

# Shaping Knowledge Graphs

## ISWC'24 Tutorial

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WESO Research group  
University of Oviedo, Spain



# About me...

Main researcher at WESO (Web Semantics Oviedo)

Some books:

"*Web semántica*" (in Spanish), 2012

"*Validating RDF data*", 2017

"Knowledge Graphs", 2021

...and software:

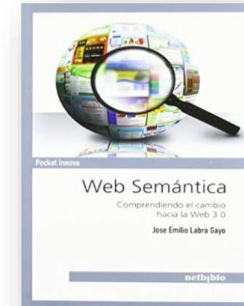
SHaclEX (Scala library, implements ShEx & SHACL)

RDFShape (RDF playground)

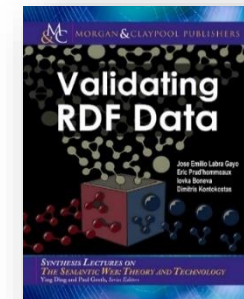
rudof (RDF & Shapes library in Rust)



<http://labra.weso.es>

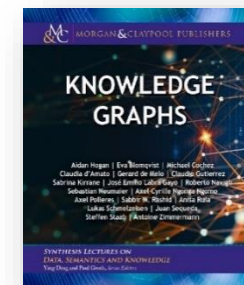


2012



2017 HTML version:

<http://book.validatingrdf.com>



2021, HTML version

<https://kgbook.org/>

# Contents



Introduction to Knowledge graphs

Types of Knowledge Graphs:

