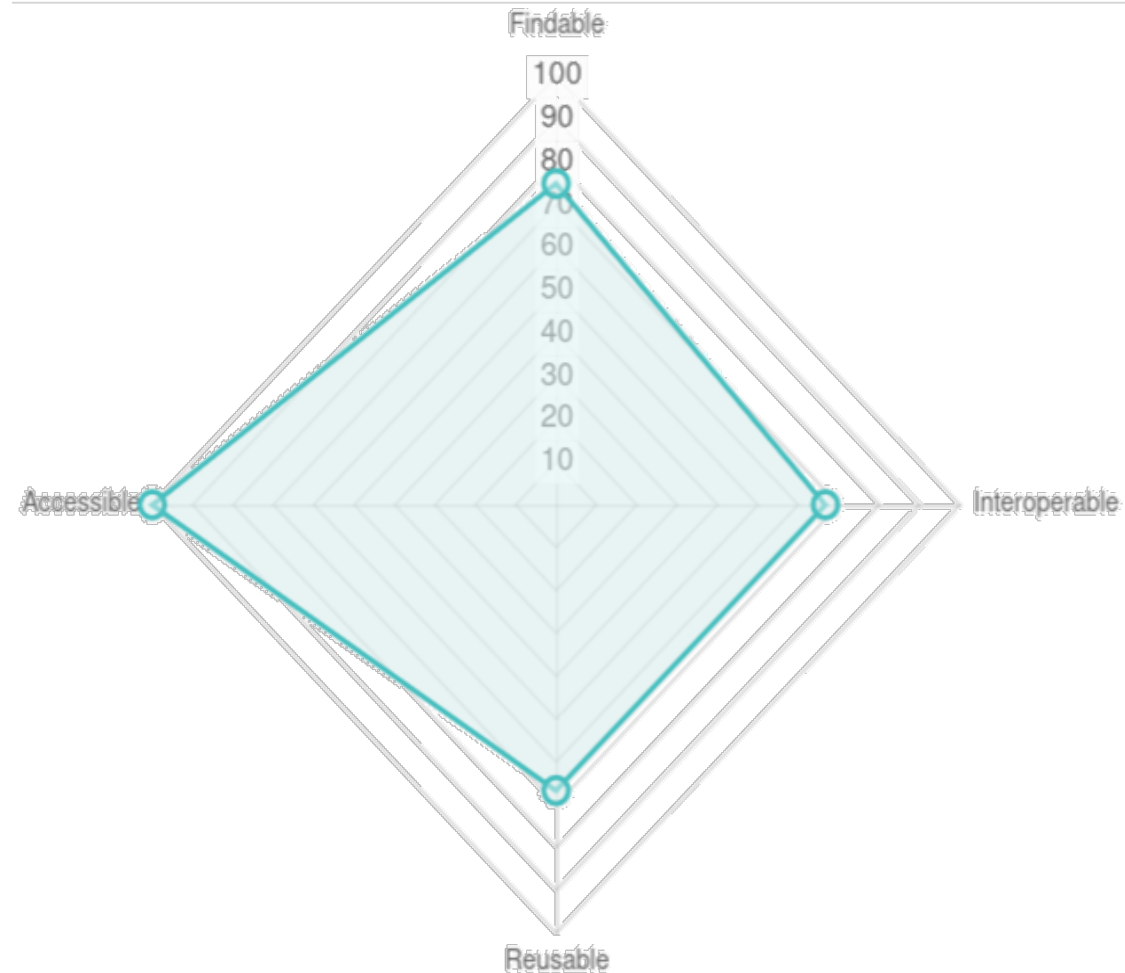
Extensible e.g. **FAIRness** measure

Findability

Accessibility

Interoperability

Reusability



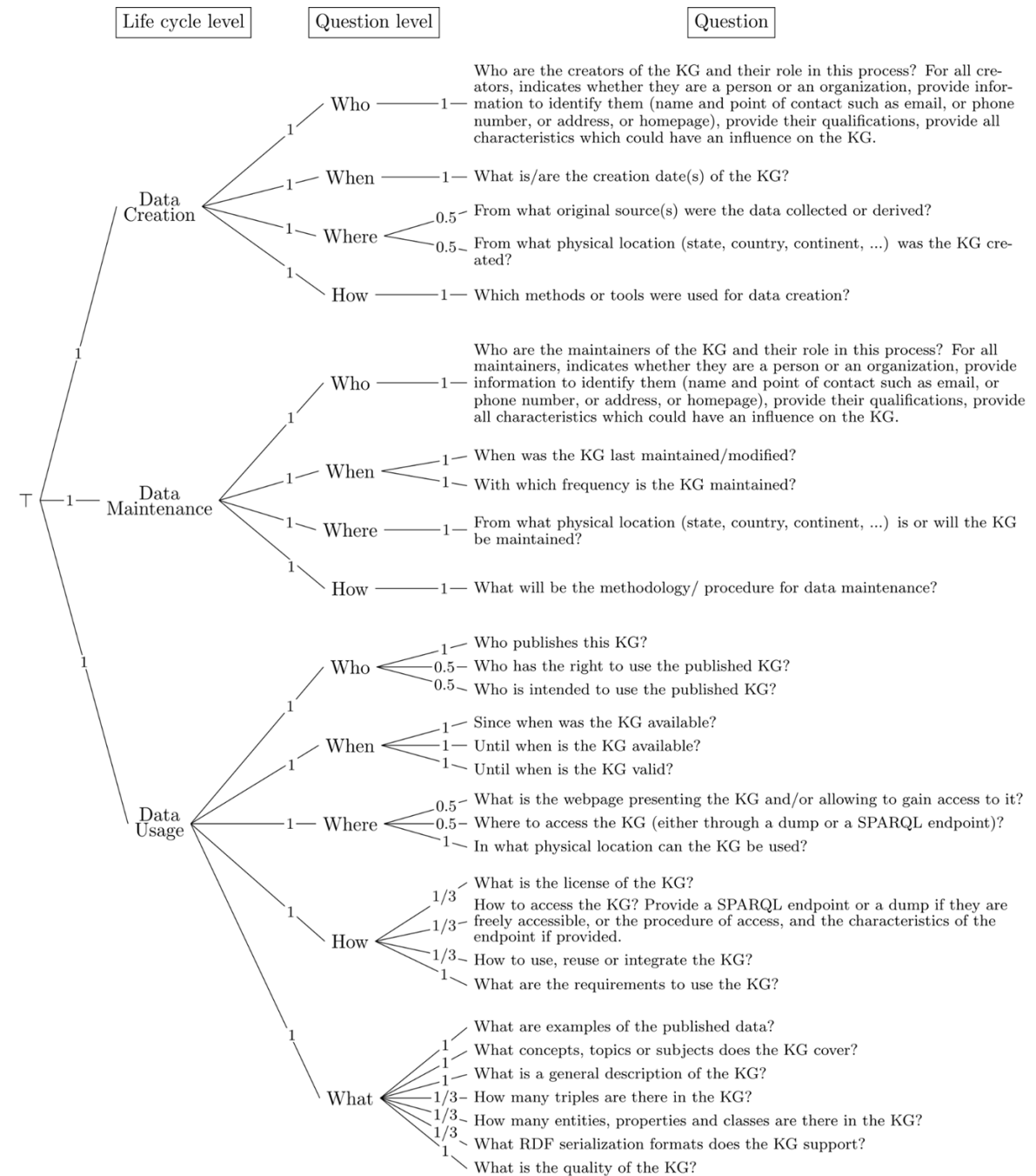
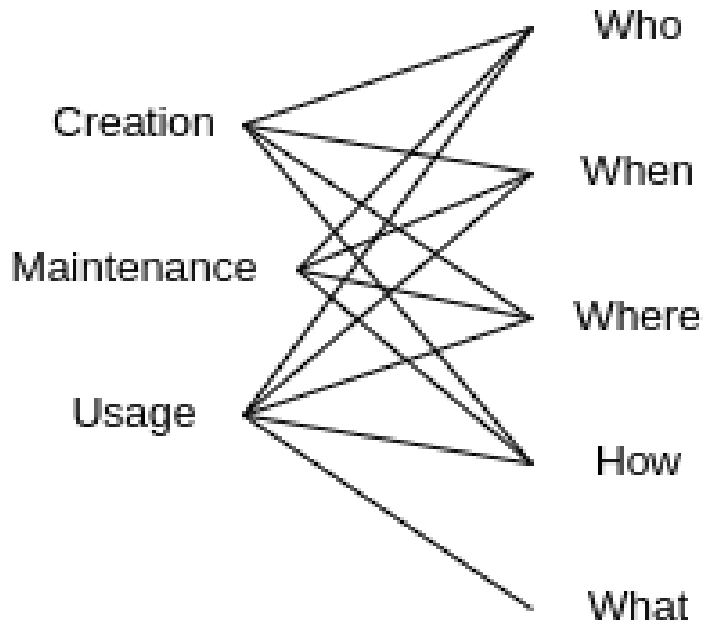
reproduce **FAIR-Checker** [Gaignard et al. 2023]

specialized in bioinformatics datasets

Accountability

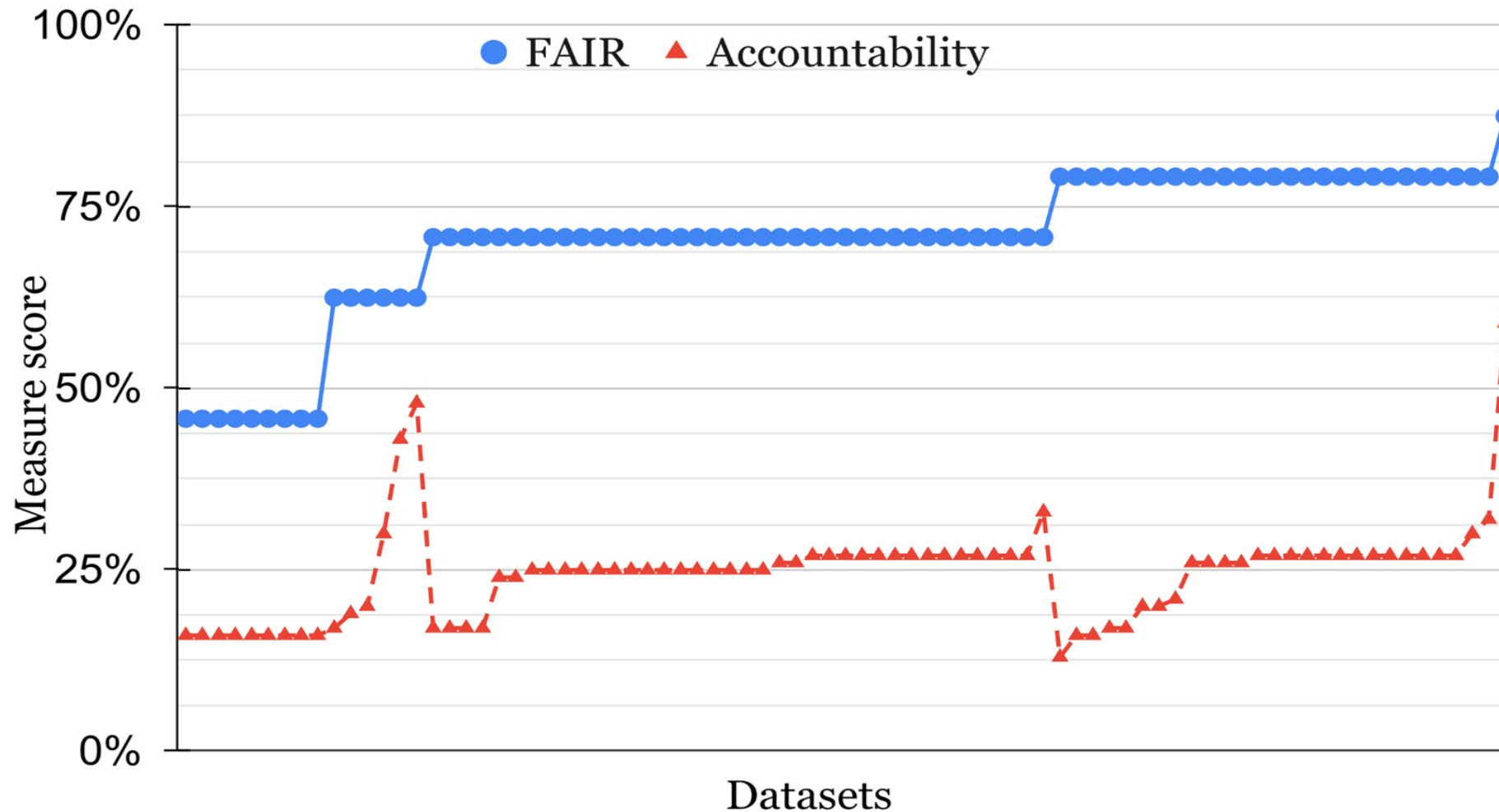
Andersen et al. 2023

Evaluation based on the description provided by the dataset to answer questions defined for each step of the life cycle

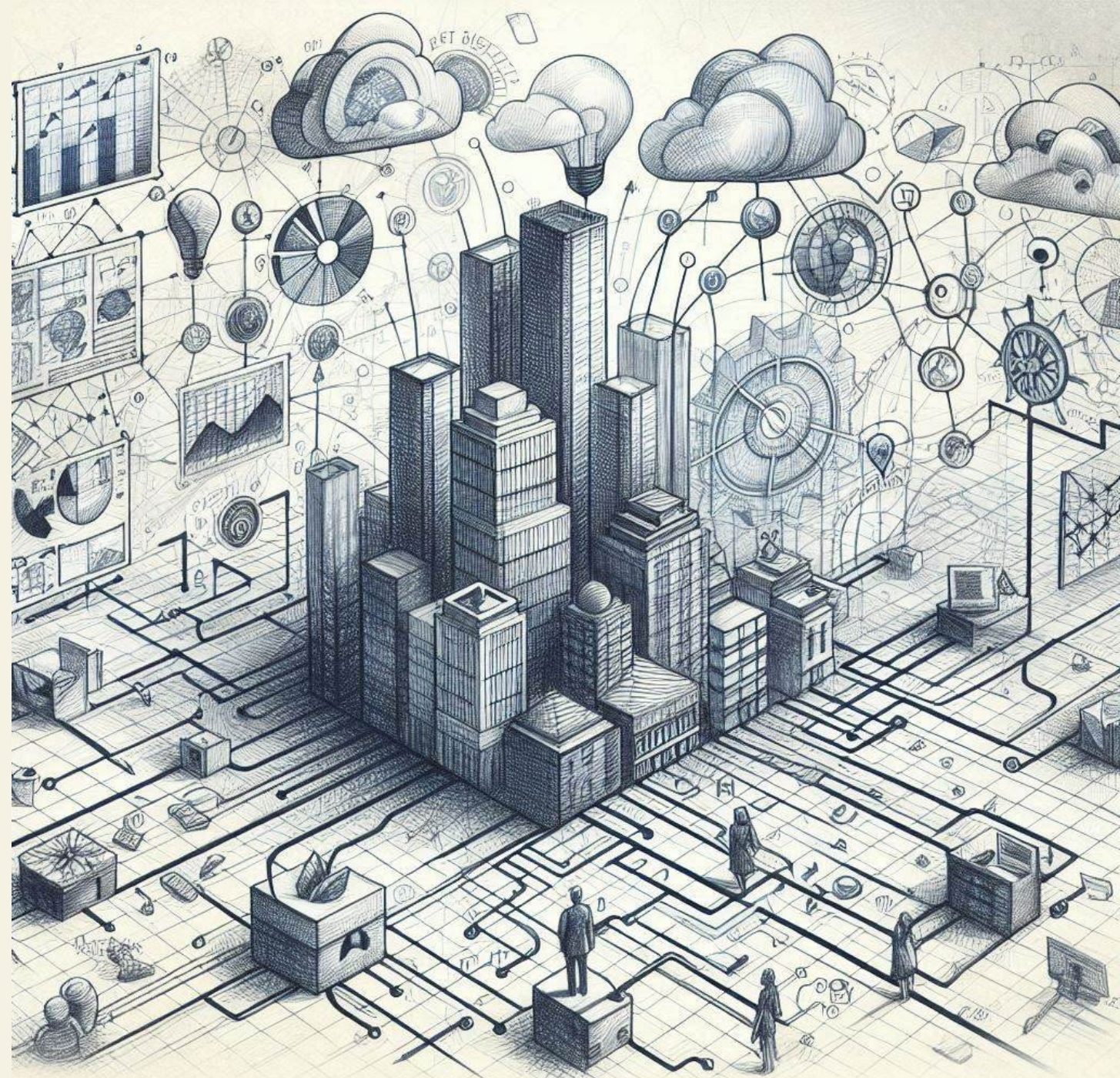


Comparing metrics Maillot, Andersen et al. 2023

Comparison of FAIR-Checker and Accountability in same conditions over 339 active endpoints



Contextualizing data,
requests, ...

