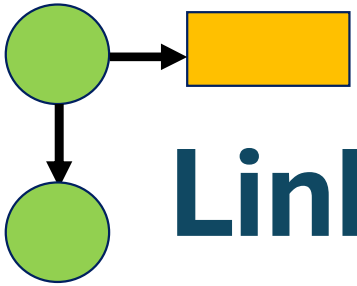

# Linked data for libraries

## An introduction

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last revised: 2024-10-17

# Agenda

- What is linked data?
- Why linked data for libraries?
- Examples

- Linked data basics
  - RDF triple, serialization, triplestore, SPARQL and vocabulary

## Semantic web and linked data

**Linked data** was coined in 2006 by **Tim Berners-Lee**, the founder of the World Wide Web.

He advocated the idea of **semantic web**, in which resources (data) are published and linked on the Web according to a set of principles.

**Linked data principles**

- Use **URI**s as names for **things**
- Use **HTTP** URIs so that people can **look up** those names
- When someone looks up a URI, **provide useful information, using the (web) standards** (RDF, SPARQL)
- **Include links** to other URIs so that they can **discover** more things

https://www.w3.org/DesignIssues/LinkedData.html

# Linked data facilitates semantic inference

**Given** the following knowledge that is structured as linked data (each line is a triple):

```
:oxford :locatedIn :oxfordshire.
:oxfordshire :locatedIn :england.
:england :locatedIn :uk.
```

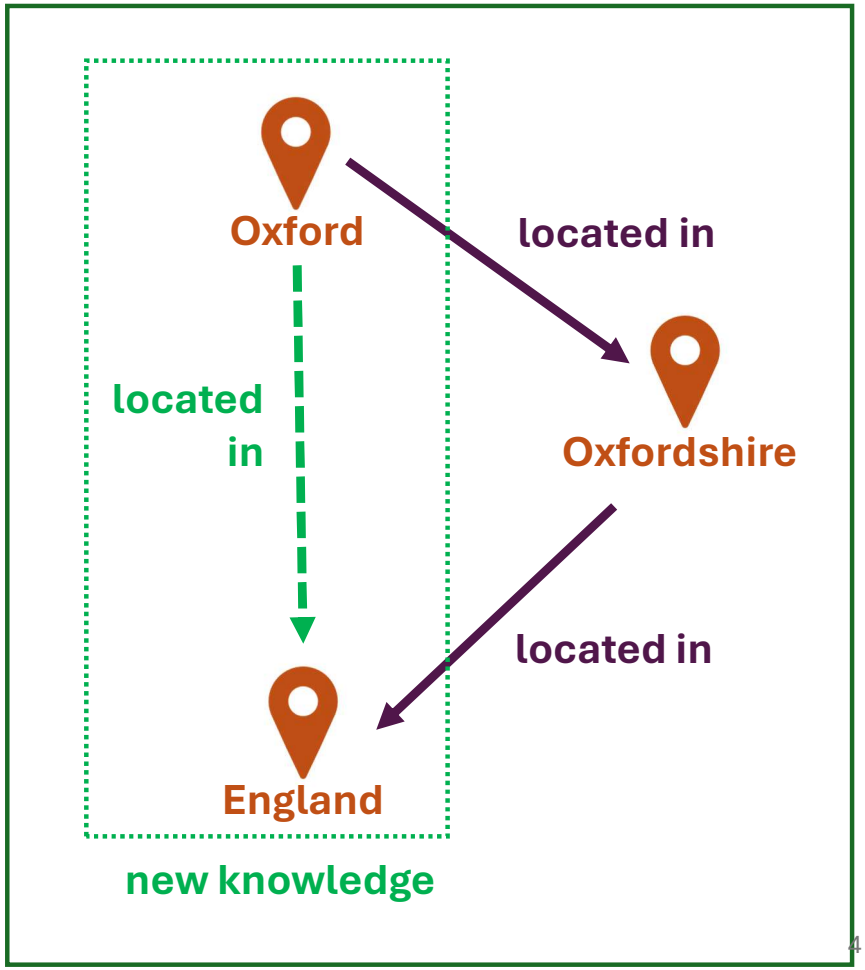
and **a rule**:
**IF (:a :locatedIn :b) AND (:b locatedIn :c)**
**THEN (:a :locatedIn :c)**

then machines can **infer** and generate the following **new knowledge**:

```
:oxford :locatedIn :england.
:oxford :locatedIn :uk.
:oxfordshire :locatedIn :uk.
```

Example from: https://docs.oxfordsemantic.tech/reasoning.html

## Reasoning by inference

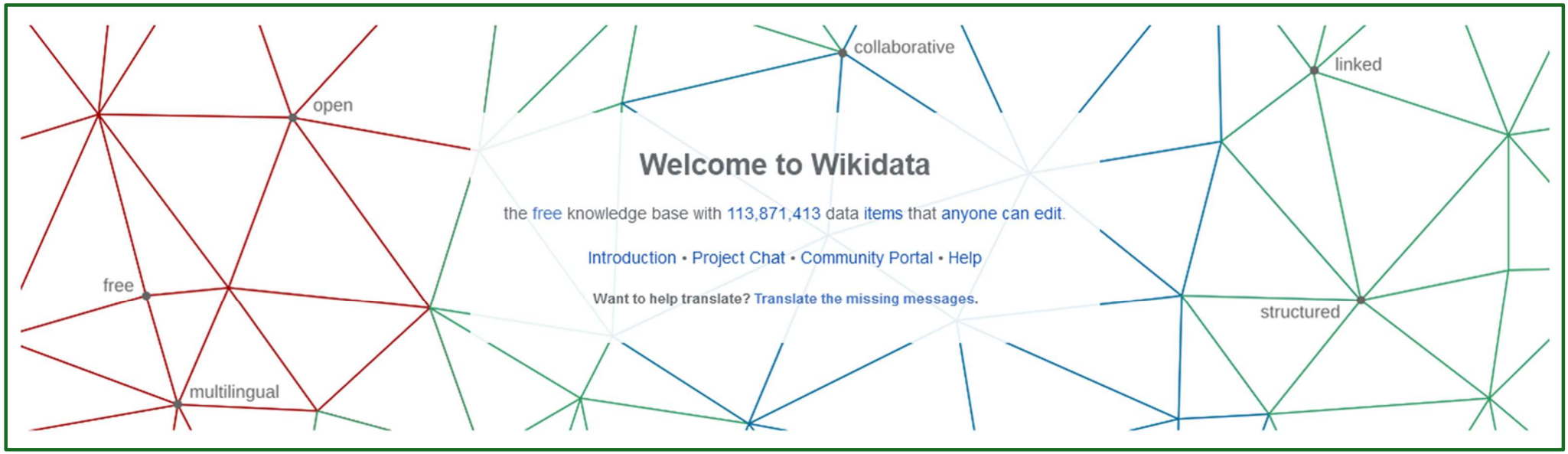


# Wikidata – an example of linked data

**Wikidata** is a huge dataset published as linked data on the Web. It is also known as **Linked Open Data** as it is openly accessible by anyone.