RDF, Property graphs, Wikibase, RDF-Star

Shaping RDF: ShEx & SHACL

Shaping Wikibase and Wikidata graphs

Shaping Property Graphs

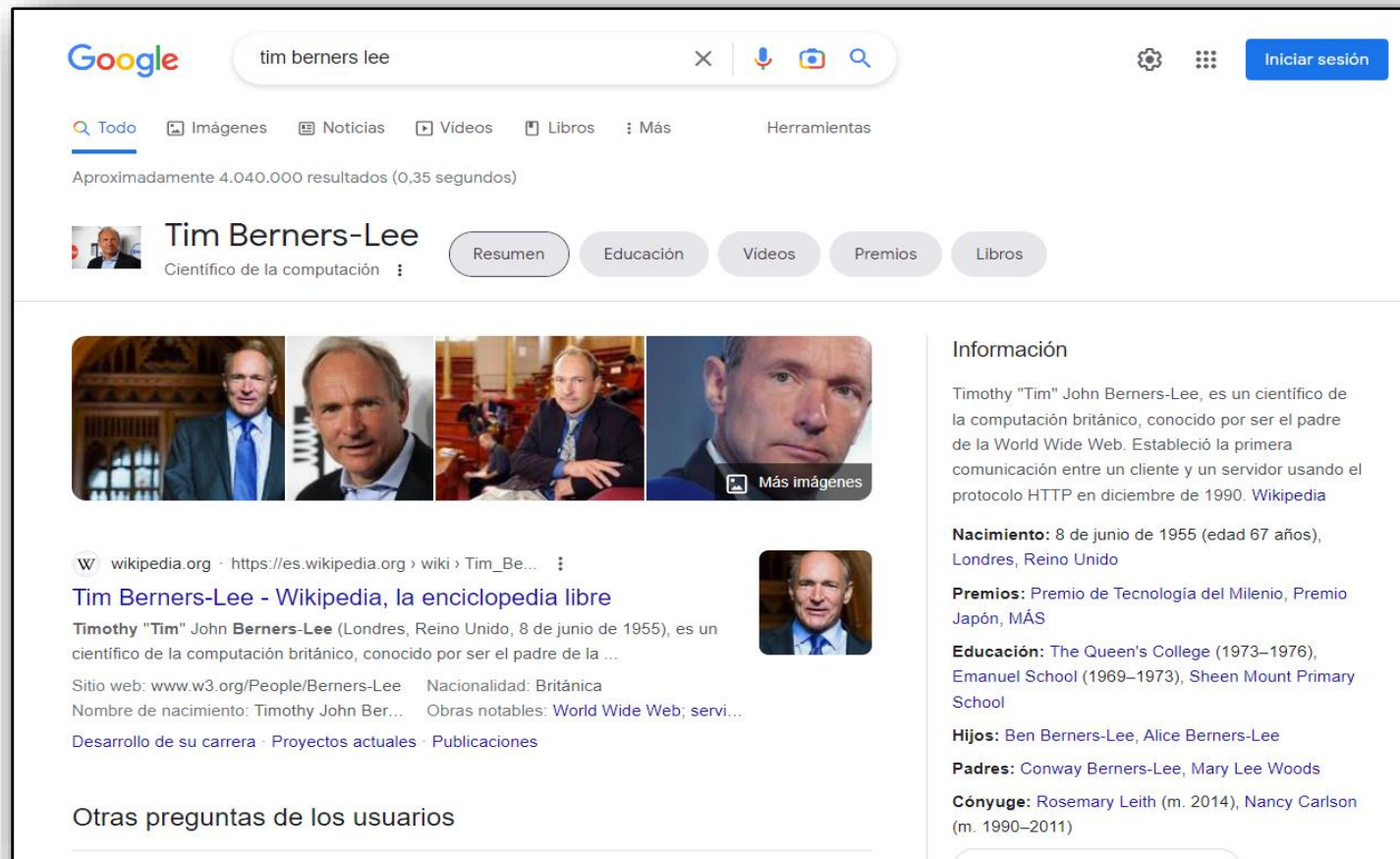
Shaping RDF-Star

Applications:

Inferring shapes from data, Knowledge Graphs Subsets, etc.