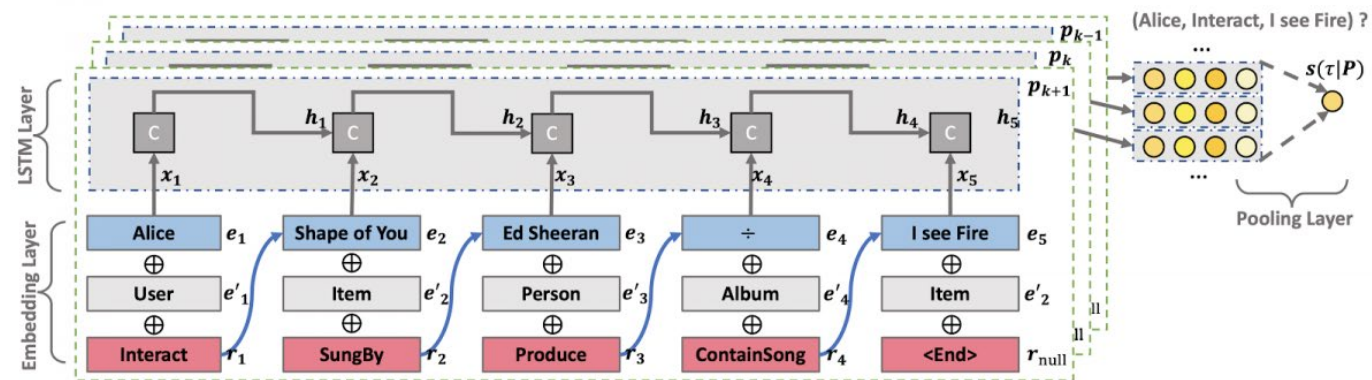
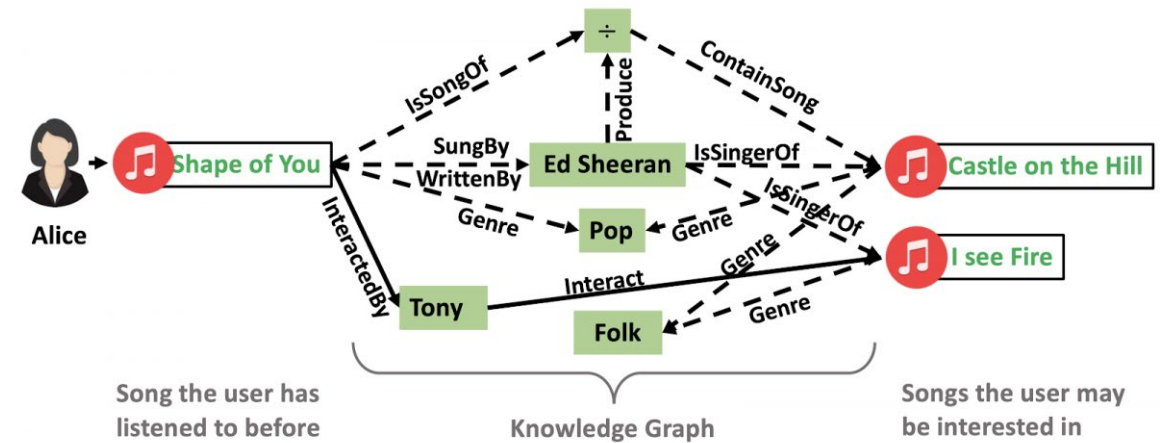


Knowledge Graphs @ ebay

extra user-item connectivity

reveals the semantics of entities & user's interest i.e. **contextualize.**

new model to exploit knowledge graphs for **recommendation** & support **explainable** reasoning



Knowledge Graphs @ amazon

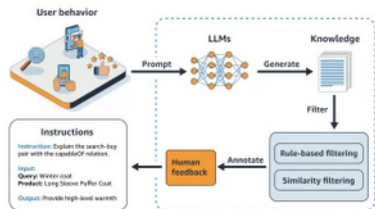
commonsense knowledge graphs to aid product recommendation.

Relationships between products and the human contexts (roles, functions, audiences, locations in which they're used, ...)

Large language models (LLMs) to extract the commonsense relationships implicit in customer interaction data.

Building commonsense knowledge graphs to aid product recommendation

Changlong Yu, Zheng Li | May 10, 2024



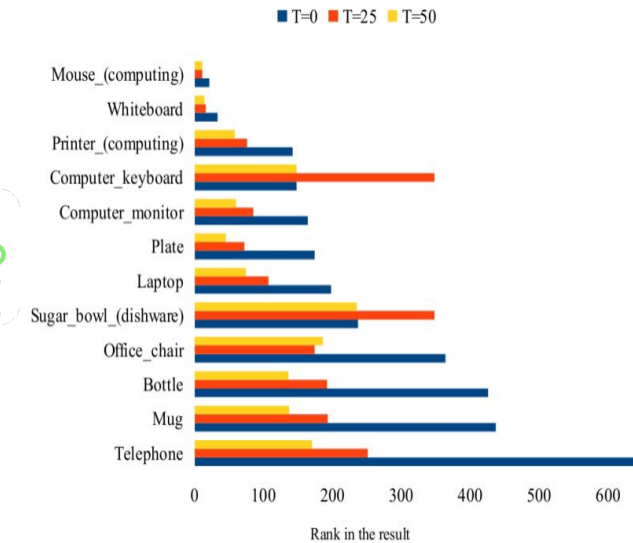
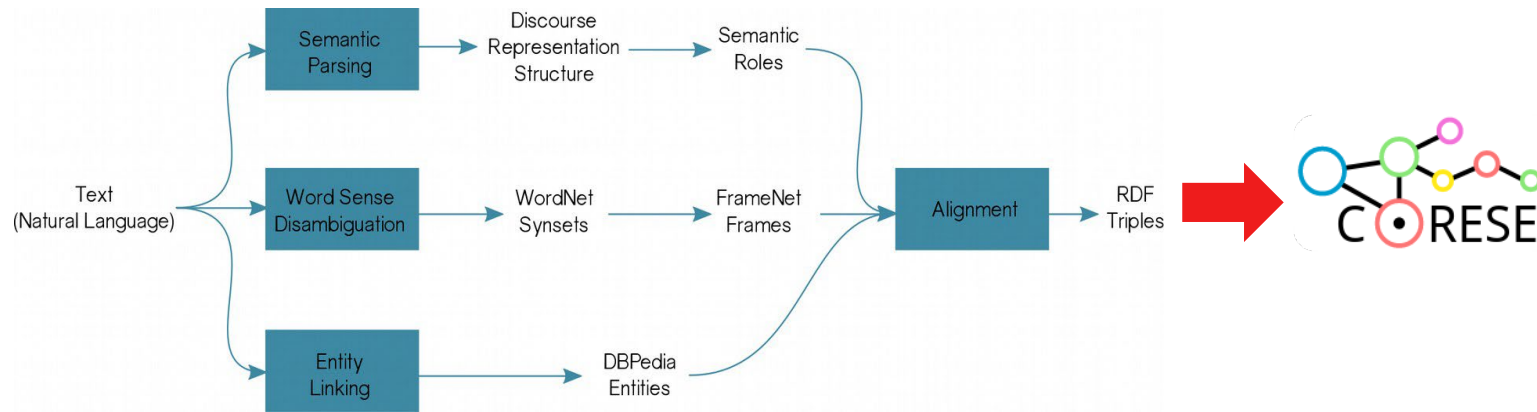
Using large language models to discern commonsense relationships can improve performance on downstream tasks by as much as 60%.

Source: Changlong Yu, Xin Liu, Jefferson Maia, Yang Li, Tianyu Cao, Yifan Gao, Yangqiu Song, Rahul Goutam, Haiyang Zhang, Bing Yin, and Zheng Li. 2024. COSMO: A Large-Scale E-commerce Common Sense Knowledge Generation and Serving System at Amazon. SIGMOD/PODS '24, 148–160.

<https://doi.org/10.1145/3626246.3653398>

ALOOF: robots learning by reading on the Web

Annie cuts the bread **in the kitchen** with her **knife** → **dbp:Knife** aloof:**Location** dbp:**Kitchen**



- Object Location Knowledge Base: 46212 co-mentions, 49 tools, 14 rooms, 101 “possible location” relations, 696 tuples <entity, relation, frame>
- Evaluation: 100 domestic instruments, 20 rooms, 2000 crowdsourcing judgements
- Shared between robots through a shared Web knowledge base

[Cabrio, Basile et al. 2017]



Knowledge Graphs @ Alibaba.com

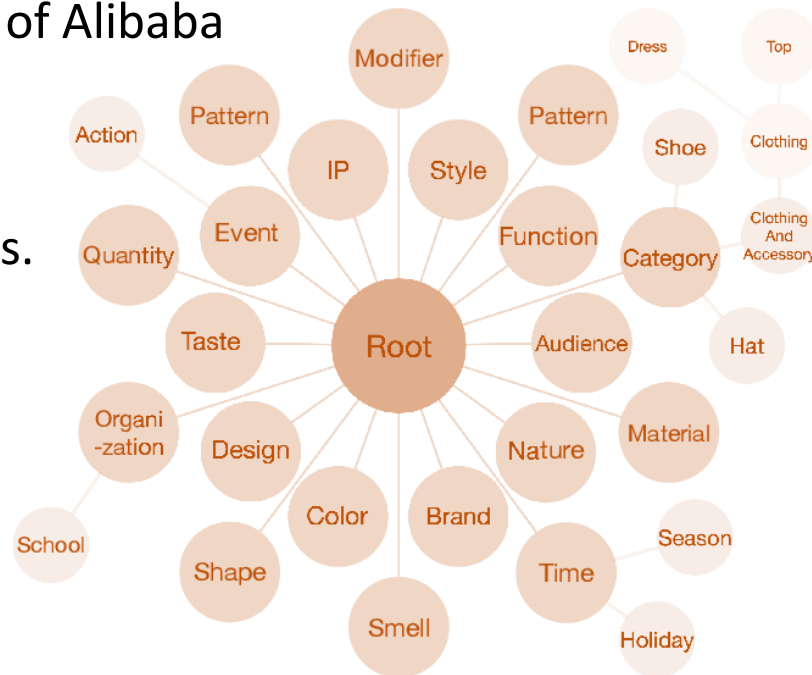
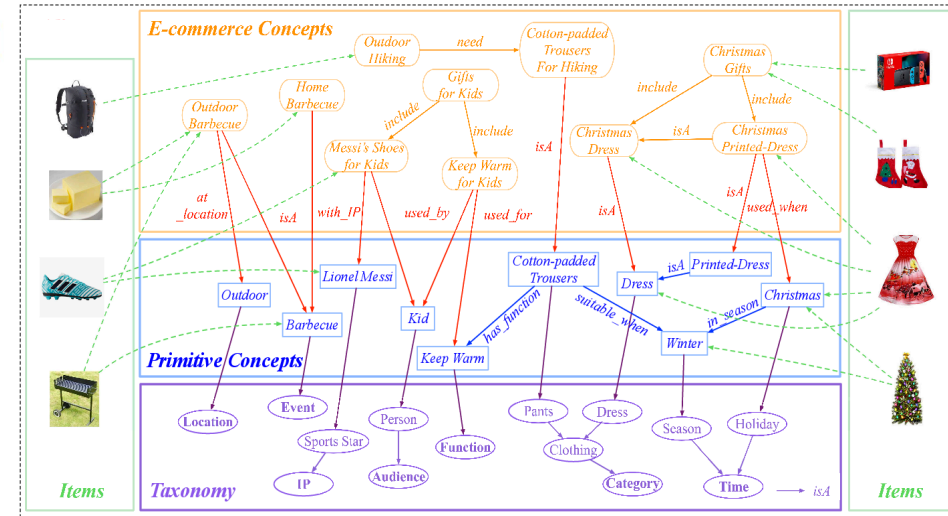
AliCoCo is a large-scale E-commerce “Cognitive Concept Net”.

unified data foundation for user, knowledge, product and content understanding.

Used in **search and recommendation algorithms** of Alibaba (largest Chinese e-commerce site).

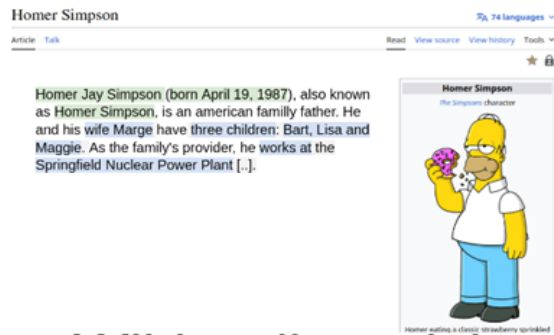
Better recognize and **contextualize** the user needs.

Constructed semi-automatically.



Sources: Luo, Xusheng et al. “AliCoCo: Alibaba E-commerce Cognitive Concept Net.” SIGMOD 2020 ; E-commerce Knowledge Graph AliCoCo , AlibabaCloud.