https://www.wikidata.org

**An open, free, multilingual, structured, linked and collaborative knowledge base**

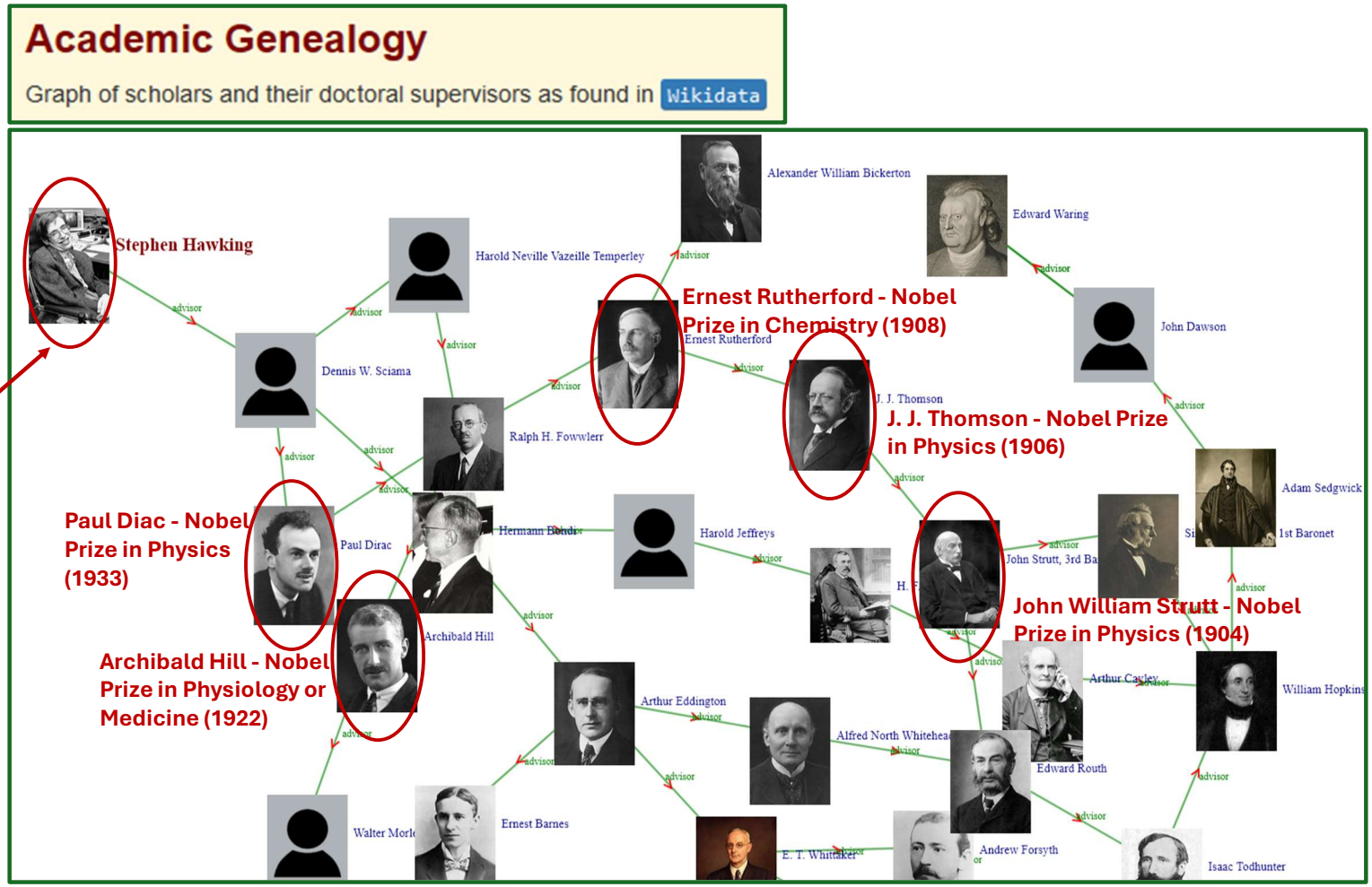



**Example**: Item of **Stephen Hawking**: <http://www.wikidata.org/entity/Q17714>

# Aggregating and blending linked data

Data from linked data sources, such as Wikidata, can be **aggregated** to give **new insights**.

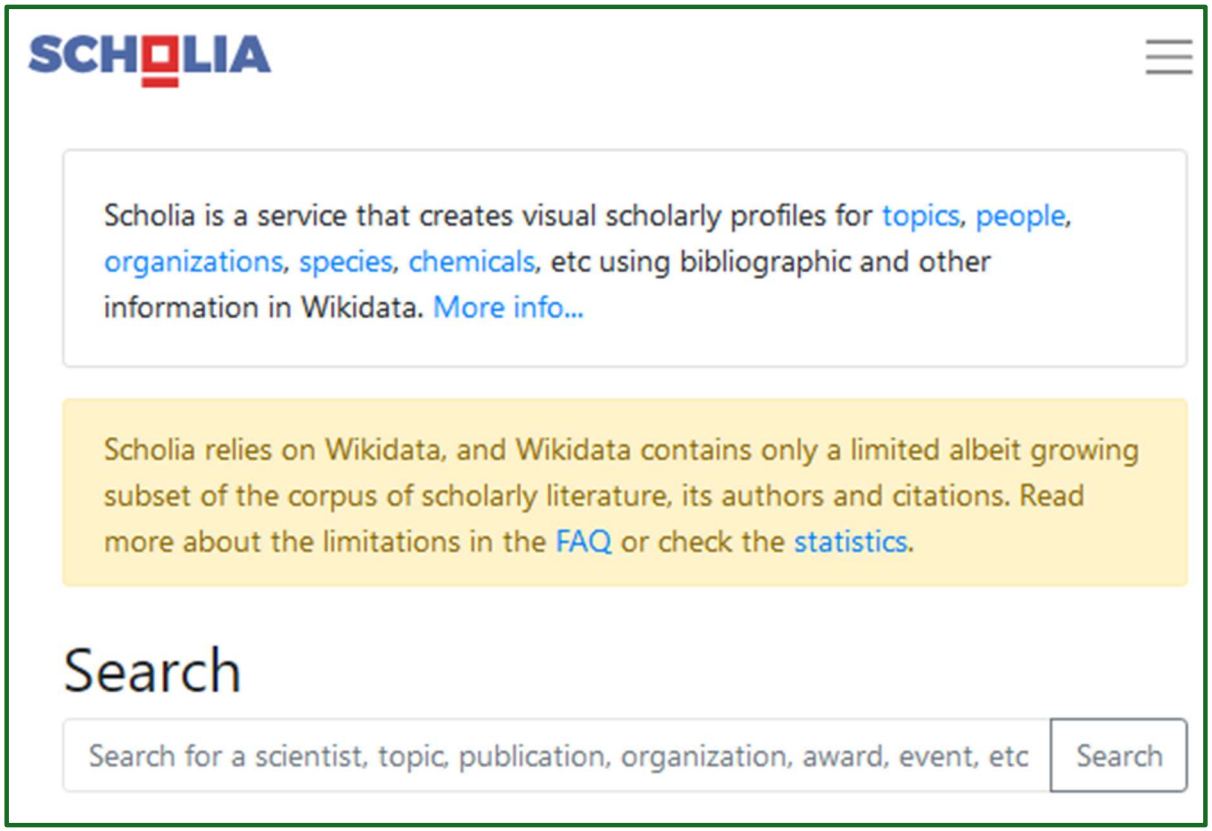
**Academic genealogy of Stephen Hawking**




https://www.sls.org.hk:8443/ktdemo/ag/ag.php?qnum=q17714

# Aggregating and blending linked data [cont.]

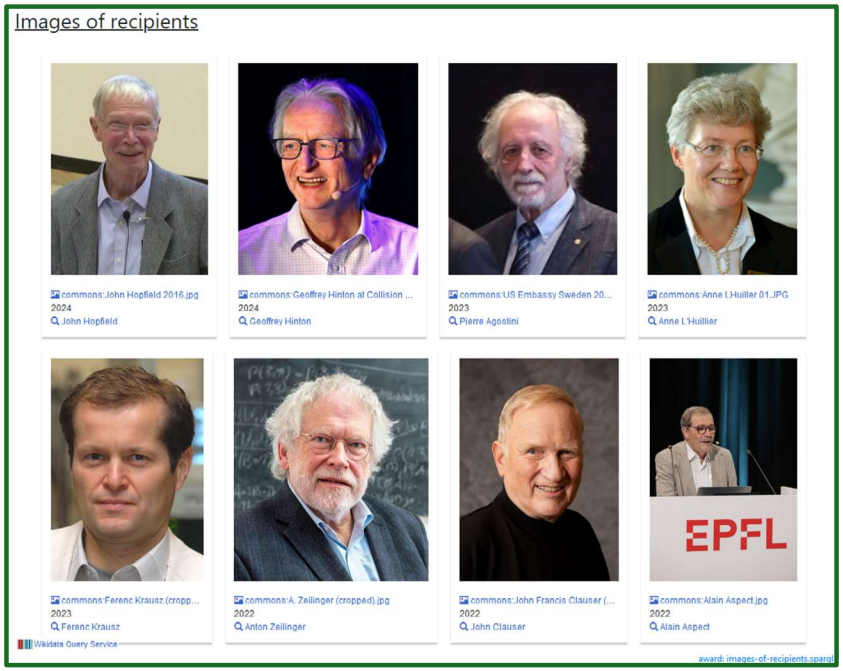
**Scholia** – aggregates scholarly information in Wikidata