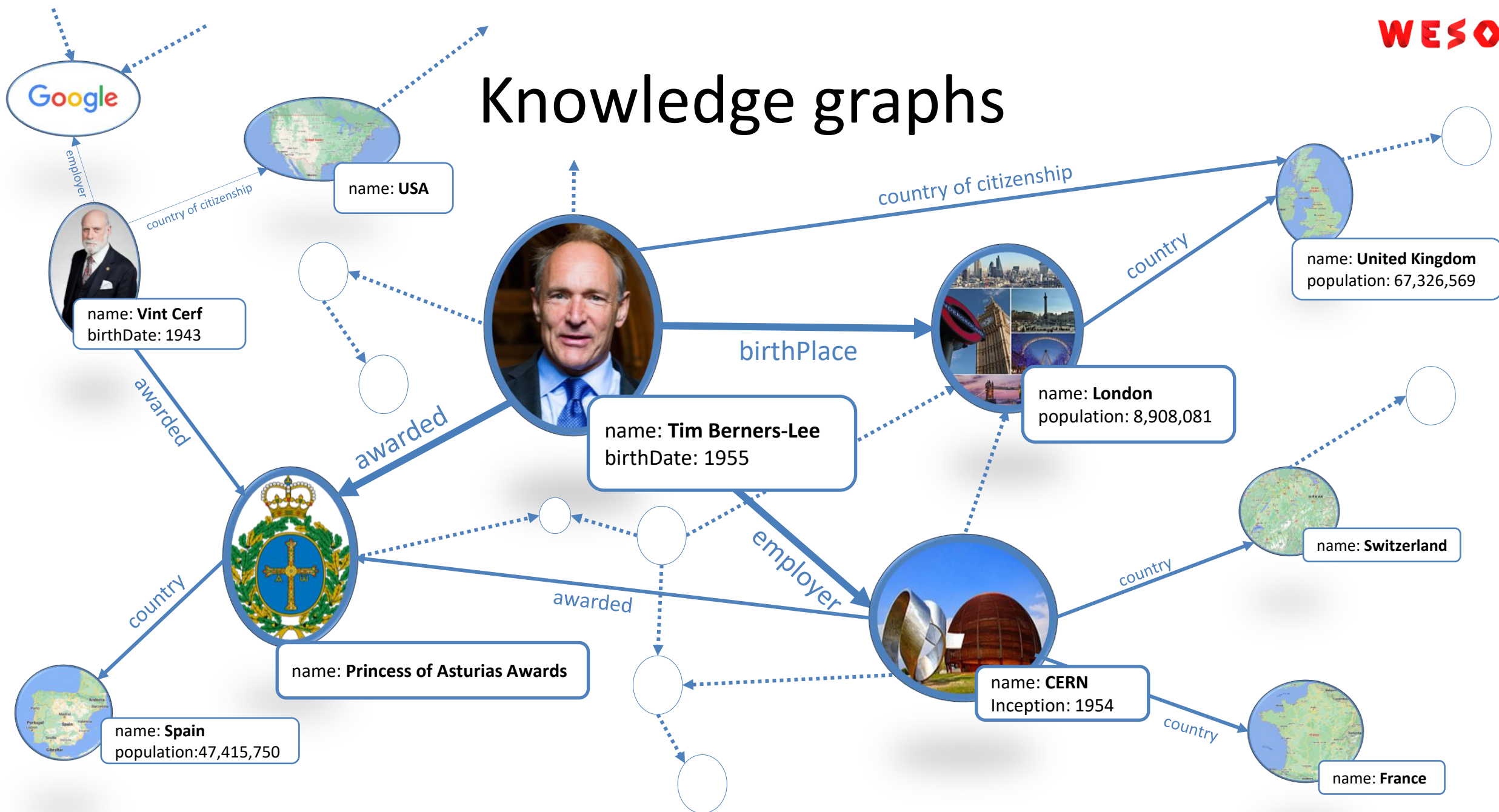
# Knowledge Graphs

Current notion of Knowledge Graphs, popular after Google, 2012\*



Link: <https://www.blog.google/products/search/introducing-knowledge-graph-things-not/>

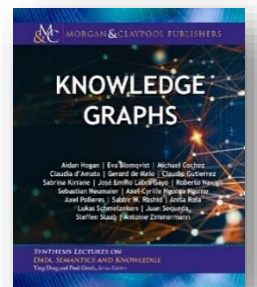
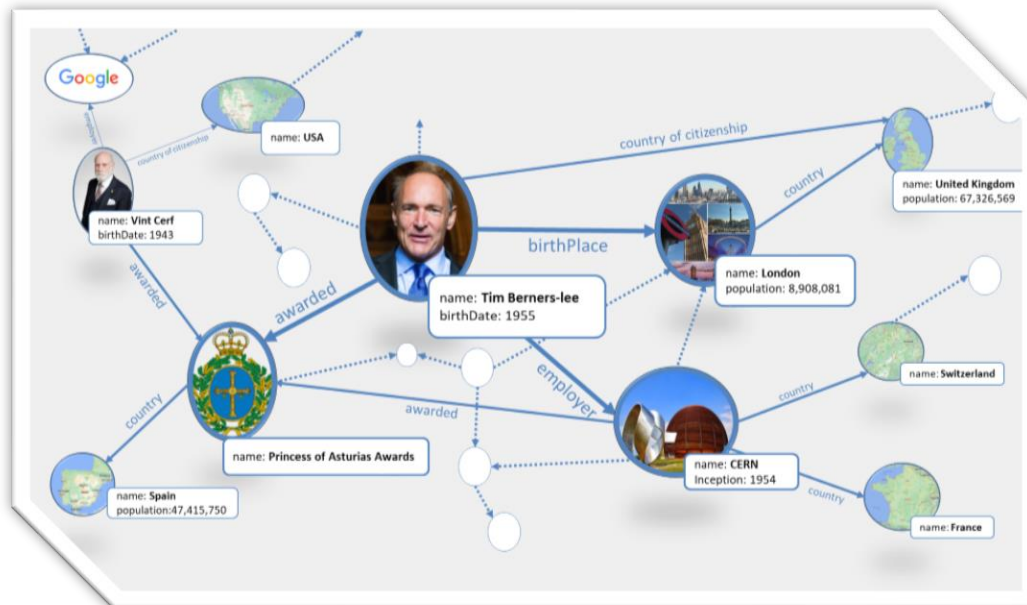
# Knowledge graphs