RDF-Pattern Based Extraction



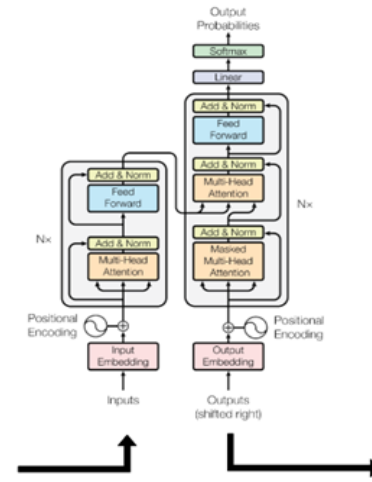
Wikipedia article

t



SHACL shape

S



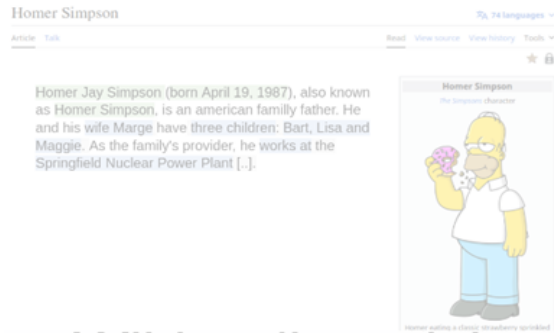
E_{Db}



Relational Graph

g

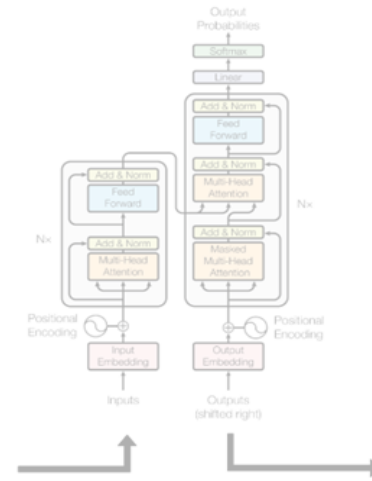
RDF-Pattern Based Extraction



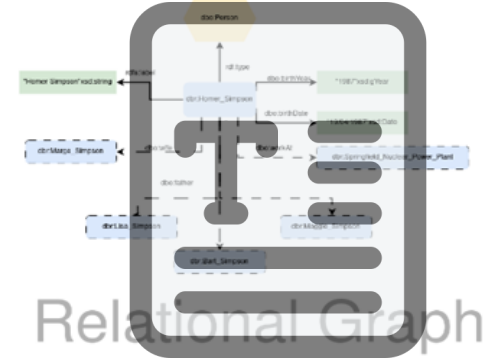
Wikipedia article



SHACL shape



GRAPH LINEARIZATION ? IMPACT



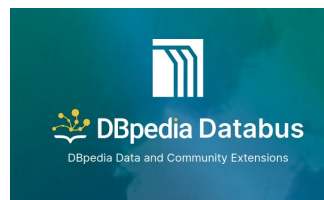
Relational Graph

Ground-truth construction



dbo:Person

`rdfs:label`, `dbo:alias`, `dbo:birthName`,
`dbo:birthDate`, `dbo:deathDate`, `dbo:birthYear`,
`dbo:deathYear`.



2022-09 snapshot - EN



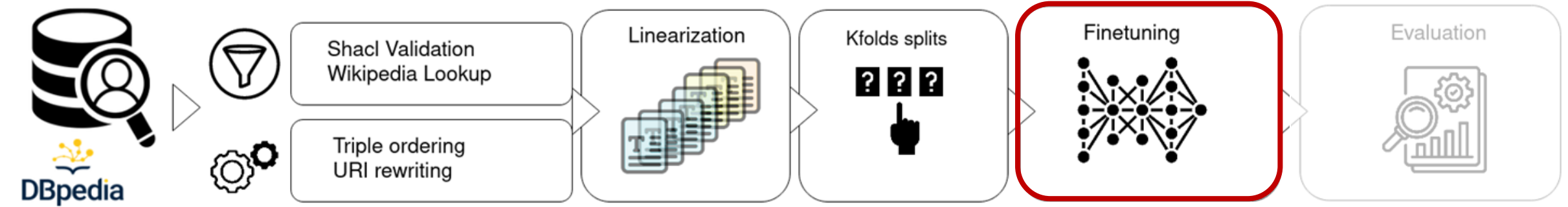
1 833 493 entities and 3 249 446 related triples

Linearization choice



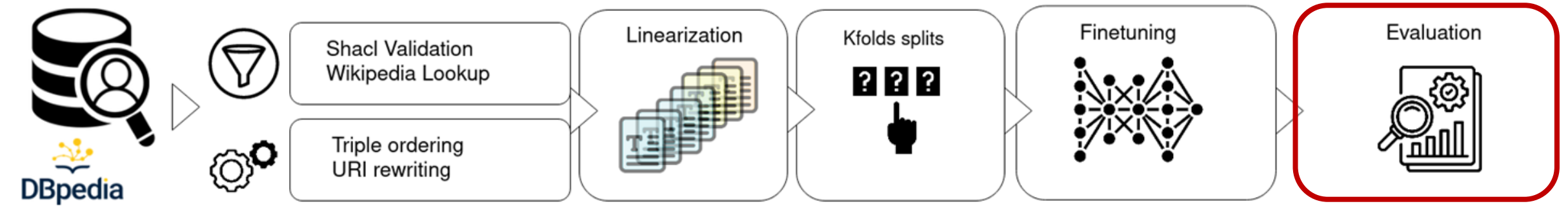
- Literature's syntaxes (Lists, Tags)
- W3C's syntaxes (XML, JSON, Ntriples, Turtle)
- Own extension (Turtle Light 🐢) even closer to English

Small Language Models : BART-base & T5-base FT



- Prompts :
 - BART: “\$entity URI : \$Abstract”
 - T5: “Translate English to \$Syntax: [\$entity URI] \$Abstract”
- Without loss change
- Without decoding strategy
- Cross entropy optimisation with patience of 3 epochs

Evaluation Models & Linearizations



Triple Validity metrics

- Rate of Parsed triples (R_{PT})
- Rate of Correct subject (R_{CS})
- Rate of Shacl validated triples (R_{SVT})

Ressource

- Time (minutes)
- Carbon consumption

Classics : (strict mode)

- RE metrics : Precision, Recall, F1
- String datatypes properties : BLEU
- Entire triple evaluation: Levenstein dist

Training behaviors

- Velocity : when does the model saturate ?
- Stability: Is the learning process stable ?
- Divergence: Is the learning process diverging ?

A light Turtle goes a long way

Config	Triple Validity			RE performances $\times 100$				Edition m.		Training behaviors						Resources		G_g	
	$\overline{R_{PT}}$	$\overline{R_{CS}}$	$\overline{R_{SVT}}$	$\overline{F_1^-}$	$\overline{F_1^+}$	$\overline{P^+}$	$\overline{R^+}$	\overline{B}	\overline{lev}	$\overline{Nb_{epochs}}$	$\overline{V_{RPT}}$	$\overline{S_{RPT}}$	$\sum D_{RPT}$	$\overline{V_{F_1^-}}$	$\overline{S_{F_1^-}}$	$\sum D_{F_1^-}$	$\overline{C_c}$		$\overline{T_t}$
$T5_{vj}$	1	1	1	99.75	95.63	100.00	94.37	1.00	0	13	0.2	\emptyset	0	0.2	\emptyset	2	0.252	137	96
B_{vgf}	1	1	1	99.69	95.47	99.29	94.28	0.97	0	15	0	\emptyset	0	0	\emptyset	1	0.042	29	95
B_{vtf1}	1	1	1	99.72	94.54	97.09	93.20	0.93	0	12	0	\emptyset	0	0.2	\emptyset	2	0.035	27	95
B_{vT}	1	1	1	99.73	94.43	96.39	93.42	0.97	11	22	0	\emptyset	0	0	\emptyset	1	0.104	75	94
$T5_{vtf1}$	1	1	1	99.51	93.94	95.48	93.13	0.96	0	14	0.2	\emptyset	0	0	\emptyset	3	0.099	56	94
$T5_{vx}$	1	1	1	99.58	92.86	96.81	91.91	0.95	2	18	0.4	\emptyset	1	0.4	\emptyset	2	0.324	206	93
B_{vg}	1	1	1	99.62	92.57	96.34	91.08	0.94	0	17	0	\emptyset	0	0	\emptyset	0	0.053	46	93
$T5_{vt}$	1	1	1	99.55	92.34	95.19	91.40	0.97	0	11	0.8	\emptyset	1	0.6	\emptyset	1	0.118	75	92
B_{vtf}	1	1	1	99.63	91.99	96.68	90.49	1.00	2	12	0	\emptyset	0	0	\emptyset	1	0.04	29	92
B_{vt}	1	1	1	99.62	92.03	94.75	90.37	0.90	18	18	0	\emptyset	0	0	\emptyset	1	0.064	54	92
B_{vtf}	1	1	1	99.49	90.72	95.45	89.13	0.97	0	12	0	\emptyset	0	0	\emptyset	0	0.029	26	91
$T5_{vgf}$	1	0.96	1	99.57	94.18	96.76	92.51	0.98	1	13	0.2	\emptyset	0	0.2	\emptyset	1	0.087	45	91
$T5_{vtf}$	1	1	1	99.33	90.72	95.81	88.72	0.96	1	10	0.8	\emptyset	1	0.4	\emptyset	1	0.072	44	90
B_{vj}	1	1	1	99.52	90.27	95.14	88.85	0.96	47	11	0.2	\emptyset	0	0	\emptyset	0	0.093	74	90
B_{vx}	1	1	1	99.46	89.87	96.69	88.85	0.97	17	14	0	\emptyset	0	0.2	\emptyset	1	0.092	75	90
$T5_{vt1}$	0.97	1	1	99.34	91.73	95.32	89.68	0.97	99	10	0	\emptyset	0	0	\emptyset	2	0.109	56	89
$T5_{vtf}$	1	0.98	1	99.32	90.32	94.28	89.43	0.88	205	11	1	\emptyset	1	0	\emptyset	4	0.081	49	88
B_{vn}	1	1	1	99.36	87.73	97.01	85.48	0.99	81	24	0	\emptyset	0	0.4	\emptyset	1	0.134	119	88
$T5_{vg}$	0.98	1	1	99.29	88.72	96.15	86.28	0.94	18	15	0.4	\emptyset	1	0	\emptyset	1	0.107	76	87
$T5_{vt}$	0.97	1	1	99.24	88.41	92.60	86.61	0.94	29	14	0.2	\emptyset	1	0.2	\emptyset	3	0.115	79	85
B_{vt1}	0.97	1	1	99.32	86.15	94.13	83.89	0.99	20	16	0	\emptyset	0	0	\emptyset	1	0.047	41	83
B_{vt}	0.97	1	1	99.34	85.68	93.52	83.64	0.98	13	14	0	\emptyset	0	0	\emptyset	1	0.053	43	83
$T5_{vT}$	0.82	1	1	99.25	88.41	92.60	86.61	0.97	810	15	0.8	0.5	2	0.4	\emptyset	3	0.221	139	72
$T5_{vn}$	0.75	1	1	99.39	90.61	97.98	88.17	0.97	137	13	1.6	0.4	3	0.2	0.5	3	0.25	160	67
μ	0.98	1.00	1	99.49	91.42	96.02	89.87	0.96	63	14	0.3	\emptyset	0.5	0.1	\emptyset	1.5	0.11	73	89
σ	0.1	0.0	0	0.2	2.7	1.7	3	0.0	163	3	0.4	\emptyset	0.7	0.2	\emptyset	1	0.1	46	6.8



Knowledge Graphs @

Samsung acquires  Oxford Semantic Technologies and its AI reasoning engine based on RDF.
(follows investment of Samsung Ventures and collaboration since 2018)

- Enhance the understanding of product or service and services usage.
- Integrate and connect data.
- Enable rapid information retrieval and recommendation.
- Run on any device and where the data is.



“considered one of the key technologies for realizing more sophisticated and personalized AI solutions”

Knowledge Graphs @ NOKIA

AI and knowledge graphs to transform telecom inventory solutions.

Automation in network infrastructures and mobile network software supply chain

“billions of dollars worth of potential energy savings”



Sources: “Learn how AI and graph databases transform telecom inventory solutions”, Oleksandr Dmytriiev, Nokia Blog ; “A Billion Dollar Opportunity: Superscaling Knowledge at NOKIA”, Chris Brockmann, eccenca, KGC 2023

Knowledge Graphs @ BOSCH

“impossible to see the big picture, the overarching relationships, because the databases were not connected.”

ePLM Navigator: unlocking and connecting data silos with knowledge Graphs

Bosch Semantic Stack: **connect** and **access** backend systems to **leverage data across product life cycle**

Open Standards for a Wider Range of Applications.

Knowledge-driven machine learning: learning visual models with knowledge graph as a trainer (robust, transferable, faster training)

Knowledge-infused machine learning: combining explicit and contextualized domain knowledge (symbolic AI) with data-driven machine learning methods (sub-symbolic AI).

Neuro-symbolic AI approaches: domain knowledge graphs to gain further knowledge via reasoning and prediction, and exploit knowledge for search, exploration, machine learning and problem solving.