https://scholia.toolforge.org

**Nobel Prize in Physics**

https://scholia.toolforge.org/award/Q38104

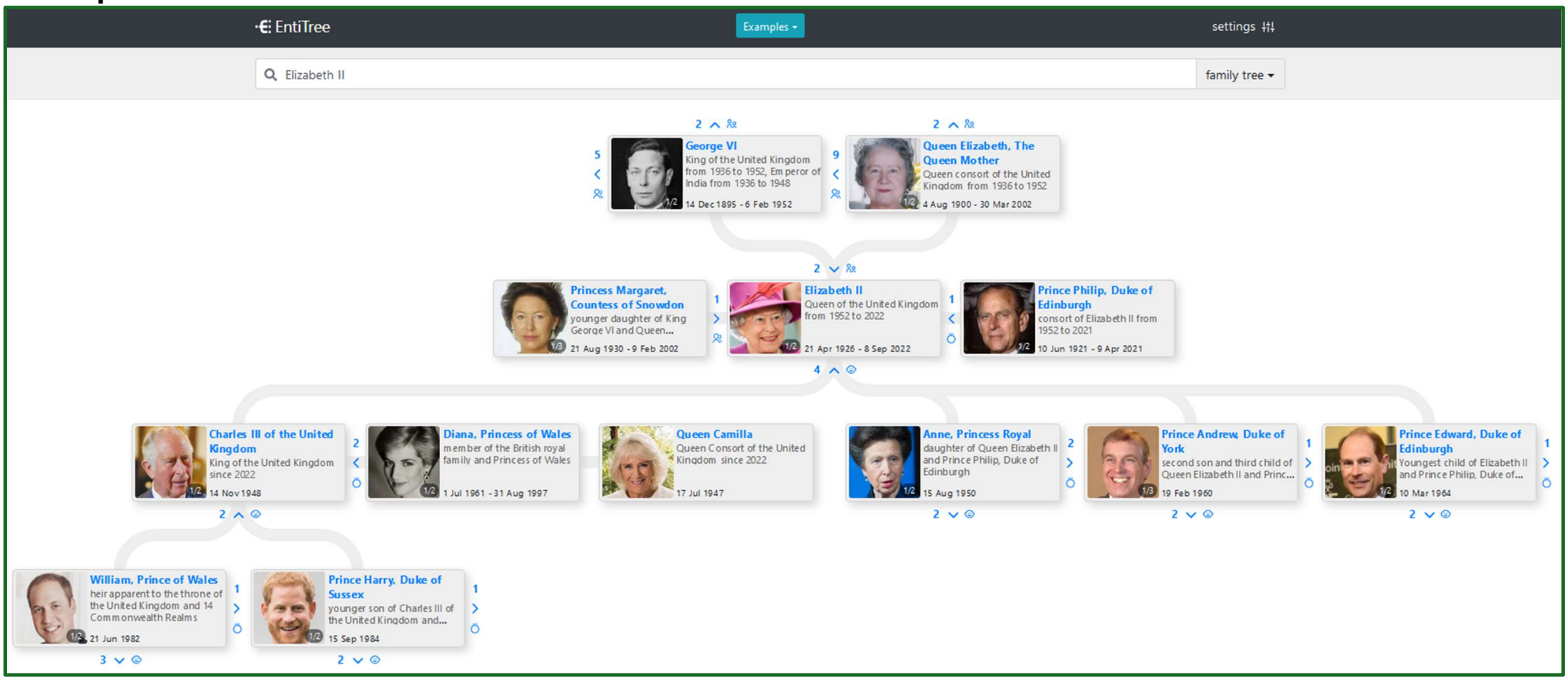


# Aggregating and blending linked data [cont.]

**EntiTree** – an application that blends Wikidata content into its websites

**Example: Elizabeth II**

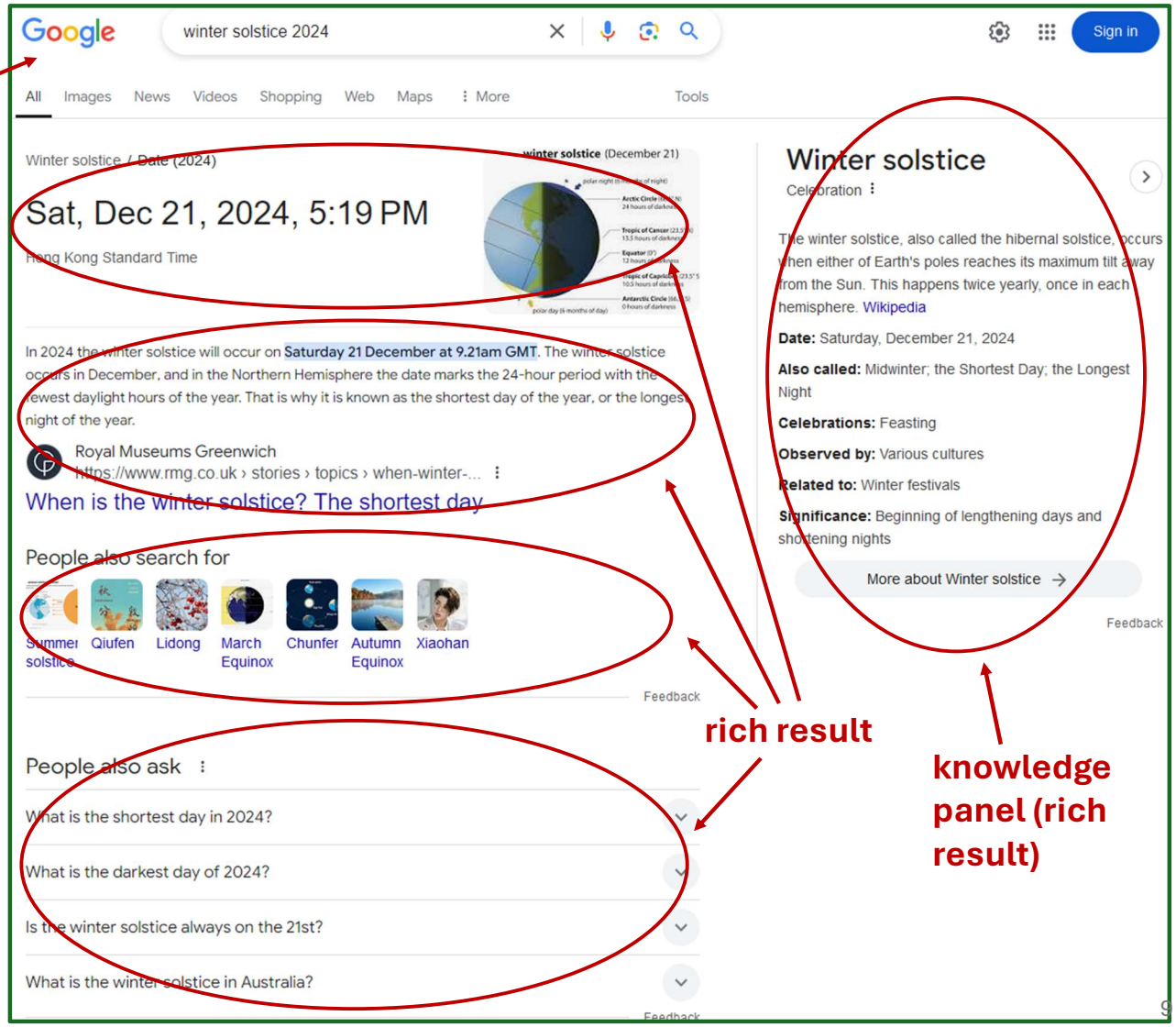
https://www.entitree.com/en/family_tree/Elizabeth_II



# Google Knowledge Graph

Google maintains a database of linked (structured) data known as **Knowledge Graph**.

It serves content of knowledge panel and other rich results that are found in a Google Search Result Page.