# Knowledge graphs

Knowledge graph = *a **graph of data***

*intended to accumulate and convey **knowledge** of the real world  
whose **nodes** represent **entities** of interest and  
whose **edges** represent **relations** between these entities.*

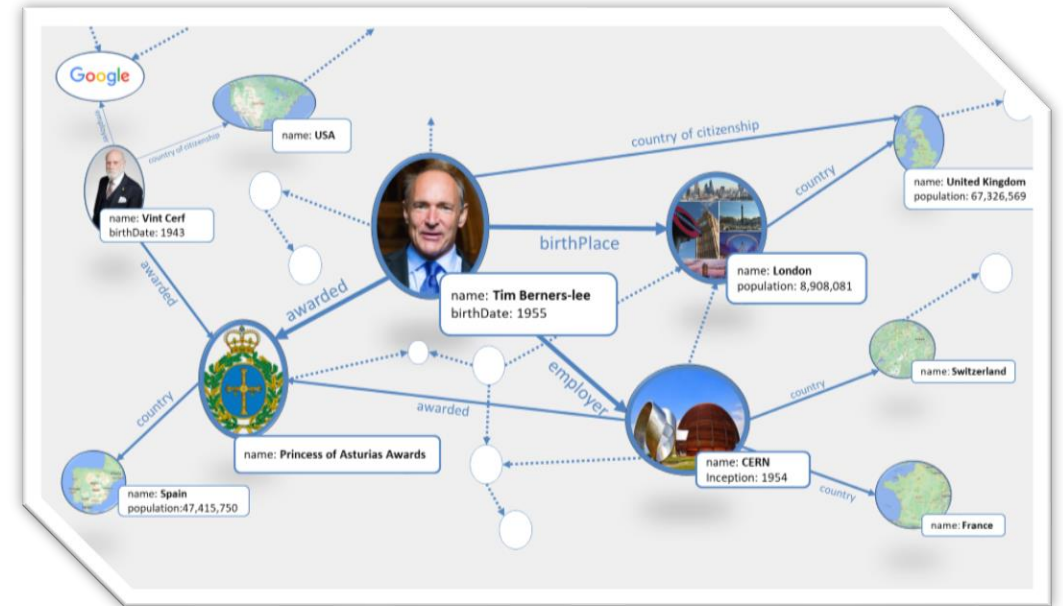


<https://kgbook.org/>



# Chatbots and NLP

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Types of Knowledge Graphs:

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Shaping other types of Knowledge graphs:

Wikibase and Wikidata graphs

Property Graphs

RDF-Star

Applications:

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# Types of Knowledge graphs

## Open Knowledge graphs

Cross-domain: Wikidata, Dbpedia, Freebase, YAGO, ...

Domain specific

Academic: Open citations, SciGraph, Microsoft Academic Knowledge Graph, ...

Life sciences: UniProt, PubChem, PDB, ...

Government: EU Knowledge graph, ...

...

## Enterprise Knowledge graphs

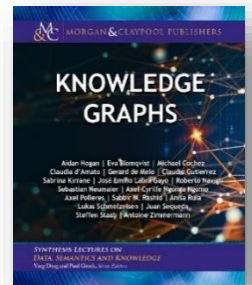
Web search: Google, Bing...

Commerce: AirBnb, Amazon, eBay, Uber,...

Social networks: Linkedin, Facebook,...

Finance: Banca d'Italia, Bloomberg, Wells Fargo, Capital One,...

...