Sources: "ePLM Navigator", CONWEAVER, Article ; "A Survey on Visual Transfer Using Knowledge Graphs", Sebastian Monka, Bosch Center for Artificial Intelligence (BCAI) ; Learning visual models using a knowledge graph as a trainer, Bosch Research Blog, Sebastian Monka, Lavdim Halilaj and Stefan Schmid; "Bosch Semantic Stack", Product-centric digital transformation



Sexe	Date	Cause	CISP2	...	History	Observations
H	25/04/2012	vaccin-antitétanique	A44	...	Appendicite	EN CP - Bon état général - auscult pulm libre; bdc rég sans souffle - tympan ok-

Element	Number
Patients	55 823
Consultations	364 684
Past medical history	187 290
Biometric data	293 908
Semiotics	250 669
Diagnosis	117 442
Row of prescribed drugs	847 422
Symptoms	23 488
Health care procedures	11 850
Additional examination	871 590
Paramedical prescription	17 222
Observations/notes	56 143

PREDICT HOSPITALIZATION

[Gazzotti, Faron et al. 2017]

- Physician's records classification to predict hospitalization
- Study enrichment and features impact and combinations on different ML methods

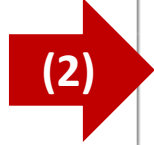
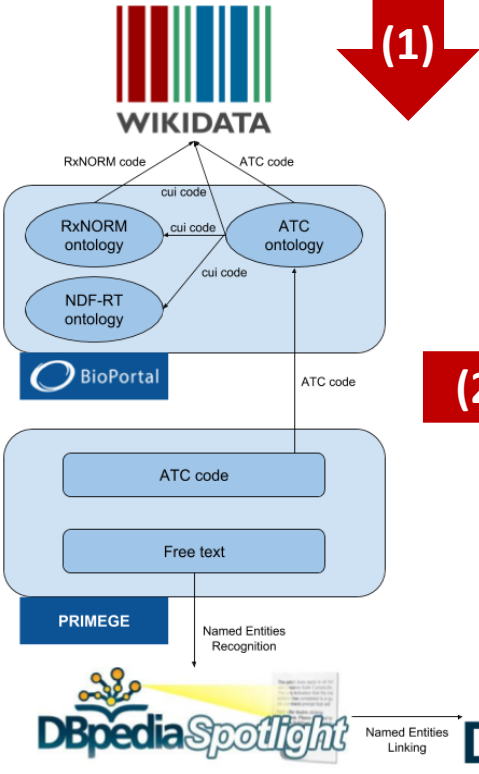
Sexe	Date	Cause	CISP2	...	History	Observations
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PREDICT HOSPITALIZATION

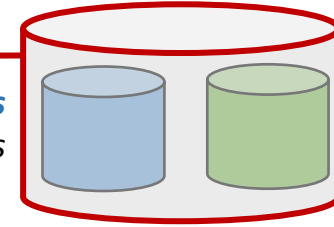
[Gazzotti, Faron et al. 2017]

- Physician's records classification to predict hospitalization
- Study enrichment and features impact and combinations on different ML methods



Représentation	SGD	SVC	RF	Log	Moyenne
<i>référence</i>	0.7877	0.8270	0.8533	0.8491	0.8293
+t	0.8054	0.8239	0.8522	0.8545	0.8340
+s	0.7889	0.8221	0.8522	0.8485	0.8279
+s*	0.7985	0.8339	0.8449	0.8514	0.8322
+c ₁	0.7859	0.8235	0.8433	0.8453	0.8245
+c ₁₋₂	0.7871	0.8254	0.8480	0.8510	0.8279
+c ₂	0.8209	0.8348	0.8522	0.8505	0.8396
+d _{prevent}	0.7796	0.8254	0.8506	0.8479	0.8259
+d _{treat}	0.7925	0.8338	0.8472	0.8481	0.8304
+d _{C1}	0.8108	0.8281	0.8498	0.8460	0.8337
+wa	0.8065	0.8223	0.8468	0.8545	0.8325
+wi	0.8137	0.8149	0.8484	0.8501	0.8318
+wm	0.7991	0.8221	0.8453	0.8458	0.8281
+t + s + c ₂ + wa + wi	0.7782	0.8258	0.8486	0.8547	0.8268
+t + s * + c ₂ + wa + wi	0.7801	0.8239	0.8494	0.8543	0.8269
+t + c ₂ + wa + wi	0.7707	0.8140	0.8531	0.8571	0.8237

350 000 *images*
of artworks



RDF *metadata* based
on external thesauri



[Bobasheva et al. 2020]

- reason & query on RDF to build training sets.
- transfer learning & CNN classifiers on targeted categories (topics, techniques, etc.)
- reason & query RDF of results to address **silence**, **noise** and explain



Image	Metadata	Score <input type="checkbox"/>
	figure (saint Eloi de Noyon, évêque, en pied, bénédiction, vêtement liturgique, mitre, attribut, cheval , marteau, outil : ferronnerie) 000SC022652 C:/Joconde/joconde\0355\m079806_bsa0030101_p.jpg	cheval: 0.006



Image	Metadata	Score <input checked="" type="checkbox"/>
	portrait 50350012455 C:/Joconde/joconde\0138\m503501_d0012455-000_p.jpg	cheval: 0.999

```

prefix skos: <http://www.w3.org/2004/02/skos/core#>
prefix jcl: <http://jocondelab.iri-research.org/ns/jocondelab/>

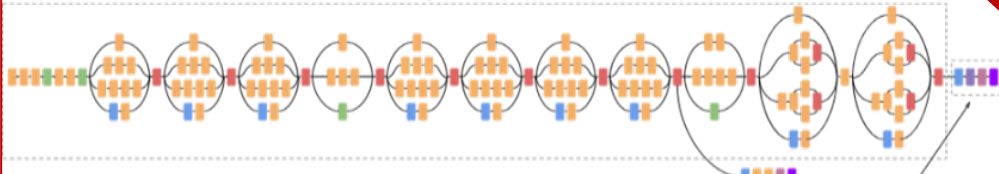
select(
  replace(group_concat(?topCategory_label; separator="+"), "\\$", "") as ?label)
  (sample(?noticeRepresentation) as ?repr)
  (sample(?imagePath) as ?image_path)
  (sample(?noticeReference) as ?ref)
where
{
  values (?topCategory_label) { ("chien"@fr) ("cheval"@fr) }.

  ?topCategory a jcl:Term;
               skos:prefLabel ?topCategory_label;
               skos:narrower* | skos:related/skos:narrower* ?subCategory.

  ?subCategory skos:prefLabel ?subCategory_label.

  ?notice jcl:noticeReprTerm ?subCategory;
          jcl:noticeHasImage true;
          jcl:noticeRef ?noticeReference.
}
group by ?noticeReference
  
```

Input: 299x299x3, Output: 8x8x2048



Legend:

- Convolution
- AvgPool
- MaxPool
- Concat
- Dropout
- Fully connected
- Softmax

Input: 299x299x3 → Output: 8x8x2048

Final part: 8x8x2048 → 1001

```

@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#>.
@prefix jcl: <http://jocondelab.iri-research.org/ns/jocondelab/>.
@prefix t: <http://data.culture.fr/thesaurus/resource/ark:/67717/>.
@prefix ml: <http://ns.inria.fr/monalia/>.

ml:classifierRepresentedSubject a rdfs:Class;
ml:classifier40_classes rdfs:label "40_classes";
rdfs:subClassOf ml:classifierRepresentedSubject.

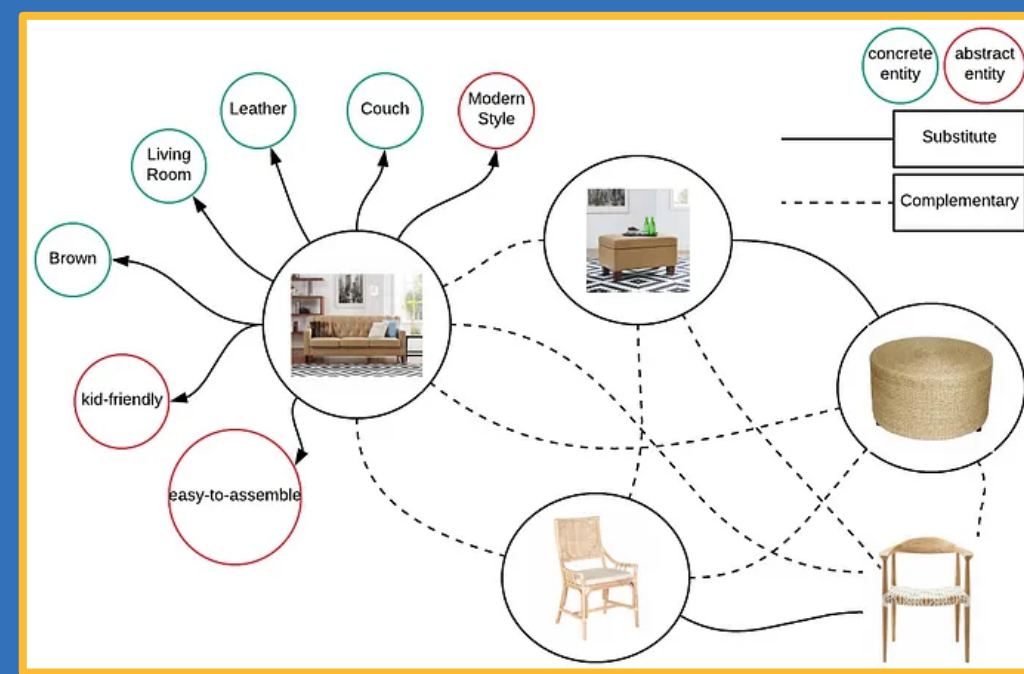
<https://jocondelab.iri-research.org/data/notice/00000055013> ml:imageClassifier [ a ml:classifier40_classes;
ml:detected [ a t:T523-6519; ml:score 0.8102 ],
[ a t:T523-6209; ml:score 0.0219 ],
[ a t:T523-175; ml:score 0.3843 ],
...
[ a t:T523-2037; ml:score 0.0121 ].
  
```



Knowledge Graphs @ Walmart

Retail Graph : products and their related entities (material, activities, rooms, etc.)

- To help customers discover products and catalog.
- Leverage **taxonomies** and enrich the entities
- To power semantic **search, recommendation** system
- To **answer questions** about products and related knowledge



Source: "Retail Graph — Walmart's Product Knowledge Graph", Karthik Deivasigamani, Walmart Global Tech Blog, Medium

LLMs everywhere... good and bad, like sugar



How can biochemists query this massive knowledge graph?

Louis-Félix Nothias et al.



Pierre Fabre
plant collection (17,000+ extracts)



96 well plates

EXPANDED SET
(2,000+ extracts)

OPEN KNOWLEDGE MANAGEMENT
ON NATURAL PRODUCTS



Rutz A, et al. 2022,
eLife 11:e70780,
[10.7554/eLife.70780](https://doi.org/10.7554/eLife.70780)

BIOACTIVITY SCREENING

> Anti-infectious > Pro-metabolic

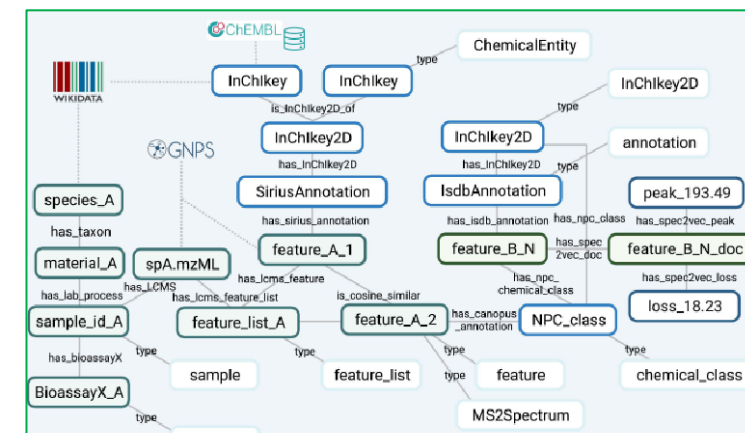


Pr. Thierry Soldati

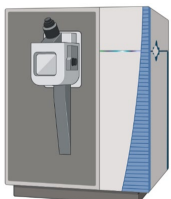


Pr. Christian Wolfrum

SYSTEMATIC METABOLITE ANNOTATION



DEEP METABOLOMICS



Exploris

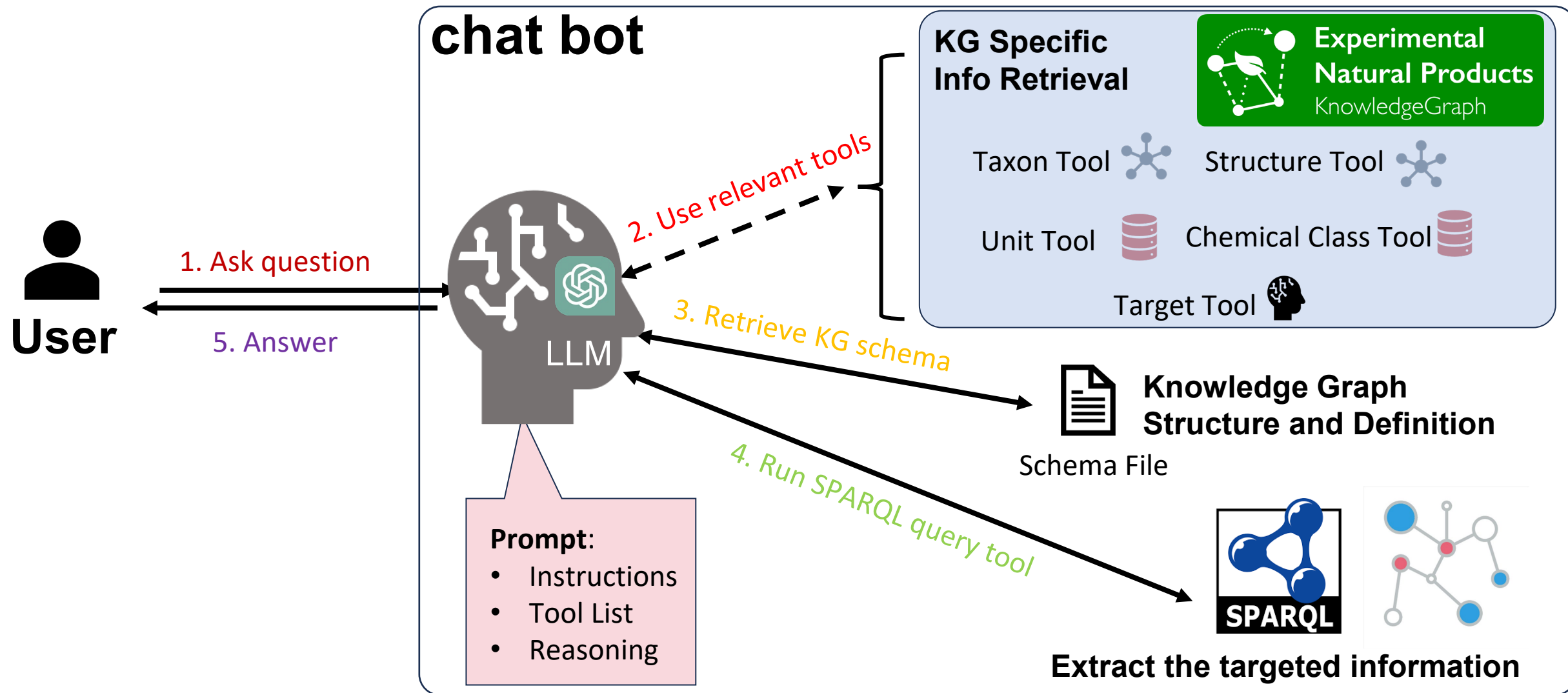
Iterative Optimized
LC-HRMS/MS

Zuo et al, et al. 2021, *Bioinformatics*, p
i231-i236
[10.1093/bioinformatics/btab279](https://doi.org/10.1093/bioinformatics/btab279)

Experimental
Natural Products
KnowledgeGraph

Gaudry A, et al. ChemRxiv July 2023,
[10.26434/chemrxiv-2023-sljbt](https://doi.org/10.26434/chemrxiv-2023-sljbt)

Louis-Félix Nothias, Emma Tysinger *et al.*



Successful interactions

Louis-Félix Nothias, Emma Tysinger *et al.*



Filter the pos ionization mode features of the *Melochia umbellata* taxon annotated as [M+H]⁺ by SIRIUS to keep the ones for which a feature in neg ionization mode is detected with the same retention time (+/- 3 seconds) and a mass corresponding to the [M-H]⁻ adduct (+/- 5ppm).