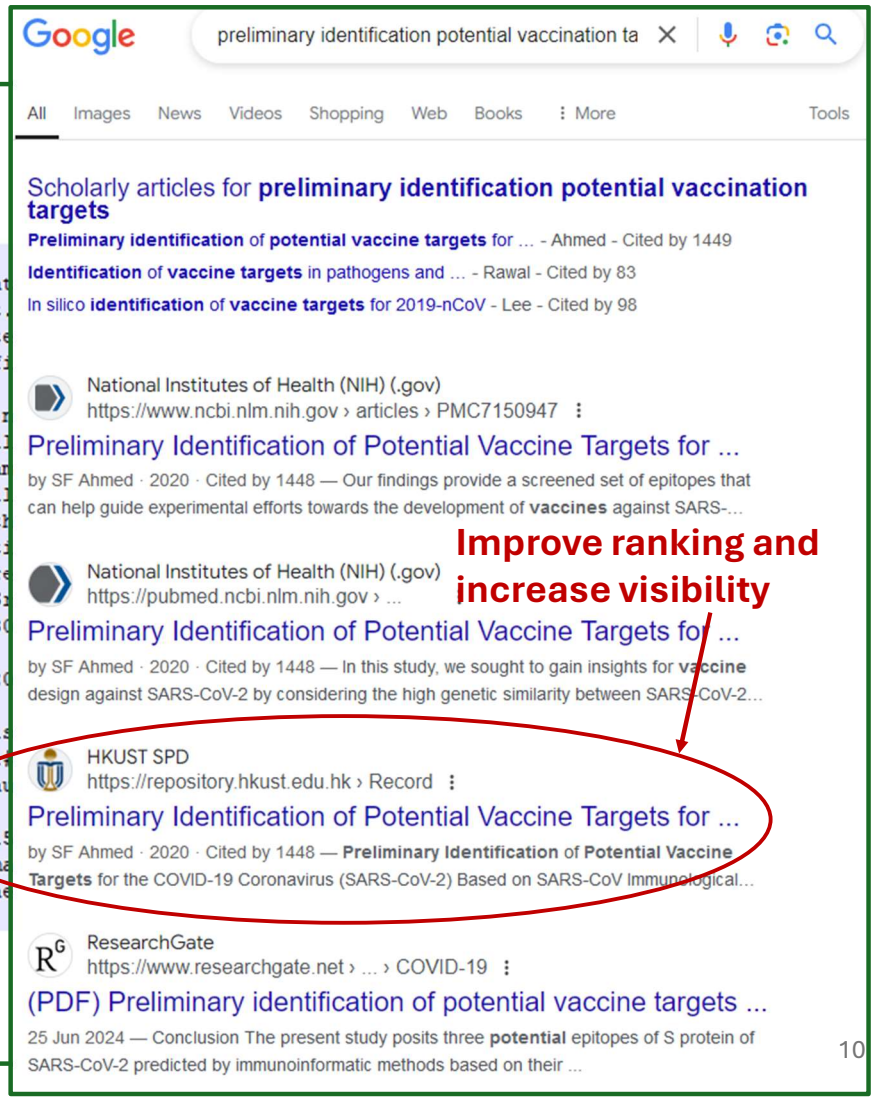


# Linked data for Search Engine Optimization (SEO)

https://repository.hkust.edu.hk/ir/Record/1783.1-101451

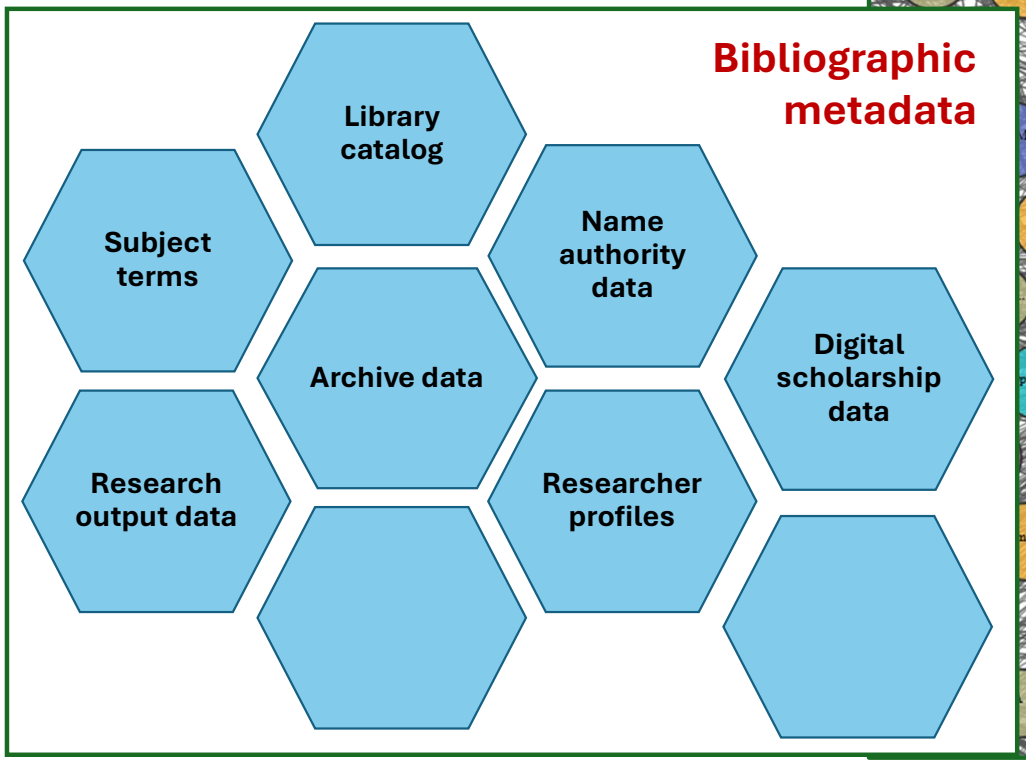
```
<!DOCTYPE html>
<html>
<head>...</head>
.
.
.
<script
type="application/ld+json">{"@context":{"schema":"http:\/\/schema.org\/","spditem":"ht
file":"https:\/\/repository.ust.hk\/profile\/","spdfunding":"https:\/\/repository.ust.
erpa.ac.uk\/id\/publication\/"},"@graph":[{"@type":"schema:CreativeWork","@id":"spdite
:\/\/repository.ust.hk\/ir\/Record\/1783.1-101451","schema:name":"Preliminary Identifi
the COVID-19 Coronavirus (SARS-CoV-2) Based on SARS-CoV Immunological
Studies","schema:author":[{"@type":"schema:Person","@id":"spdprofile:X19424","schema:n
Faraz","schema:affiliation":{"@type":"schema:Organization","@id":"spditem:101451#Affil
HKUST"}},{"@type":"schema:Person","@id":"spdprofile:16129","schema:name":"Quadeer, Ahm
Abdul","schema:affiliation":{"@type":"schema:Organization","@id":"spditem:101451#Affil
HKUST"}},{"@type":"schema:Person","@id":"spdprofile:11106","schema:name":"Mckay, Matth
R","schema:affiliation":{"@type":"schema:Organization","@id":"spditem:101451#Affiliati
HKUST"}}],"schema:datePublished":"2020","schema:sameAs":["https:\/\/www.scopus.com\/re
-85081251137","https:\/\/gateway.isiknowledge.com\/gateway\/Gateway.cgi?GWVersion=2&Sr
Type=FullRecord&DestApp=WOS&KeyUT=000525486800026","https:\/\/doi.org\/10.3390\/v12030
2020 has seen the emergence of COVID-19 outbreak caused by a novel
coronavirus...","schema:inLanguage":"en","schema:about":["Coronavirus","2019-nCoV","20
coronavirus","SARS-CoV-2","COVID-19","SARS-CoV","MERS-CoV","T cell epitopes","B cell
epitopes","vaccine"],"schema:identifier":["rgc-funded","oa-article","oa-version-Publis
:"article","schema:isPartOf":{"@type":"schema:PublicationIssue","@id":"spditem:101451
(3), 25 February 2020, article number 254","schema:issueNumber":"v. 12 (3), article nu
February
2020","schema:isPartOf":{"@type":"schema:Periodical","@id":"spditem:101451#Periodical
:"1999-4915","schema:offers":{"@type":"schema:Offer","@id":"romeopub:17528"}}},"schema
12\/3\/254\/pdf","schema:funder":[{"@type":"schema:Grant","@id":"spdfunding:grf","sche
ema:Grant","@id":"spdfunding:hkpfs"}]}]}</script>
.
.
.
</body>
</html>
```