<https://kgbook.org/>

# Wikidata as an example

Wikidata created in 2012 as a collaborative knowledge graph

Initial goal:

Support multilingual infoboxes in Wikipedia



# Wikidata as an example

English Wikipedia page of Tim Berners-Lee

WIKIPEDIA  
The Free Encyclopedia

Article Talk

Read View source View history Search Wikipedia

## Tim Berners-Lee

From Wikipedia, the free encyclopedia

**Sir Timothy John Berners-Lee**, OM, KBE, FRS, FREng, FRSA, DFBCS, RDI (born 8 June 1955),<sup>[1]</sup> also known as **TimBL**, is an English computer scientist best known as the inventor of the World Wide Web. He is a Professorial Fellow of Computer Science at the University of Oxford<sup>[2]</sup> and a professor at the Massachusetts Institute of Technology (MIT).<sup>[3]</sup><sup>[4]</sup> Berners-Lee proposed an information management system on 12 March 1989,<sup>[5]</sup><sup>[6]</sup> then implemented the first successful communication between a *Hypertext Transfer Protocol* (HTTP) client and server via the Internet in mid-November.<sup>[7]</sup><sup>[8]</sup><sup>[9]</sup><sup>[10]</sup><sup>[11]</sup>

Berners-Lee is the director of the World Wide Web Consortium (W3C), which oversees the continued development of the Web. He co-founded (with his then wife-to-be Rosemary Leith) the World Wide Web Foundation. He is a senior researcher and holder of the 3Com founder's chair at the MIT Computer Science and Artificial Intelligence Laboratory (CSAIL).<sup>[12]</sup> He is a director of the Web Science Research Initiative.

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Wikimedia Foundation

विकिपीडिया  
एगो मुक्त ज्ञानकोष

खाला बनाई ...

टिम बर्नर्स-ली

पन्ना बातचीत

विकिपीडिया से

सर टिमोथी जॉन बर्नर्स-ली एगो अंगरेज इंजीनियर आ बैज्ञानिक हवें। इनके परसिद्धि वल्ल वाइड वेब के बनावेवाला के रूप में बा आ आजकालह ई ऑक्सफोर्ड युनिवर्सिटी आ मैसाचुसेट्स युनिवर्सिटी में प्रोफेसर बाड़ें।

**Sir Tim Berners-Lee**  
OM KBE FRS FREng FRSA FBSC

Berners-Lee in 2014

जनम Timothy John Berners-Lee  
8 जून 1955 (उमिर 67)  
लंदन, इंग्लैंड, यूनाइटेड किंगडम

दूसरा नाँव TimBL  
TBL

शिक्षा Emanuel School

<http://www.wikidata.org/entity/Q80>

WIKIDATA

Main page  
Community portal  
Project chat  
Create a new item  
Recent changes  
Random item  
Query Service  
Nearby  
Help  
Donate

Lexicographical data  
Create a new Lexeme  
Recent changes  
Random Lexeme

Tools  
What links here  
Related changes  
Special pages  
Permanent link  
Page information  
Concept URI  
Cite this page

## Tim Berners-Lee (Q80)

English computer scientist, inventor of the World Wide Web (born 1955)  
TimBL | Sir Tim Berners-Lee | Timothy John Berners-Lee | TBL | T. Berners-Lee | T Berners-Lee | Tim Berners Lee | T.J. Berners-Lee | Sir Timothy John Berners-Lee

► In more languages

### Statements

instance of human edit

► 1 reference + add value

image edit

Sir Tim Berners-Lee (cropped).jpg  
570 × 713; 178 KB

point in time 2014

media legend

Tim Berners-Lee in 2014. (English)  
Tim Berners-Lee i 2014. (Norwegian Bokmål)  
Tim Berners-Lee i 2014. (Norwegian Nynorsk)