Here are the positive ionization mode features of the *Melochia umbellata* taxon annotated as [M+H]⁺ by SIRIUS that have a corresponding feature in negative ionization mode detected with the same retention time (+/- 3 seconds) and a mass corresponding to the [M-H]⁻ adduct (+/- 5ppm):

2-3 minutes

Cost: 0.3€

1. [Positive feature](#) and [Negative feature](#)
2. [Positive feature](#) and [Negative feature](#)
3. [Positive feature](#) and [Negative feature](#)
4. [Positive feature](#) and [Negative feature](#)
5. [Positive feature](#) and [Negative feature](#)
6. [Positive feature](#) and [Negative feature](#)

The SPARQL query used to retrieve this information is as follows:

```
PREFIX enpkg: <https://enpkg.common-s-lab.org/kg/>
PREFIX enpkg_module: <https://enpkg.common-s-lab.org/module/>
SELECT DISTINCT ?posFeature ?negFeature
WHERE {
  ?extract a enpkg:LabExtract .
  FILTER(?extract = <https://enpkg.common-s-lab.org/kg/VGF156_A06>) .
  ?extract enpkg:has_LCMS ?posLCMS .
```

Partially successful interactions

Louis-Félix Nothias et al.



For features from the *Melochia umbellata* taxon in positionization mode with SIRIUS annotations, get the ones for which a feature in negionization mode with the same retention time (+/- 3 seconds) has the same SIRIUS annotation by comparing the InChIKey 2D. Return the features, retention times, and InChIKey2D



I'm sorry, but the results from the query are too long to display here. You can run the SPARQL query manually to get the results to your question. Here is the SPARQL query:

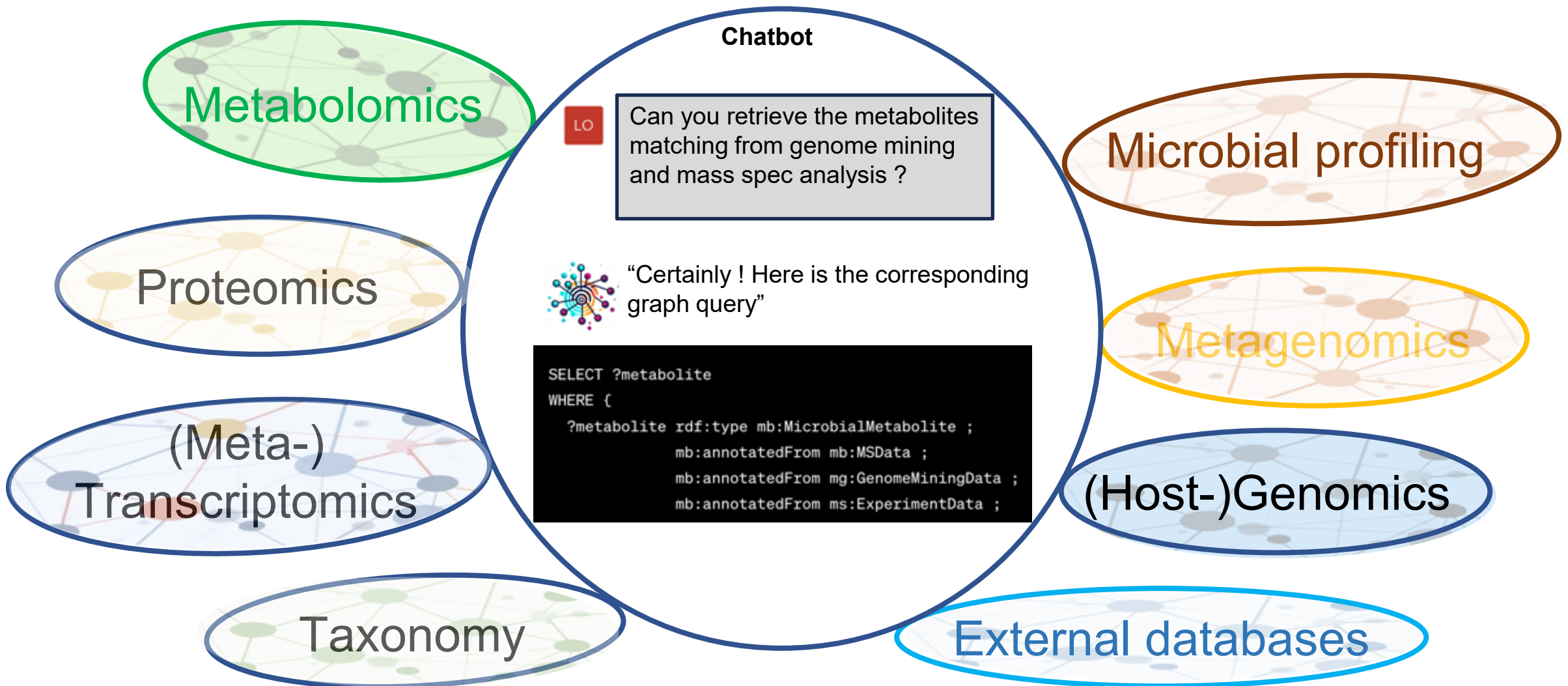


```
PREFIX enpkg: <https://enpkg.common-lab.org/kg/>
PREFIX enpkg_module: <https://enpkg.common-lab.org/module/>

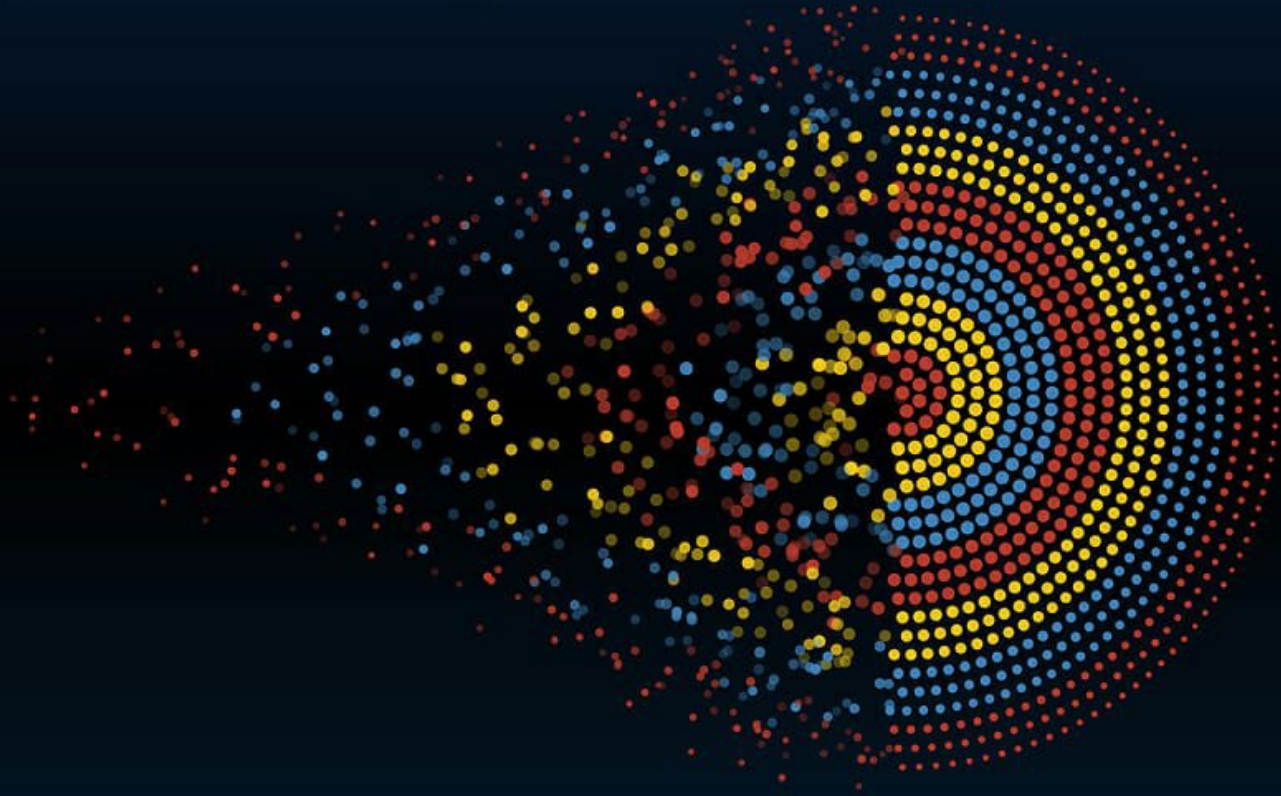
SELECT DISTINCT ?feature_pos ?rt_pos ?inchikey2d_pos ?feature_neg ?rt_neg ?inchikey2d_neg
WHERE {
  ?extract a enpkg:LabExtract .
  FILTER(?extract = <https://enpkg.common-lab.org/kg/VGF156_A06>)
  ?extract enpkg:has_LCMS ?lcms_pos .
  ?lcms_pos a enpkg:LCMSAnalysisPos .
  ?lcms_pos enpkg:has_lcms_feature_list ?fl_pos .
  ?fl_pos enpkg:has_lcms_feature ?feature_pos .
  ?feature_pos enpkg:has_sirius_annotation ?annotation_pos .
  ?annotation_pos enpkg:has_InChIkey2D ?inchikey2d_pos .
  ?feature_pos enpkg:has_retention_time ?rt_pos .
```

5 minutes
Cost: 0.5€

Holobiont-wide multi-omics integration using artificial intelligence

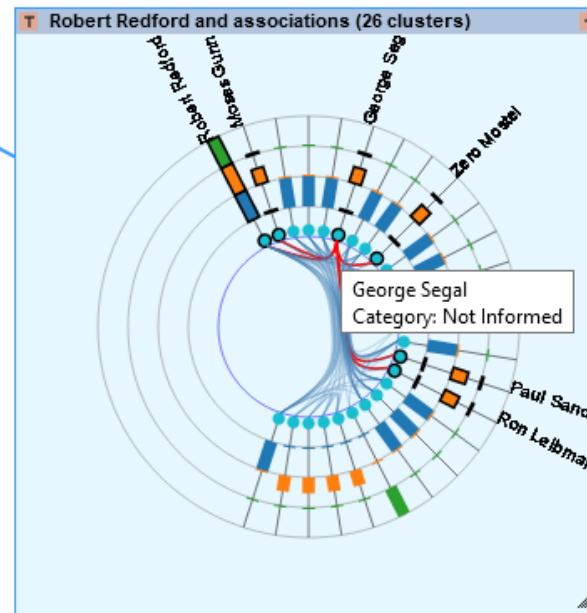
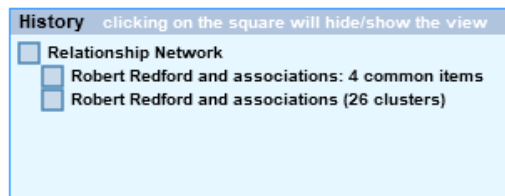
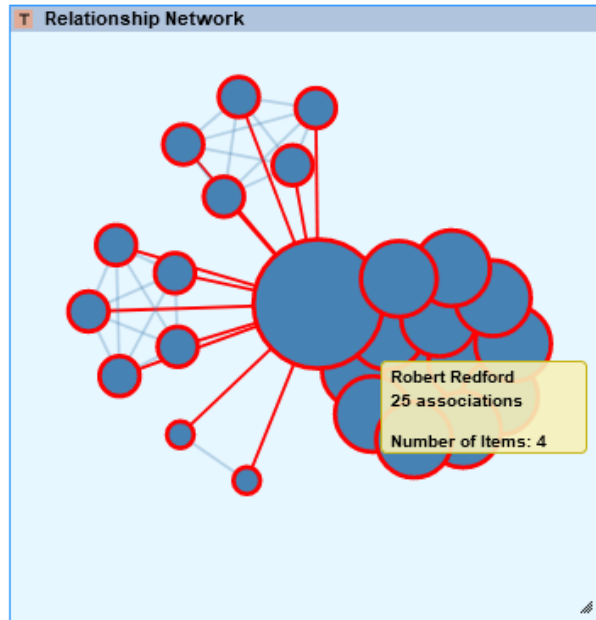


AI & HCI for human knowledge augmentation



Visual Mining of RDF Graphs [Menin, Winckler, et al. 2022]

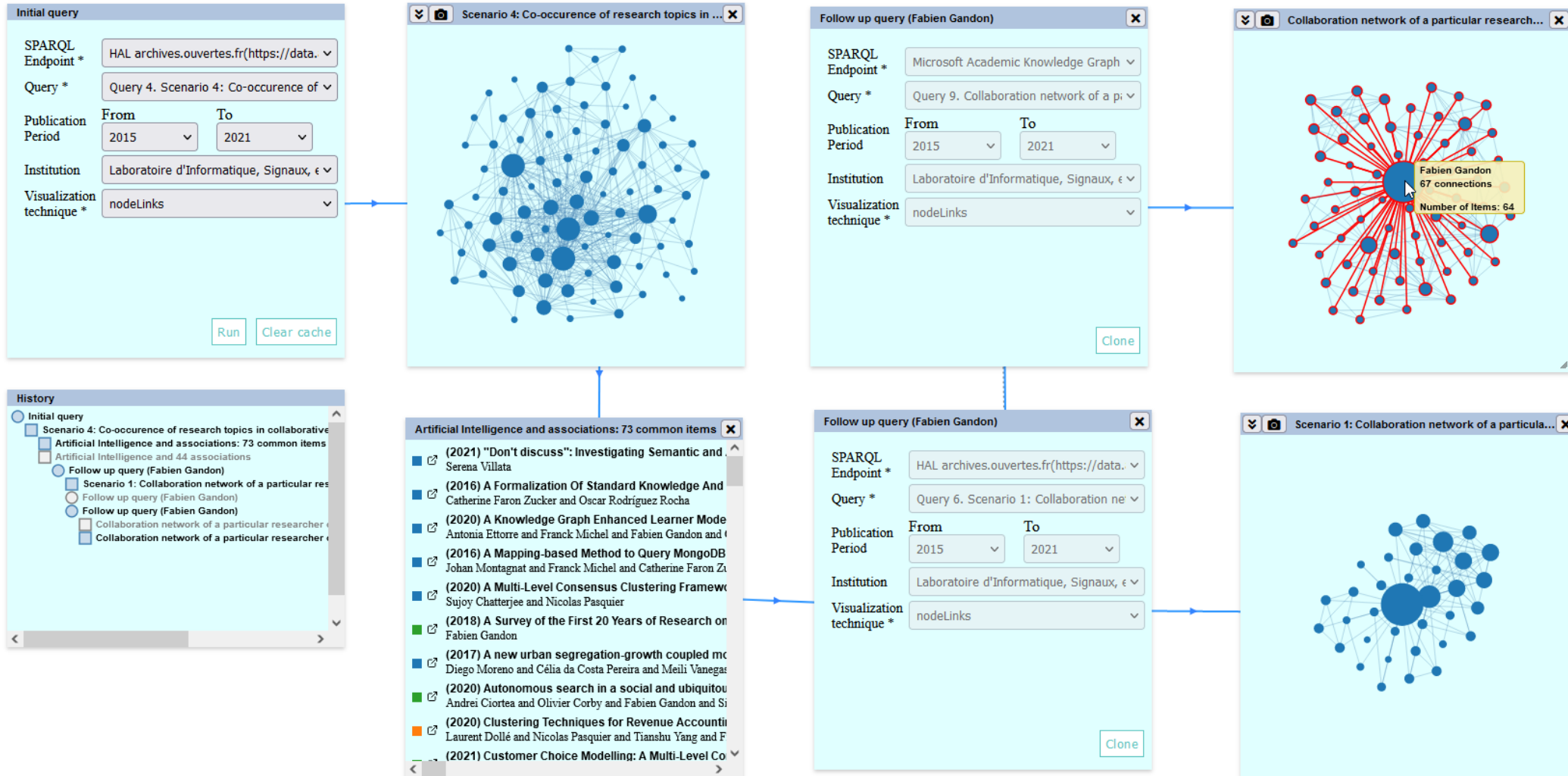
Co-starring network of Robert Redford (source DBPedia)



```
select * where {  
  ?x rdfs:label "Robert Redford"@en.  
  ?p dbo:starring ?x, ?a1, ?a2;  
  rdfs:label ?label;  
  dbp:released ?date ;  
  dbp:genre ?type .  
  
  ?a1 rdfs:label ?s .  
  ?a2 rdfs:label ?o .  
  filter (?a1 != ?a2)  
}
```