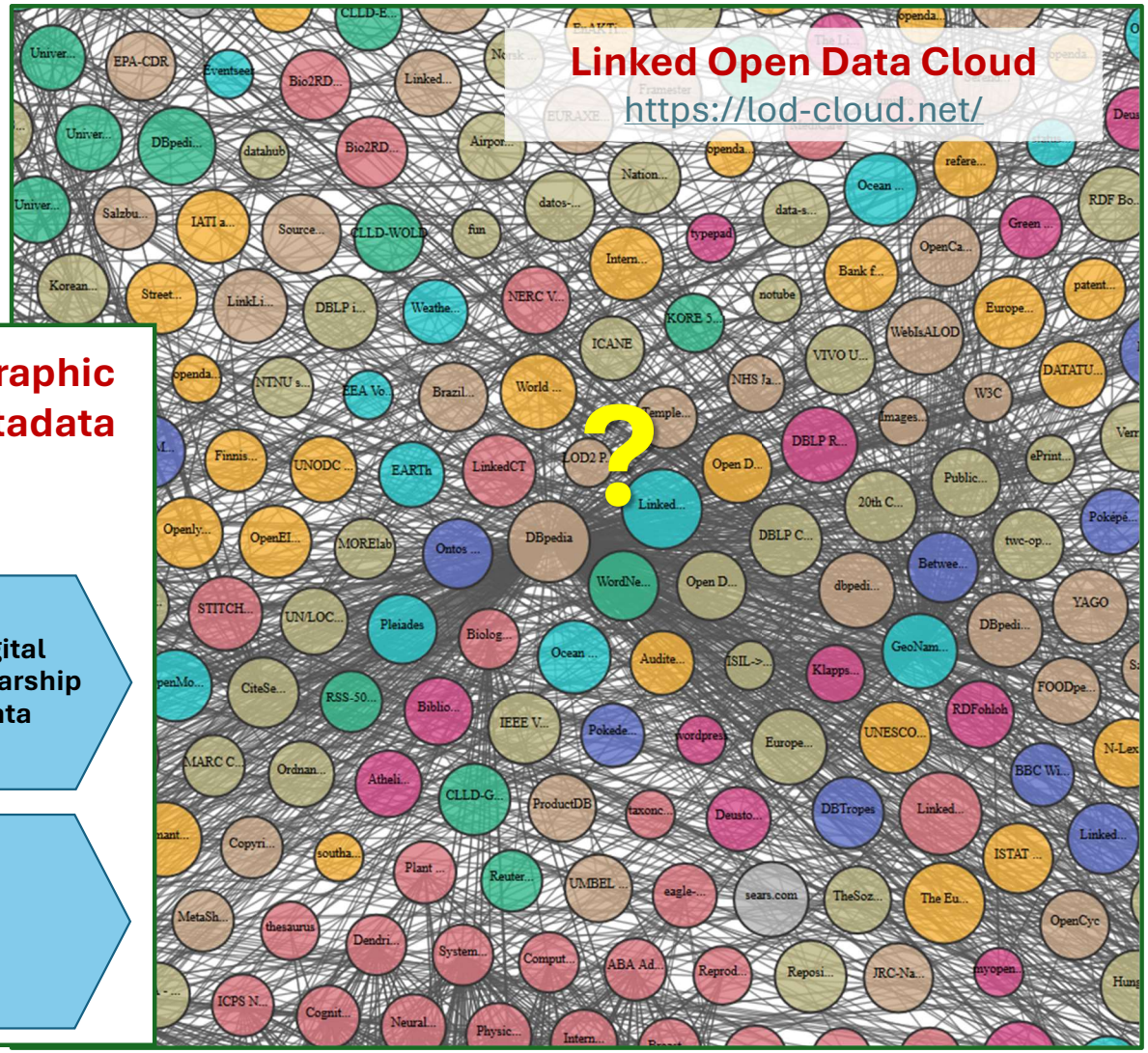
**Embed linked data in web page**



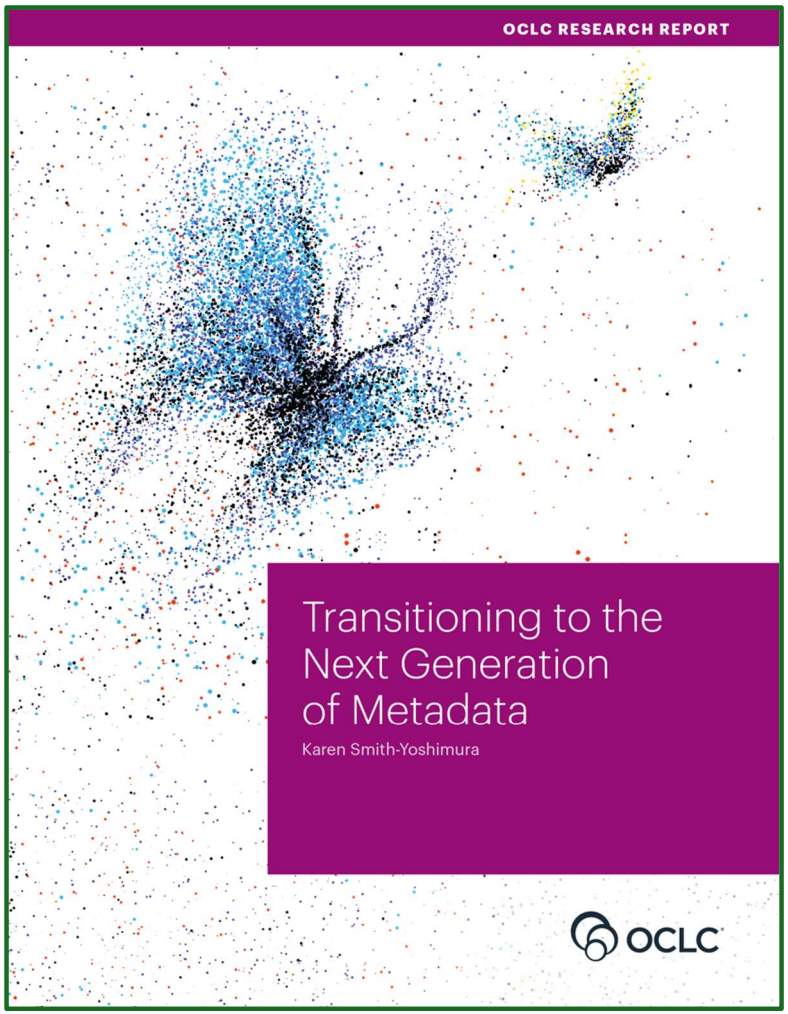
# Bibliographic presence in linked open data

**Any datasets in the library domain are present in the LOD cloud?**



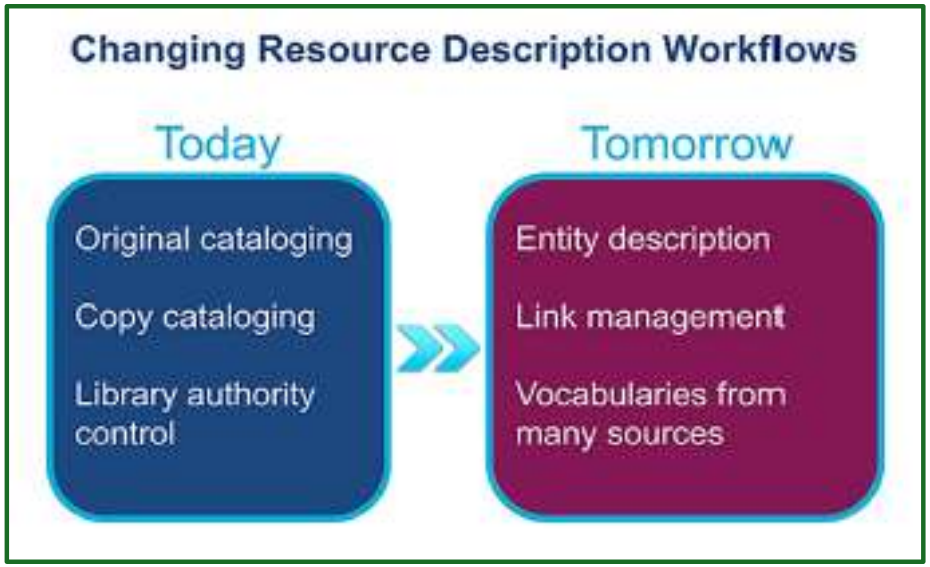
# Next generation of bibliographic metadata




**OCLC Research Report**

Smith-Yoshimura, Karen. 2020. *Transitioning to the Next Generation of Metadata*. Dublin, OH: OCLC Research. https://doi.org/10.25333/rqgd-b343.

**Call for transition to linked data and identifiers**




Source: p.4 of the Report

# MARC is linked data incapable!

```
LDR 00000nam a2200000 a 4500
001 ABcS
008 200424s2009    ch a           000 0 chi d
020    |a9789862131206
090    |a859.6 2290
100 0  |a幾米|eartist|0http://id.loc.gov/authorities/names/
       nr97011804
245 10 |a星空 =|bThe starry starry night /|c幾米
246 31 |aStarry starry night
250    |a初版
260    |a台北市 :|b大塊文化出版股份有限公司,|c2009
300    |a1 v. (unpaged) :|bchiefly col. ill. ;|c27 cm
650  0 |aCaricatures and cartoons||0http://id.loc.gov/
       authorities/subjects/sh85020312
650  0 |aChinese wit and humor, Pictorial|0http://id.loc.gov/
       authorities/subjects/sh85024383
586    |a第二十一屆中學生好書龍虎榜. 最受中學生歡迎十本好書
830  0 |a幾米作品 ;|v32
856 42 |ahttps://www.jimmyspa.com/tw/Books/FullLengthStories/
       StarryStarryNight/|z內文試閱 (幾米網站)
```

- "**MA**chine **R**eadable **C**atalog" – defined in 1960s, originally meant for printing catalog cards by machines
- **String**-based; not structured; does not facilitate **semantic inference**
- No build-in **linking capability** of things in between records; nor within a record
- MARC data is not understandable in digital space outside of the library domain; and it is **totally invisible** in linked open data

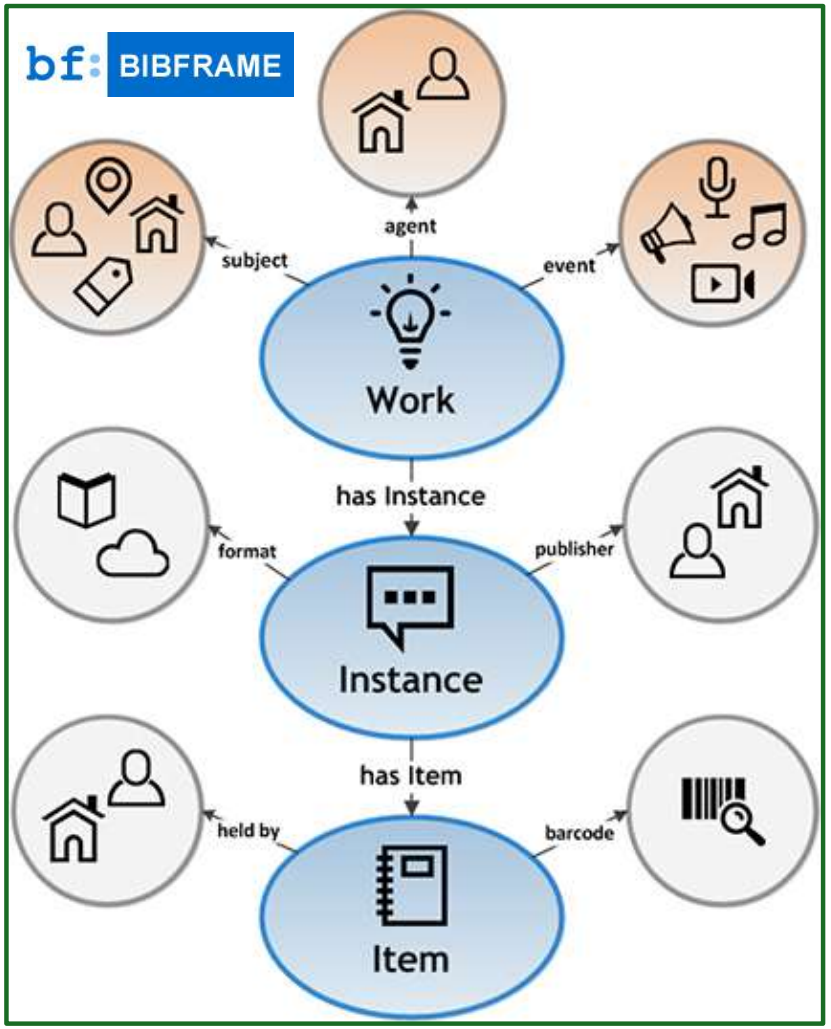
# BIBFRAME ontology

- **BIBFRAME** (Bibliographic Framework) is developed by Library of Congress, with the intention to **replace MARC**.

- First draft was release in 2012. Momentum of adoption began catching up only after **BIBFRAME 2.0** was released in 2016.

- Library of Congress has been cataloguing its own collections with BIBFRAME. Some American and European libraries are either testing it or in the early stage of implementation.

- Find out more from recent presentations:
  - BIBFRAME Workshop in Europe 2024 (https://www.bfwe.eu/helsinki_2024)
  - BIBFRAME July 2024 Update Forum (https://www.loc.gov/bibframe/news/bibframe-update-jul2024.html)




https://id.loc.gov/ontologies/bibframe.html

# Bibliographic metadata in BIBFRAME linked data

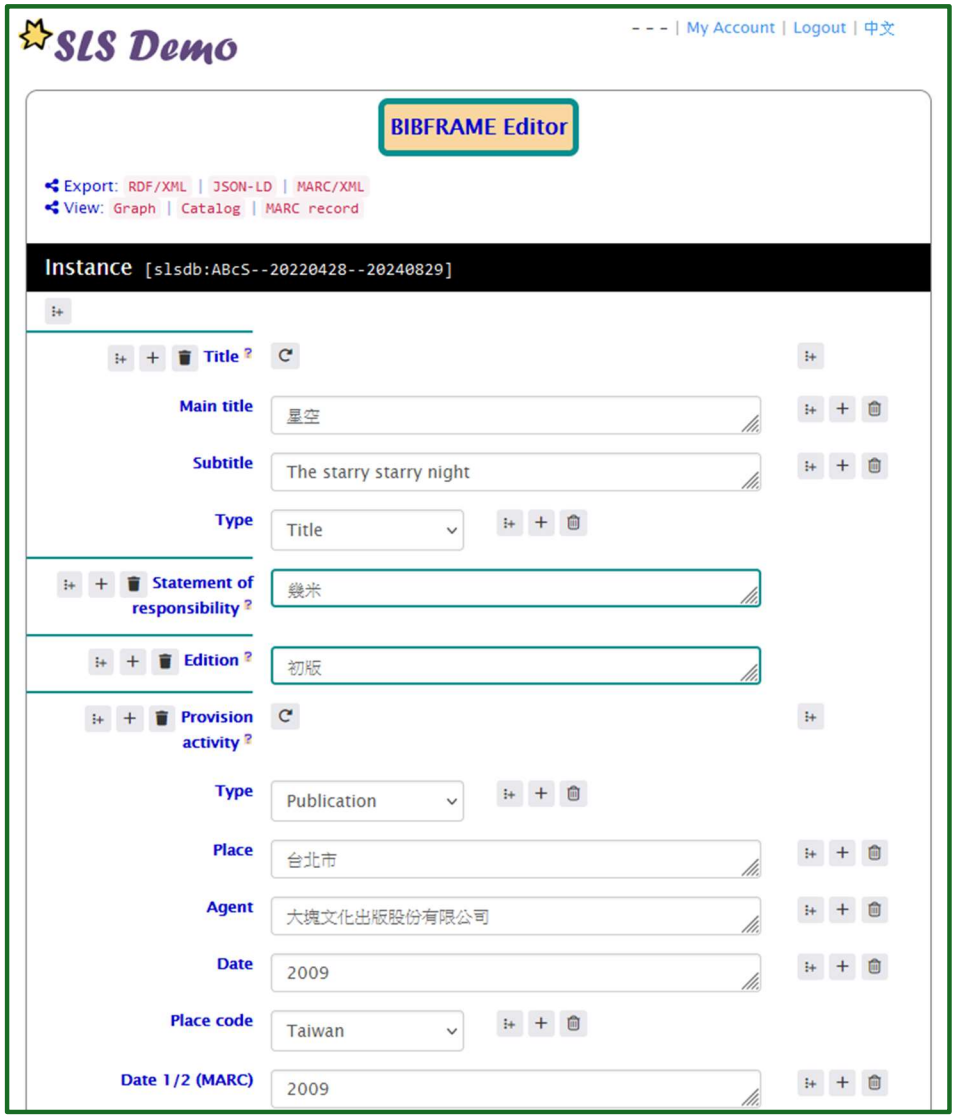
https://www.sls.org.hk:8443/opac/lod/ABcS

# SLS BIBFRAME Editor

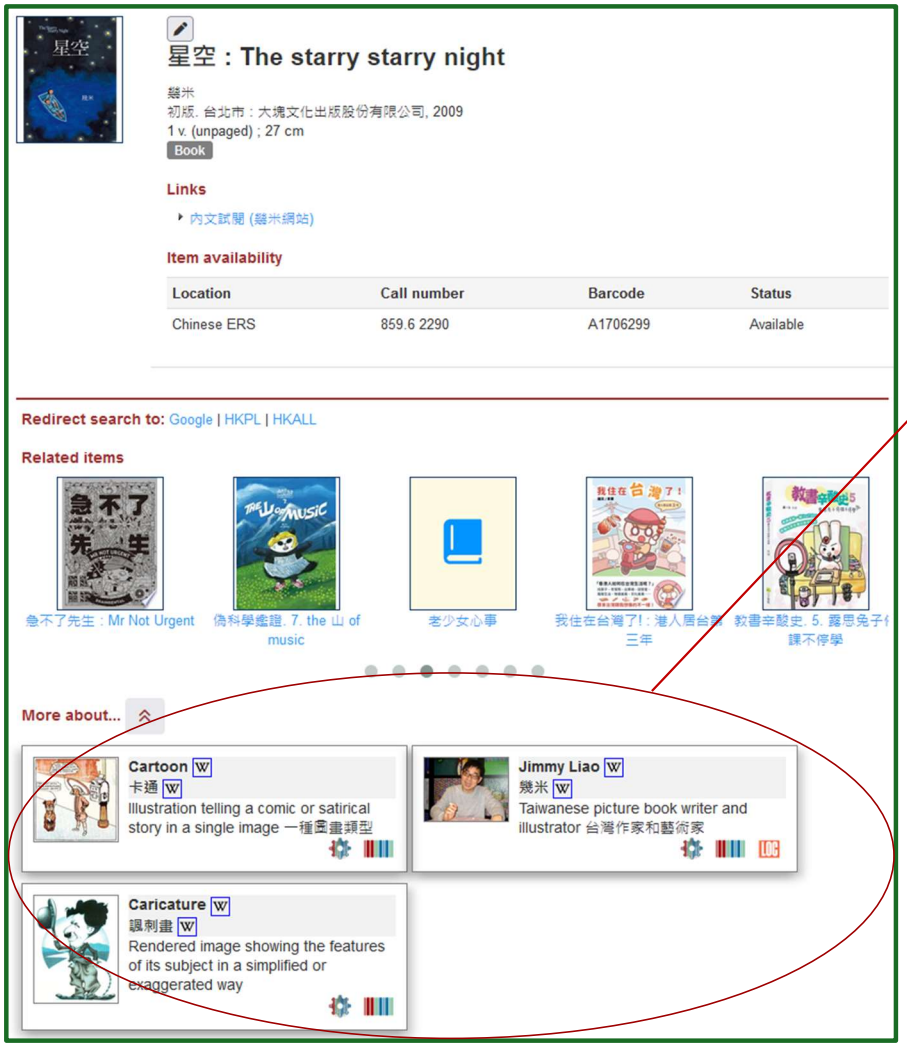
## Design principles

- Light-weight, simple, single-page.
- Meant for library staff who may not have taken proper cataloging training.

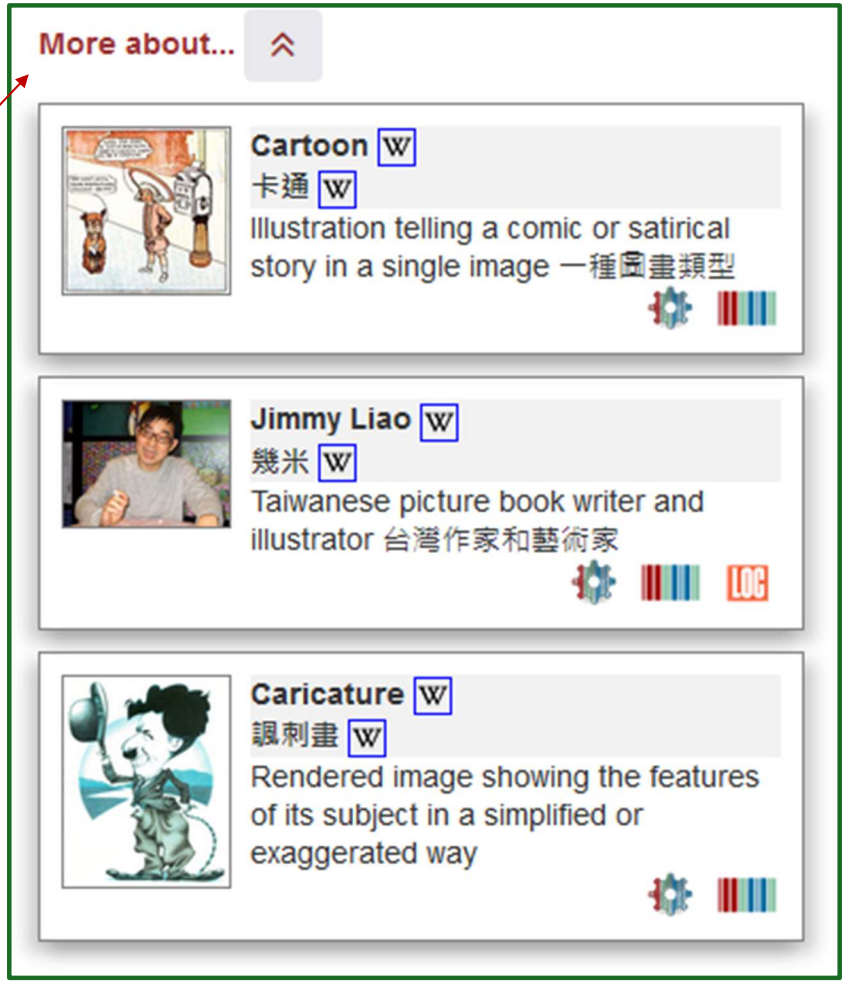
https://www.sls.org.hk:8443/opac/edit/ABcS