Incremental Data Exploration

Follow-up Queries to dynamically import data into the visualization during the exploratory process [Menin, Winckler, et al. 2022]



Data Quality exploration [Tikat, et al. 2022]

missing data, duplicated data, erroneous data

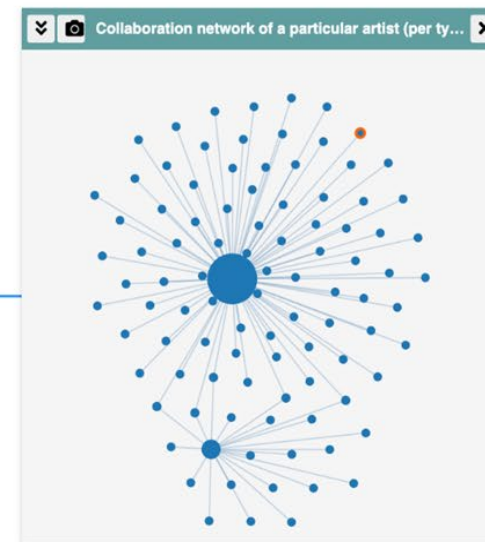
Initial query

SPARQL Endpoint * Wasabi(<http://wasabi.inria.fr/sparc> ▼)

Query * Query 3. Collaboration network of of ▼

Visualization technique * nodeLinks ▼

Run Clear cache



Pitbull (rapper) and associations: 4 common items X

- Michael Jackson, Not known, Pitbull (rapper), Not known
- Michael Jackson, Not known, Pitbull (rapper), Not known
- Michael Jackson, Not known, Pitbull (rapper), Not known
- Michael Jackson, Not known, Pitbull (rapper), Not known

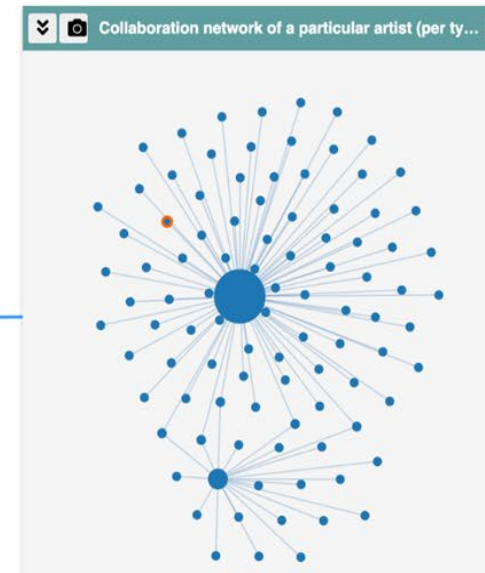
Initial query

SPARQL Endpoint * Wasabi(<http://wasabi.inria.fr/sparc> ▼)

Query * Query 3. Collaboration network of of ▼

Visualization technique * nodeLinks ▼

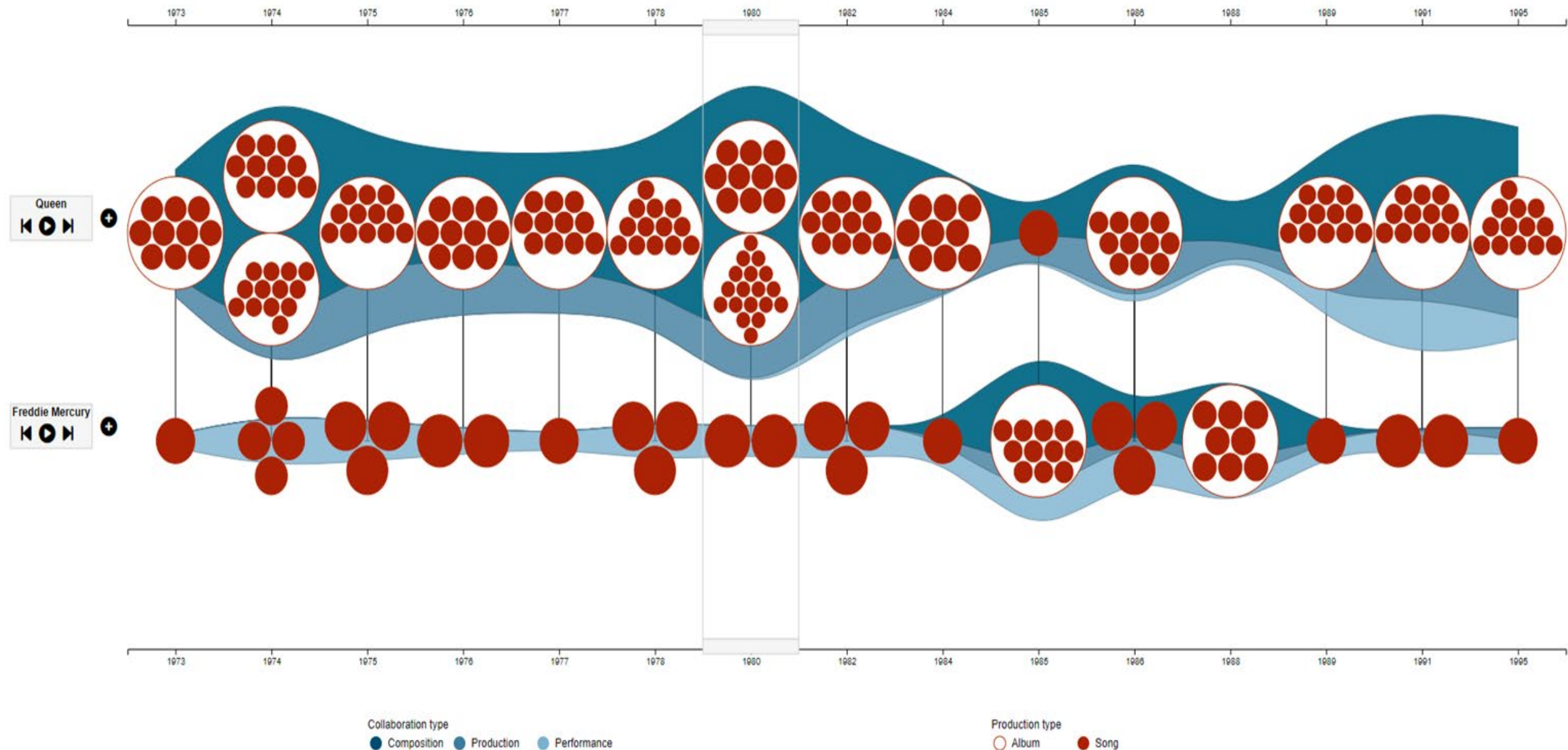
Run Clear cache



Justin Timberlake and associations: 1 common item X

- Michael Jackson, Not known, Not known, Not known, Not

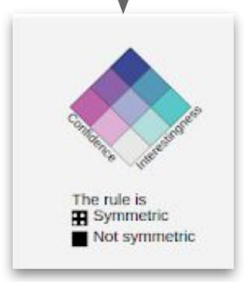
Temporal exploration: WASABI discography visualizations [Tikat, et al. 2022]



Visualization of Association found in Covid dataset

[Menin, Cadorel, Tettamanzi, Winckler]

a) Legend



b) Data Filtering

Data Filtering

Clusters

- No Clustering
- of papers
- of terms
- of papers and terms

Terms

select from the list

Measures of Interest

- Confidence 0.7 - 1
- Interestingness 0.3 - 1
- Symmetric Rules
- Non-Symmetric Rules

c) Data Sorting

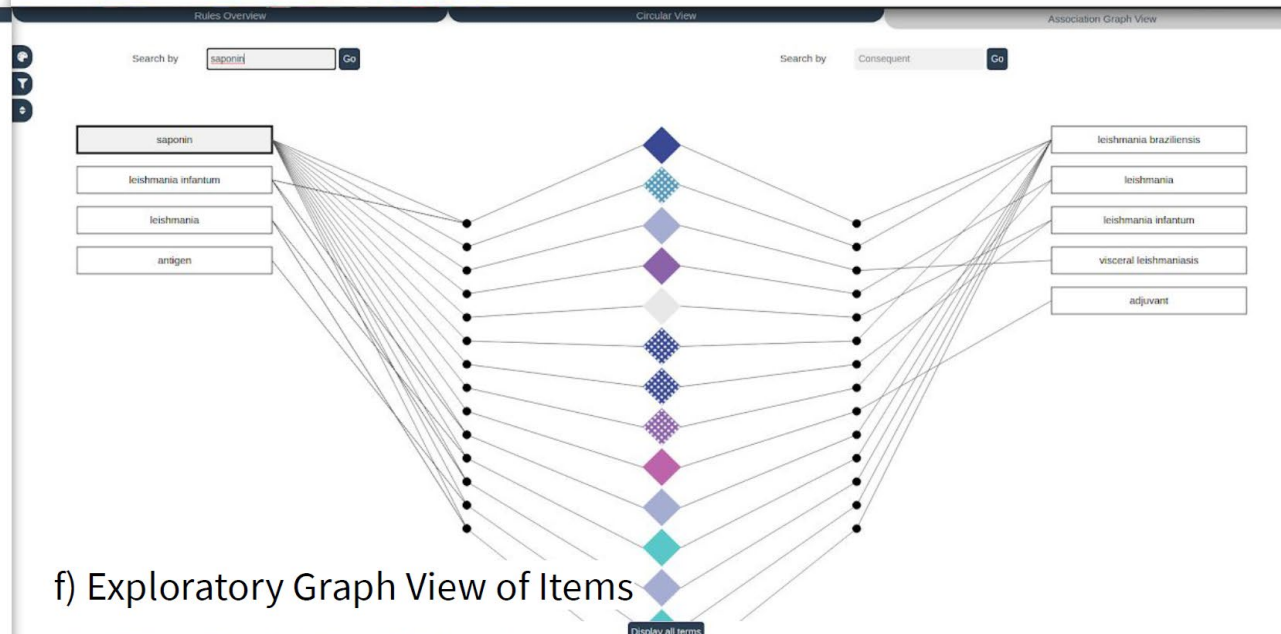
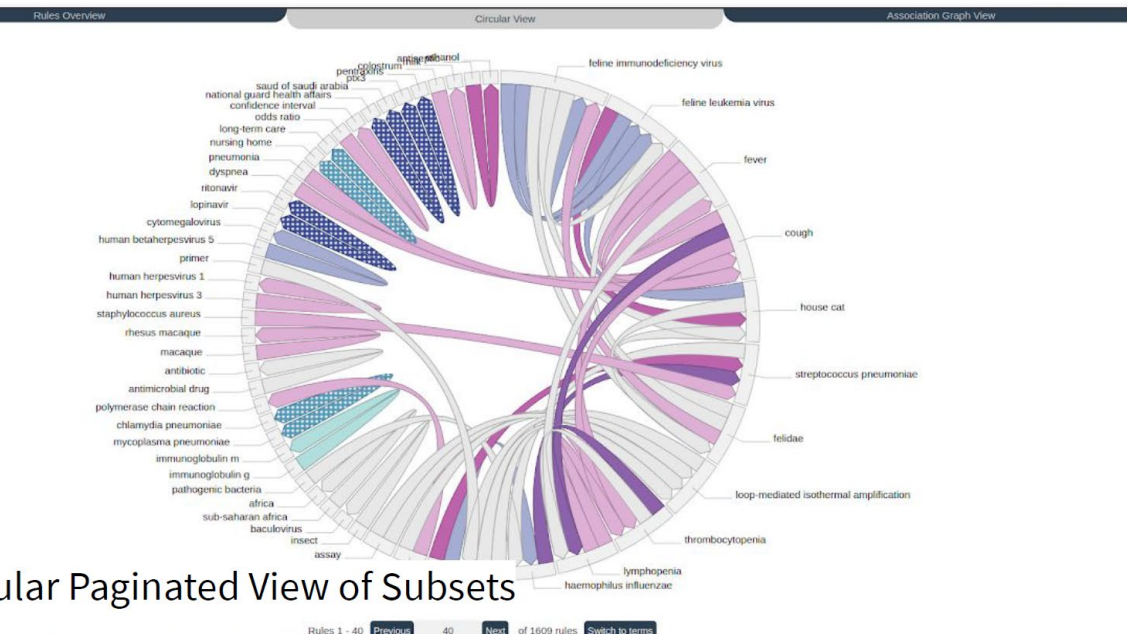
Data Sorting

Sort terms by

Number of Rules

Sort rules by

None



Conclusion: the growing potential of knowledge graphs





“Knowledge is power” *Sir Francis Bacon*

and only now are you reading this top left text... predictable means manipulable

You will read this first

Then you will read this...

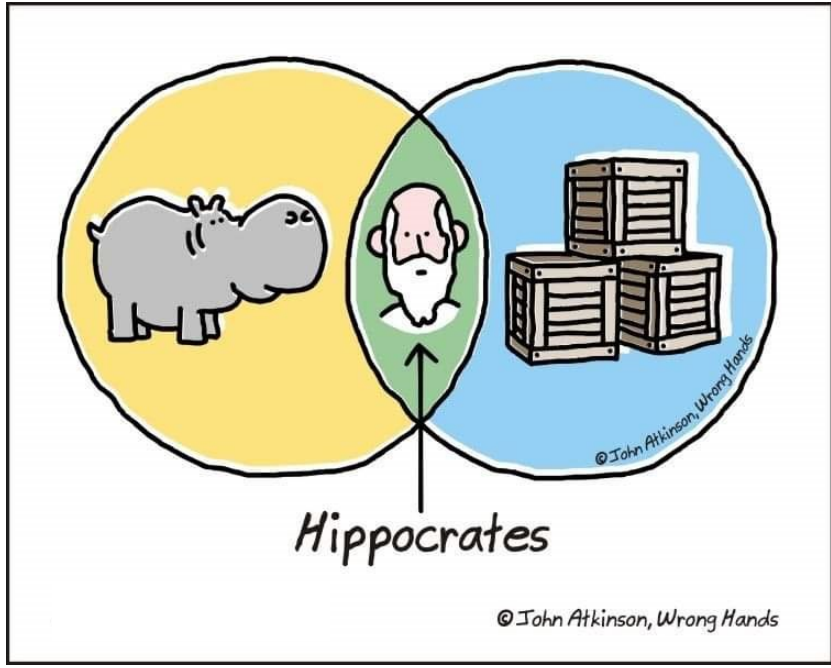
Then this...

target useful and beneficial...