# Enrichment – blending knowledge cards in library catalog




**Knowledge cards** about **subjects** and **names** are generated by blending content from Wikidata




https://www.sls.org.hk:8443/opac/bib/ABcS

# Library dedicated chatbot

*Coming soon?*

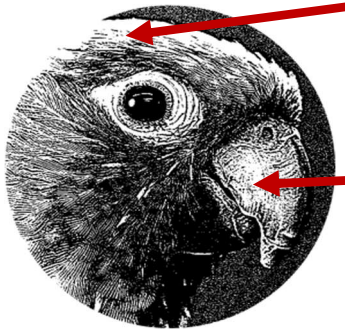
**Library dedicated chatbot deploying linked data and large language model to serve library users' information needs**

Hi chatbot,

Can you find me some books about Alan Turing that I can borrow from my nearby public library for reading in this weekend?

Hi chatbot,

I am reading this article (...) on quantum computing. Please find me ten other similar scholarly articles that I have permission to read.

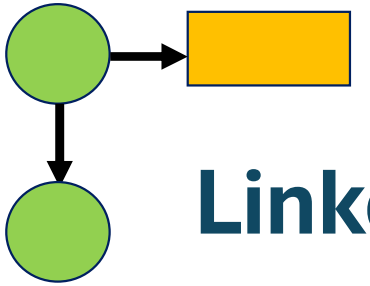


**AI Reasoning**

**Linked data** facilitates information retrieval through inference

**Generative AI**

**LLM (Large Language Model)** facilitates natural language communication between library users and chatbot



# Linked data explained

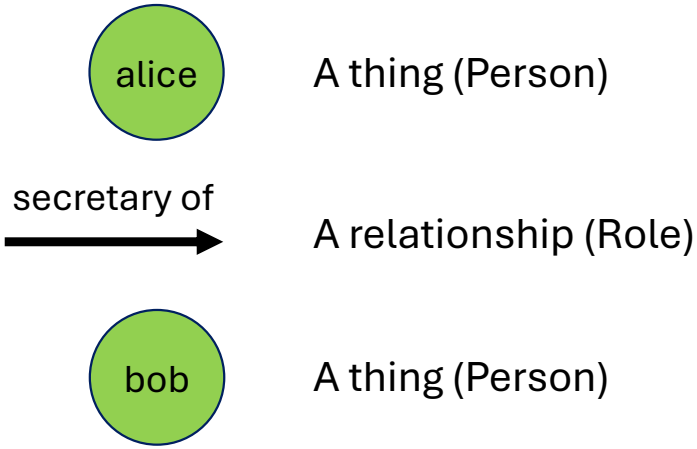
# RDF triple

## A statement in English text (literal):

**“Alice is a secretary of Bob”**

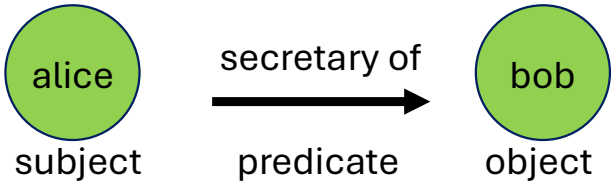
It is difficult for computers to understand the semantics conveyed in an unstructured text string

## This statement has three parts – two things and a relationship connecting them




Things – can by anything, such as people, places, concepts, events, etc. The relationship connecting things is also a thing!

## Using triple to express a statement structurally




Triple contains subject, predicate and object. It provides the semantics for computers.

# RDF triple [cont.]

**Subject, predicate and object of a triple are identified by URIs**

| | | URI | URI shortened by using prefix |
|---|---|---|---|
| **Subject** | alice | <http://example.com/person/alice> | exp:alice |
| **Predicate** | secretary of → | <http://example.com/vocab/secretaryOf> | ex:secretaryOf |
| **Object** | bob | <http://example.com/person/bob> | exp:bob |

| Prefix | Namespace |
|---|---|
| exp: | <http://example.com/person/> |
| ex: | <http://example.com/vocab/> |

Triple defined in this way is known as RDF triple. Computer can look up the URI to obtain more description about the thing.

# RDF triple [cont.]

## Triple in URIs

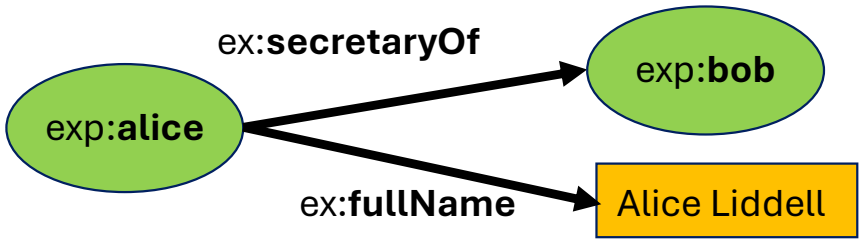
| Subject | Predicate | Object |
|---|---|---|
| exp:alice | ex:secretaryOf | exp:bob |

## Object can be an URI or a literal

| Subject | Predicate | Object |
|---|---|---|
| exp:alice | ex:fullName | “Alice Liddell” |

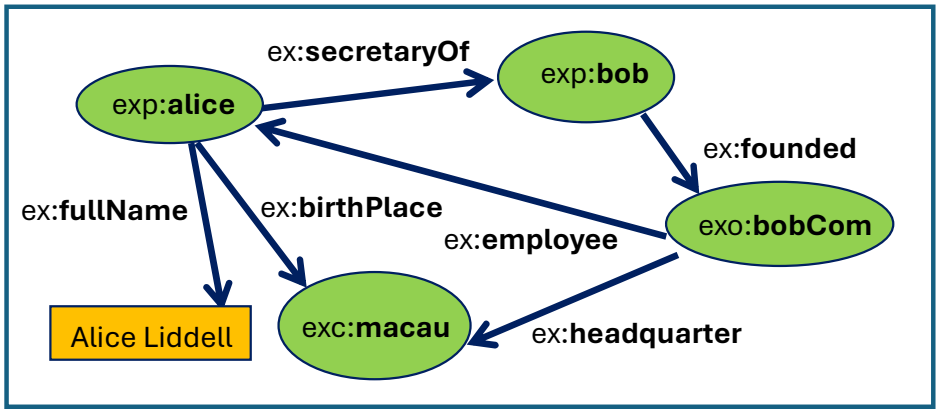
This triple tells the computer that Alice’s full name is “Alice Liddell”, which is a **literal** (text in English)

## A graph showing these two triples



# Semantic Web

**Things in URIs and literals are linked within the same dataset, thus forming linked data.**




**Things can also be linked across multiple datasets forming "web of data".**

**URIs are "understandable" by computers, resulting "semantic web"**

The term "semantic web" was coined by Tim Berners-Lee, in 1999. Berners-Lee is the inventor of World Wide Web.

**Principles of publishing structured data on the Web** - Tim Berners-Lee, 2006.

1. Use URIs as names for things
2. Use HTTP URIs so that people can look up those names.
3. When someone looks up a URI, provide useful information, using the standards (RDF, SPARQL)
4. Include links to other URIs. so that they can discover more things.

https://www.w3.org/DesignIssues/LinkedData

# Serialization

**File formats for transferring triples between computers:**

## N-Triples

```
<http://example.com/person/alice> <http://example.com/vocab/secretaryOf> <http://example.com/person/bob> .
<http://example.com/person/alice> <http://example.com/vocab/fullName> "Alice Liddell" .
```

## Turtle

```
@prefix ex: <http://example.com/vocab/> .
@prefix exp: <http://example.com/person/> .
exp:alice
  ex:secretaryOf exp:bob ;
  ex:fullName "Alice Liddell" .
```

## RDF XML

```
<?xml version="1.0" encoding="utf-8" ?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#" xmlns:ex="http://example.com/vocab/">
  <rdf:Description rdf:about="http://example.com/person/alice">
    <ex:secretaryOf rdf:resource="http://example.com/person/bob"/>
    <ex:fullName>Alice Liddell</ex:fullName>
  </rdf:Description>
</rdf:RDF>
```