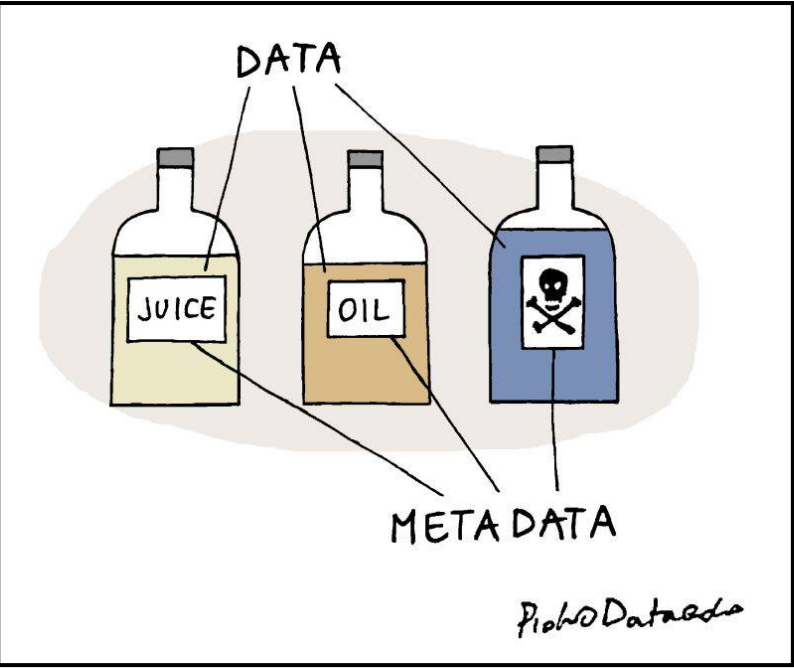
KNOWLEDGE



ONTOLOGIES



(META)DATA



**benevolent & beneficial AI by design
and not the opposite**



Pay Attention: a Call to Regulate the Attention Market and Prevent Algorithmic Emotional Governance

Franck Michel¹, Fabien Gandon²

¹University Côte d'Azur, CNRS, Inria

²University Côte d'Azur, Inria, CNRS

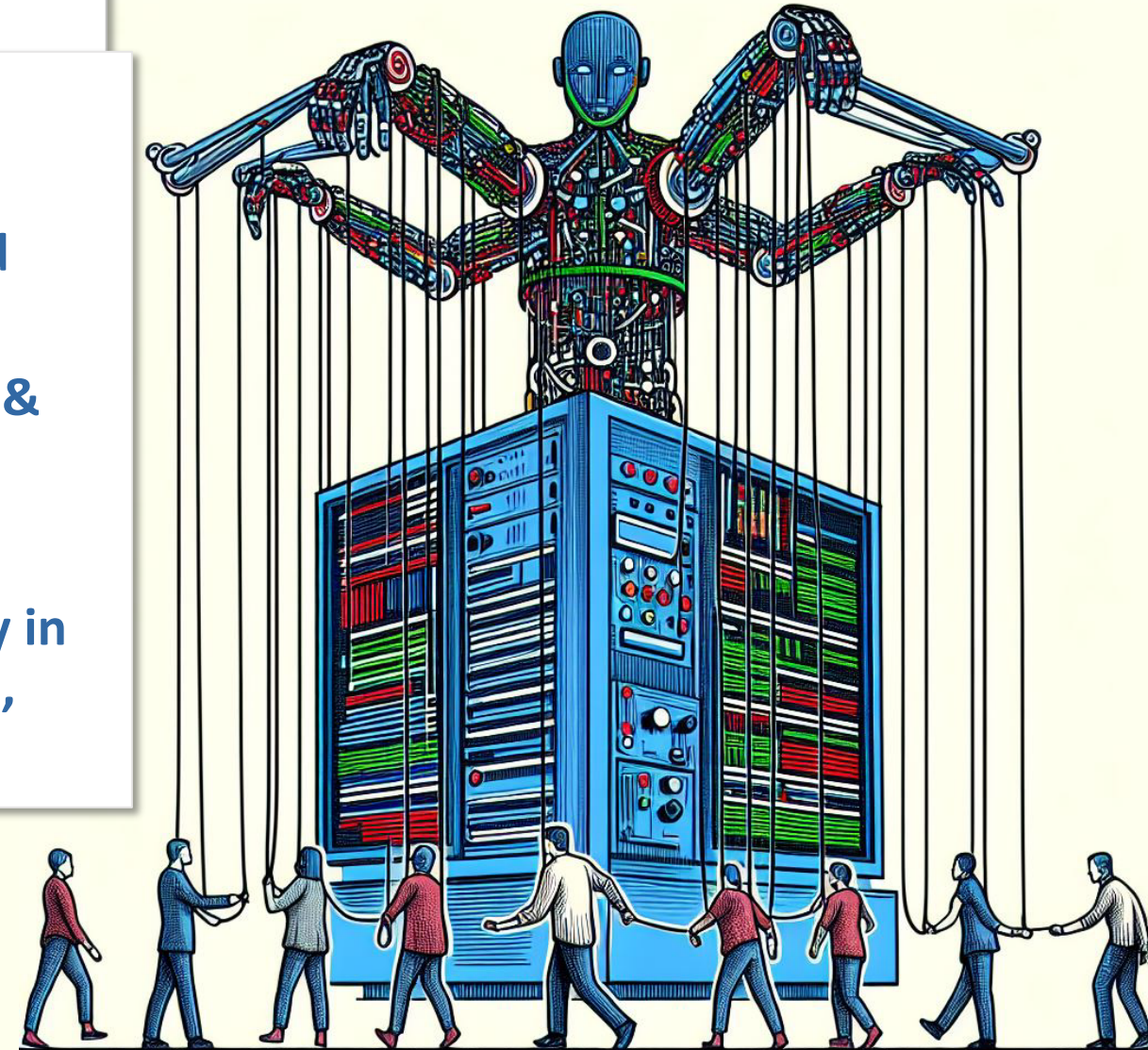
franck.michel@inria.fr, fabien.gandon@inria.fr

Abstract

Over the last 70 years, we, humans, have created an economic market where attention is being captured and turned into money thanks to advertising. During the last two decades, leveraging research in psychology, sociology, neuroscience and other domains, Web platforms have brought the process of capturing attention to an unprecedented scale. With the initial commonplace goal of making targeted advertising more effective, the generalization of attention-capturing techniques and their use of cognitive biases and emotions have multiple detrimental side effects such as polarizing opinions, spreading false information and threatening public health, economies and democracies. This is clearly a case where the Web is not used for the common good and where, in fact, all its users become a vulnerable population. This paper brings together contributions from a wide range of disciplines to analyze current practices and consequences thereof. Through a set of propositions and principles that could be used to drive further works, it calls for actions against these practices competing to capture our attention on the Web, as it would be unsustainable for a civilization to allow attention to be wasted with impunity on a world-wide scale.

[AIES AAAI, 2024]

- Question multiple disciplines
- Analyse practices and consequences
- Provide propositions & principles
- Call for actions
- KG have a role to play in tracing, documenting, explaining,... AI





“Knowledge is power” *Sir Francis Bacon*



“Code is law” *Lawrence Lessig*

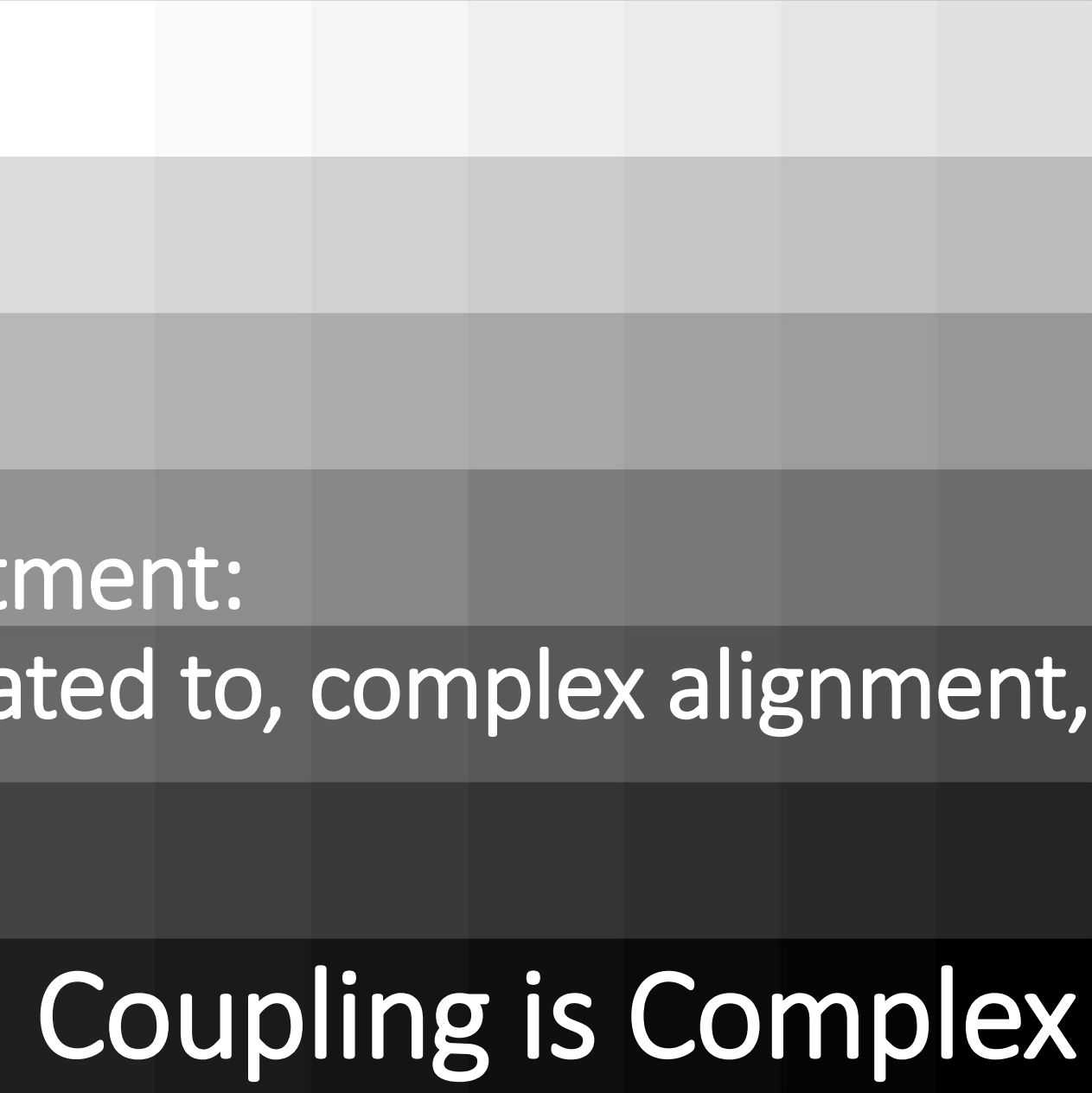
Terms & Conditions vs...



<http://conversation.which.co.uk/technology/length-of-website-terms-and-conditions/>

...Ontological Commitment

- ontological commitment vs introduction of bias vs informed consent
- an ontological commitment includes an informed consent
- tension : complexity of a commitment vs ergonomic interaction



50 shades of commitment:
extend, same As, related to, complex alignment, ...

Knowledge-level Coupling is Complex



“Knowledge is power” *Sir Francis Bacon*



“Code is law” *Lawrence Lessig*



“Knowledge encoding is a power law” *me* 😊

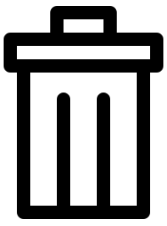
A decorative graphic consisting of a light gray, rounded rectangular shape that tapers to the right, positioned at the bottom right of the text.

How to perform Sustainable/Frugal/Affordable Knowledge Augmentation ?

- Should Knowledge acquisition be designed to be both for the machine and for us ?
- Can we reconcile user-centric and reusable knowledge engineering?
- How to avoid unknown/low quality or spammed knowledge bases?
- Should we work on knowledge lossy compression, aggregation, summary, forgetting?

...





Knowledge without intelligence is a highly perishable resource.



Intelligence without knowledge is doomed to stagnation.



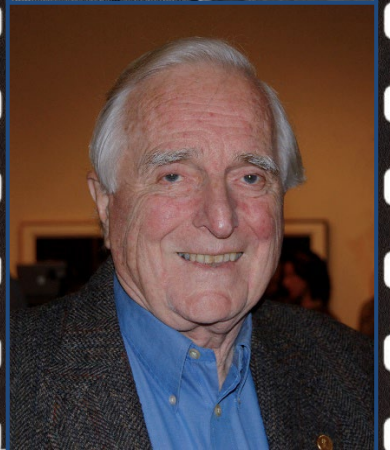
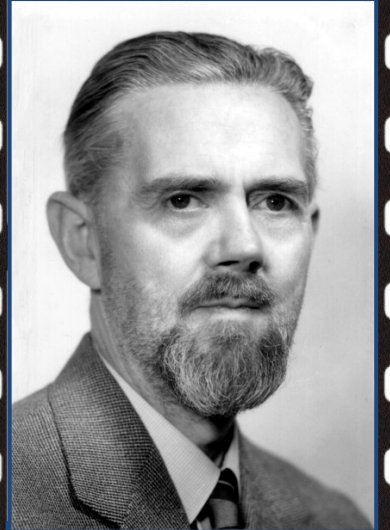
Intelligence, knowledge and their evolutions, have to be considered jointly

p@osition

AI for **Artificial Intelligence** (McCarthy et al., 1955)

AI & IA

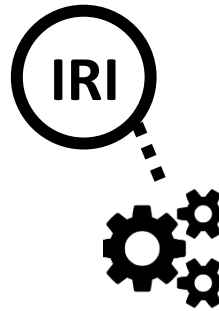
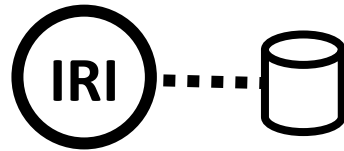
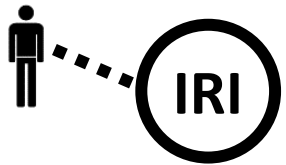
IA for **Intelligence Amplification** (Ashby, 1956) and
Intelligence Augmentation (Engelbart, 1962)



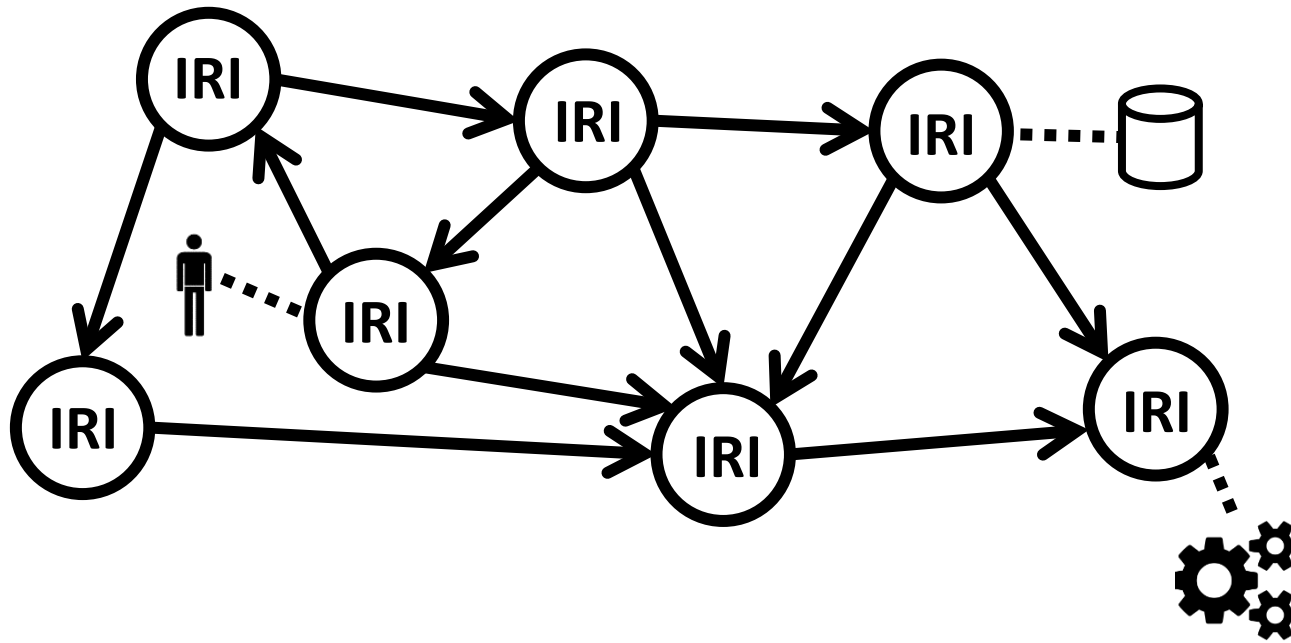
A WEB OF KGs IDENTIFYING EVERYTHING

IRI & RESOURCES

identify on the **networks** anything we want



A WEB OF KGS LINKING ALL (META)DATA



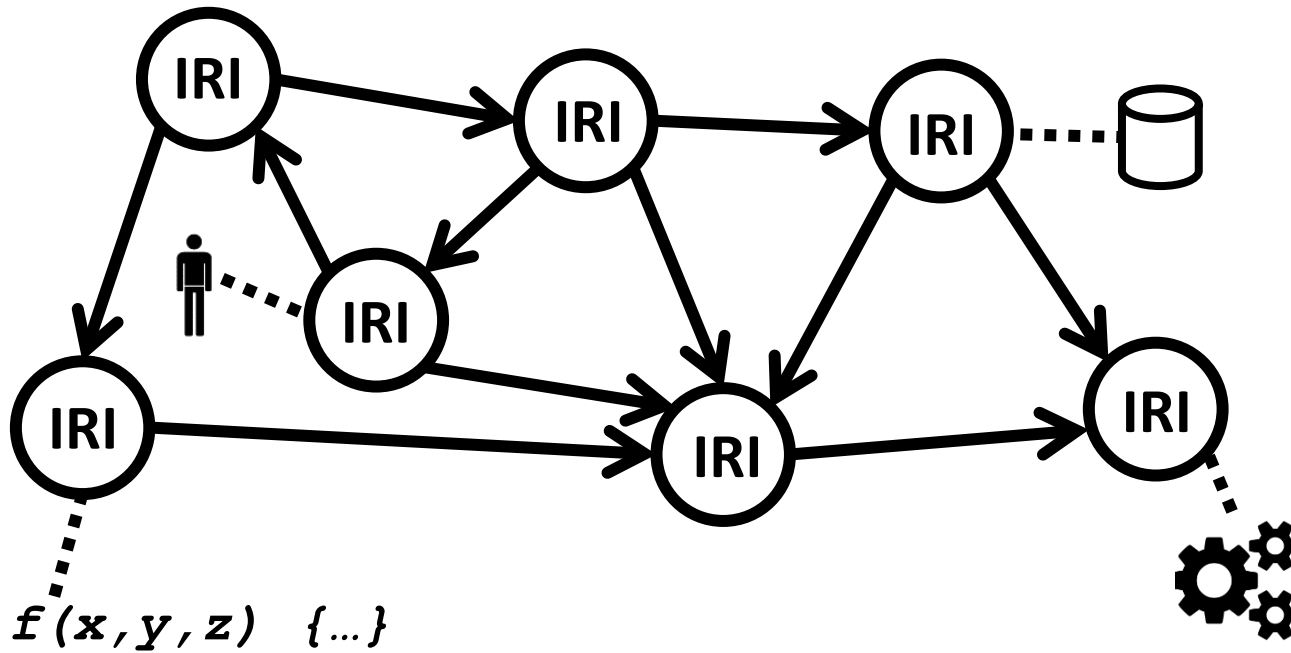
IRI & RESOURCES

identify on the **networks** anything we want

RDF & LINKED DATA

decentralized (meta)data **networks**

A WEB OF KGS LINKING ALL COMPUTATIONS



IRI & RESOURCES

identify on the **networks** anything we want

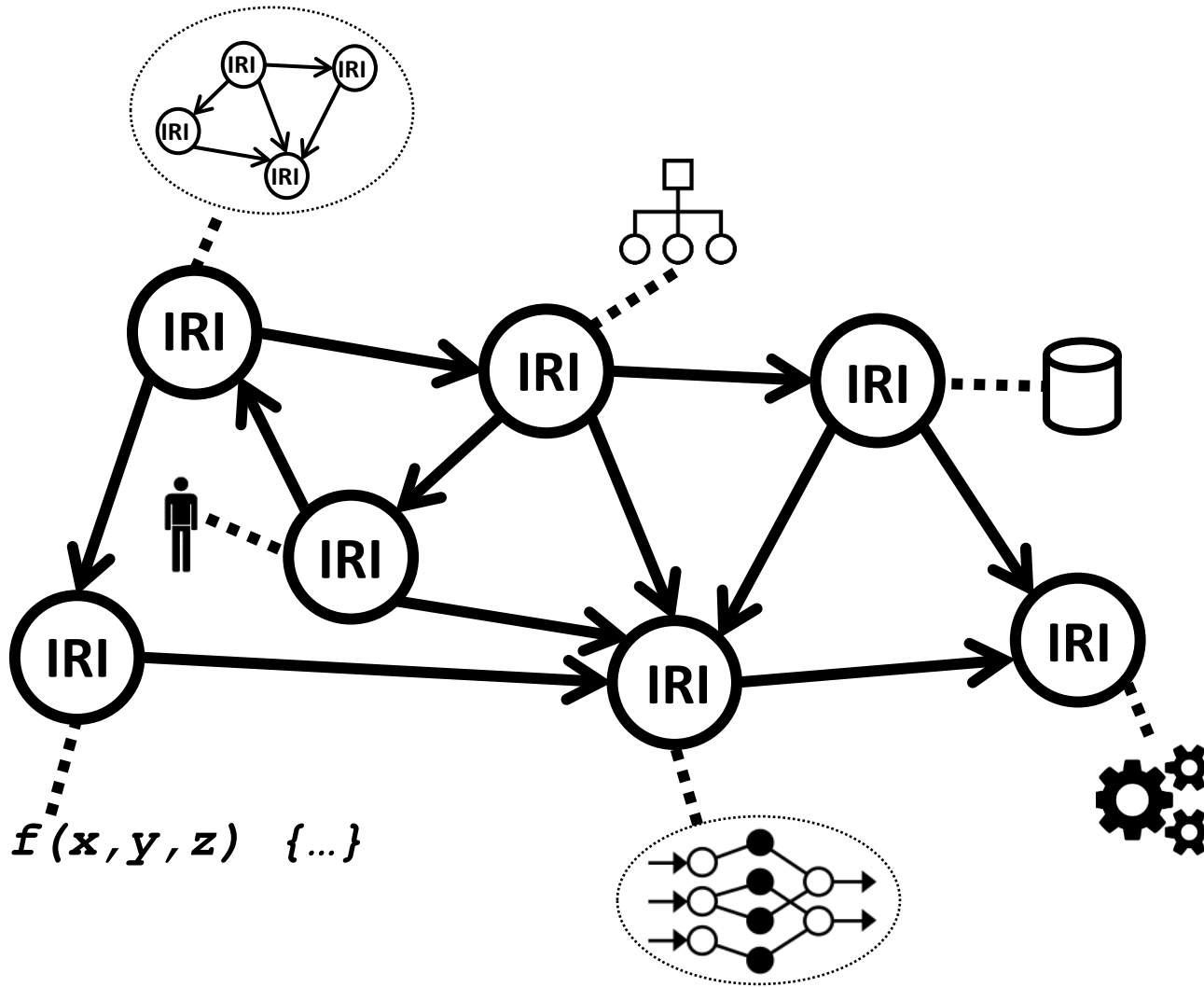
RDF & LINKED DATA

decentralized (meta)data **networks**

REST & LINKED COMPUTATIONS

decentralized computation **networks**

A WEB OF KGs LINKING ALL (COMPLEX) NETWORKS



IRI & RESOURCES

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RDF & LINKED DATA

decentralized (meta)data **networks**

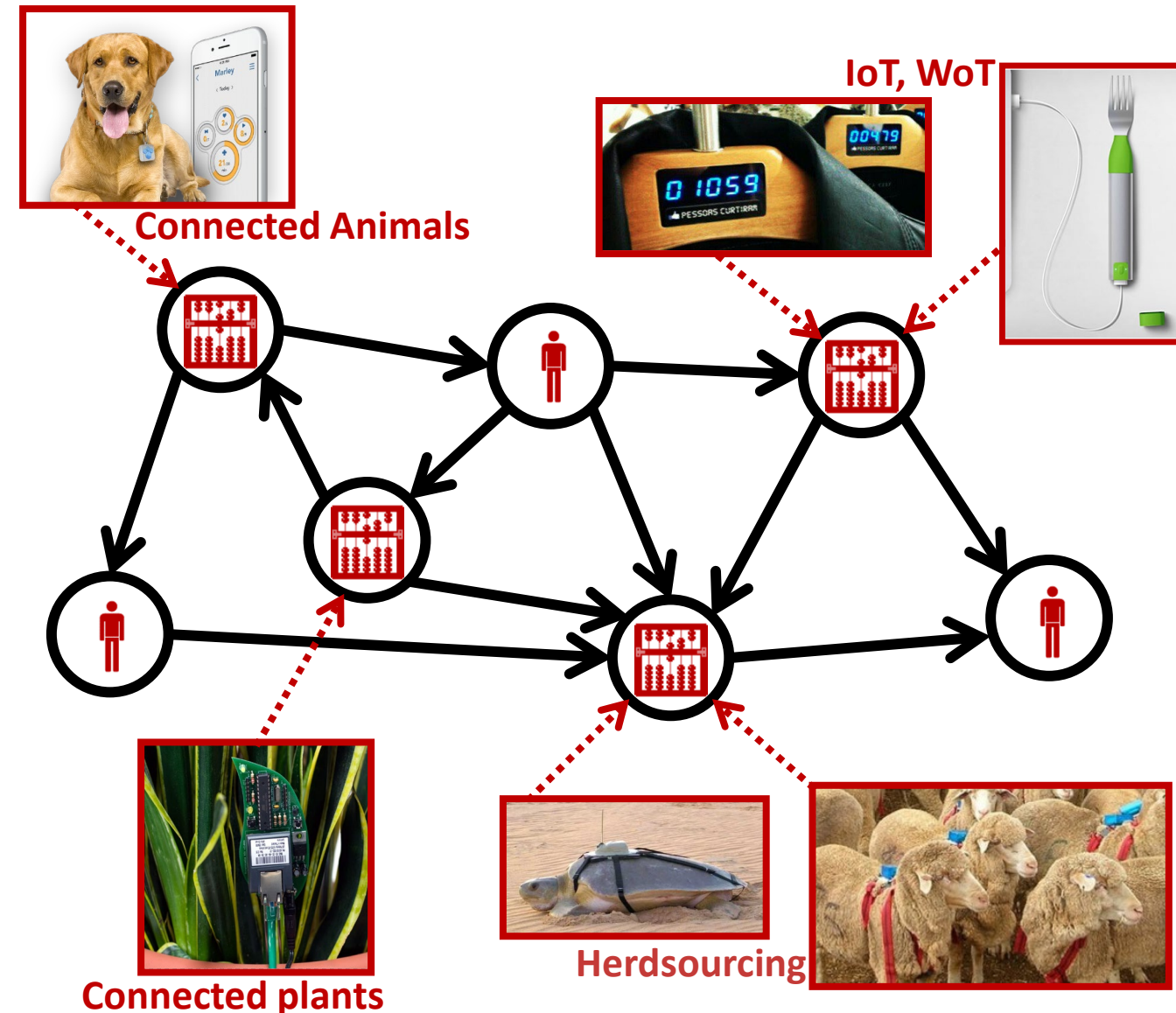
REST & LINKED COMPUTATIONS

decentralized computation **networks**

ONTOLOGIES & LINKED SEMANTICS

extensible **network** of models

A WEB OF KGs LINKING ALL KINDS OF INTELLIGENCE



IRI & RESOURCES

identify on the **networks** anything we want

RDF & LINKED DATA

decentralized (meta)data **networks**

REST & LINKED COMPUTATIONS

decentralized computation **networks**

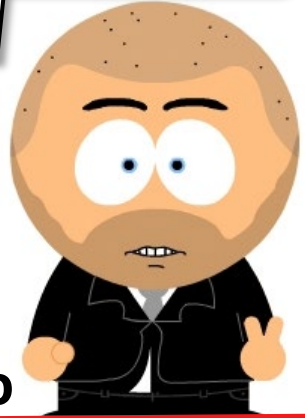
ONTOLOGIES & LINKED SEMANTICS

extensible **network** of models

AFFORDANCES & LINKED INTERFACES

extensible **network** of agents

he who controls metadata, controls the web
and through the *world-wide* web many things in our world.



Fabien Gandon - @fabien_gandon - <http://fabien.info>

Web-instrumented man-machine interactions, communities and semantics
Technical details: <http://bit.ly/wimmics-papers>



sophia antipolis