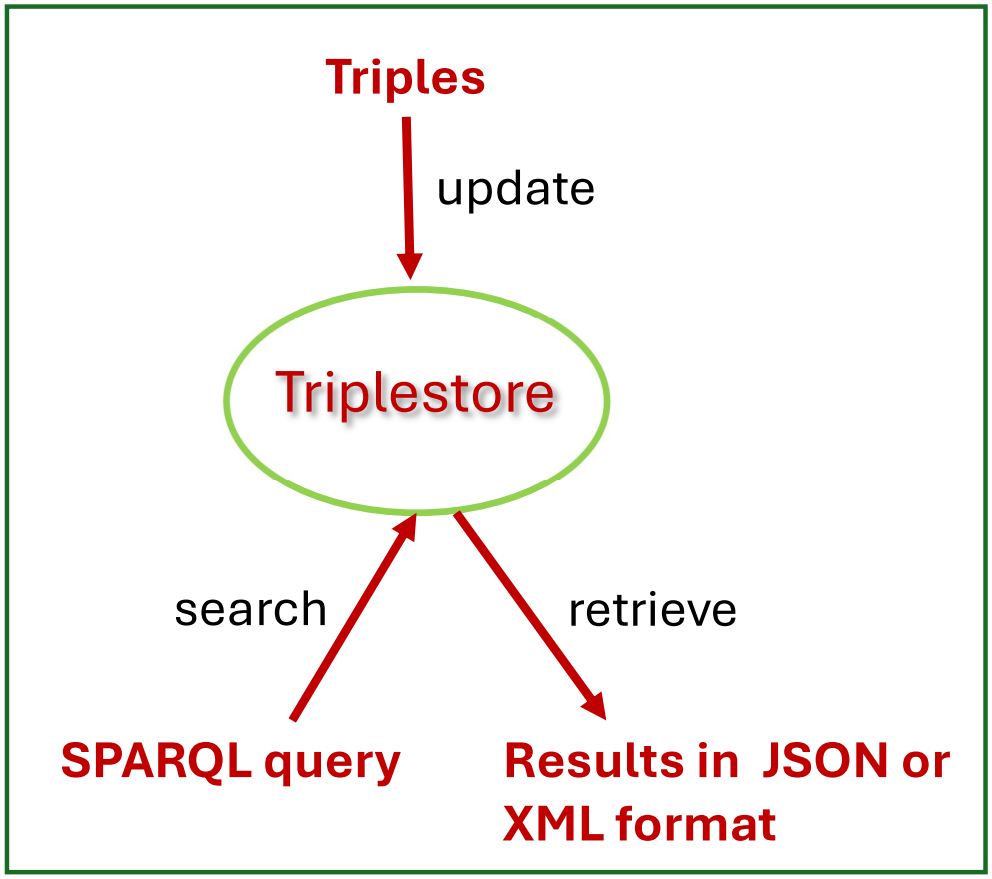
# Serialization [cont.]

## JSON-LD

```
{
  "@context": {
    "ex": "http://example.com/vocab/",
    "exp": "http://example.com/person/"
  },
  "@graph": [
    {
      "@id": "exp:alice",
      "ex:secretaryOf": {
            "@id": "exp:bob"
      },
      "ex:fullName": {
            "@value": "Alice Liddell"
      }
    }
  ]
}
```

# Triplestore

- Just as tabular data is stored in a relational database, **triples** are stored in a **triplestore**.
- SQL is the query language for relational database, while **SPARQL** is used to query triples in a **triplestore**.



# Triplestore [cont.]

**Linked data query service**
provides a front-end interface to search triplestore by SPARQL

**SPARQL query editor**

**Query result in table**

**Example: SLS linked query data**


https://www.sls.org.hk:8443/opac/lod/ABcS

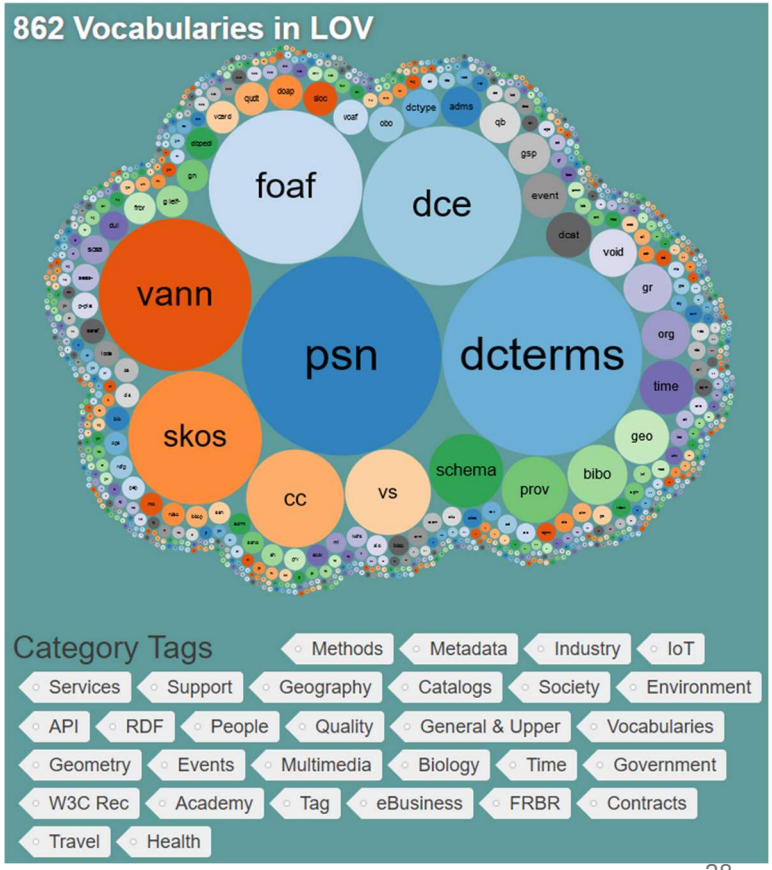
# Vocabulary

**Vocabulary** (or **ontology**, when used in more formal and complex situation) **involves naming, grouping and relating things within the domain area concerned.**

Commonly used vocabularies of linked data in the **bibliographic description** domain:

- **DCMI Metadata Terms**
  - Dublin Core Metadata Initiative
  - https://www.dublincore.org/specifications/dublin-core/dcmi-terms
- **Schema.org vocabulary**
  - General purpose, for any things
  - Maintained by web community
  - https://schema.org/docs/schemas.html
- **BIBFRAME 2.0 vocabulary**
  - Library of congress
  - https://id.loc.gov/ontologies/bibframe.html
- **RDA (Resource Description and Access) vocabularies**
  - RDA Steering Committee
  - http://www.rdaregistry.info

**Linked Open Vocabularies (LOV)**




https://lov.linkeddata.es/dataset/lov

# Vocabulary – an example

## Classes

| Class | URI | Description |
|---|---|---|
| Person | <http://example.com/vocab/Person> | A person |

## Properties

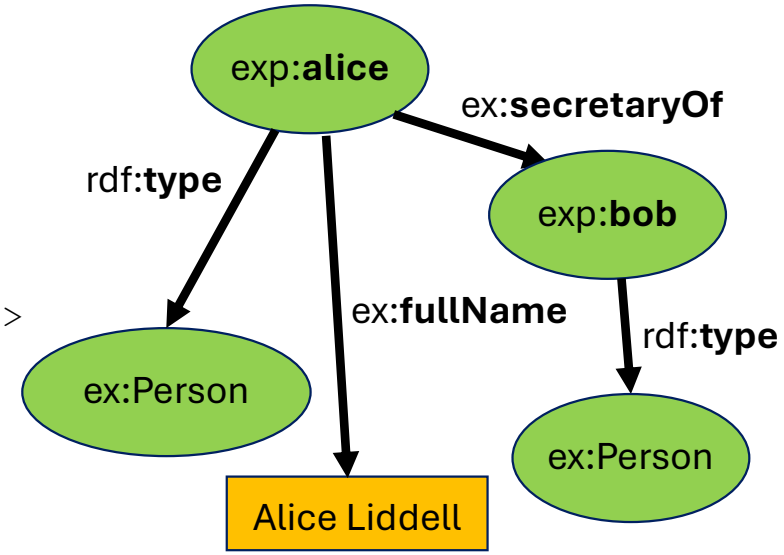
| Property | URI | Type of value | Description |
|---|---|---|---|
| fullName | <http://example.com/vocab/fullName> | Text | Full name of the person |
| secretaryOf | <http://example.com/vocab/secretaryOf> | Person | A secretary of another person |

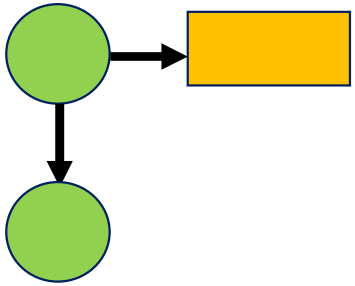
### Example data in English

```
Alice, whose full name is Alice Liddell, is a
secretary of Bob.
```

### Described in linked data

```
PREFIX exp: <http://example.com/person/>
PREFIX ex: <http://example.com/vocab/>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
exp:bob rdf:type ex:Person .
exp:alice rdf:type ex:Person .
exp:alice ex:fullName "Alice Liddell" .
exp:alice ex:secretaryOf exp:bob .
```





# Questions?