► 0 references + add reference

+ add value

sex or gender male edit

► 2 references + add value

Bihari Wikipedia of Tim Berners-Lee

# Wikidata: some features

Collaborative: anyone can edit

Free and open license

Currently (01/2023): 101m items, 1,8b edits

Co-edited by humans and bots: 23k active users, 343 bots

Open Wikidata Query Service: Public SPARQL endpoint

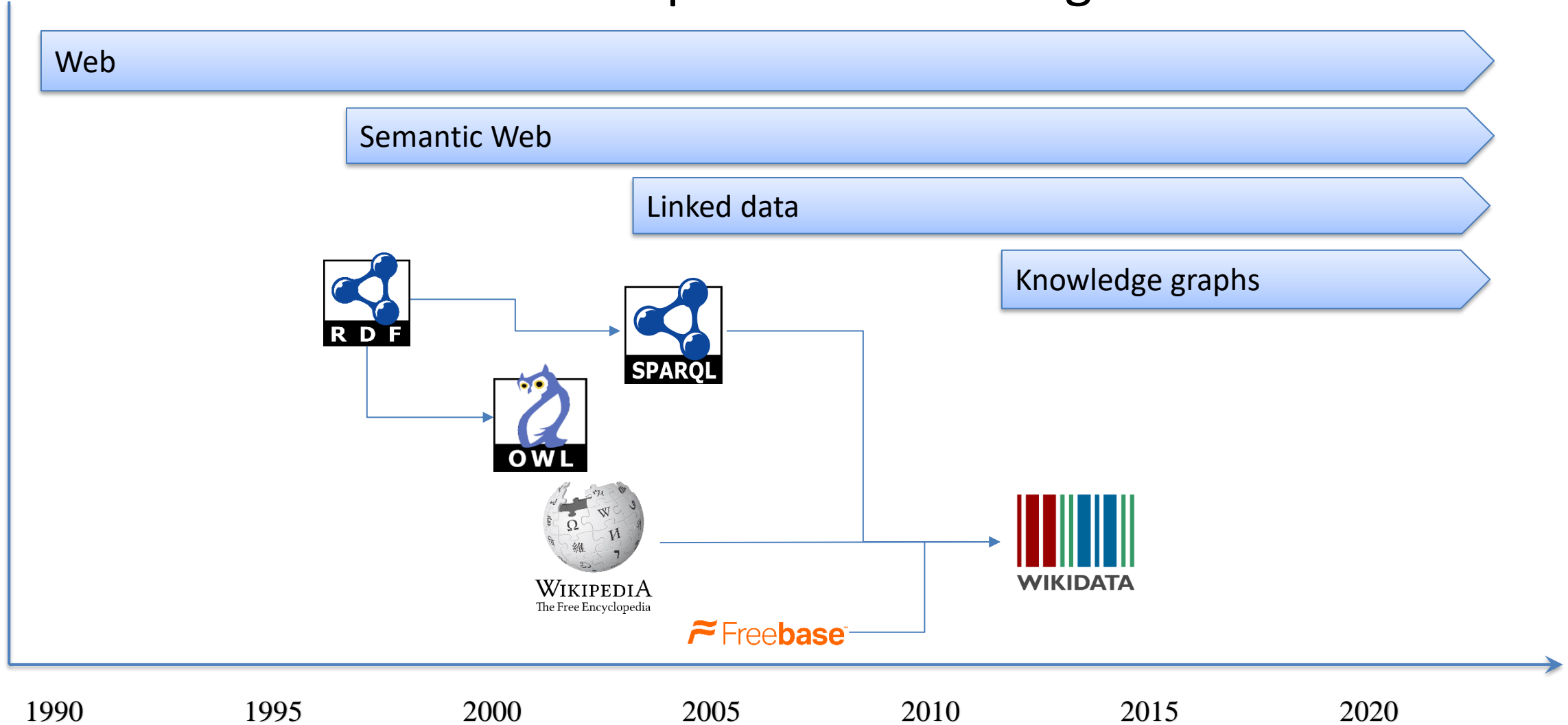
Dumps freely available: 109Gb compressed

Software that supports Wikidata = Wikibase



# Evolution

Timeline with some concepts and technologies...



# Knowledge Graphs models

## 3 popular knowledge graphs models

- RDF based
- Property graphs
- Wikibase graphs



# RDF graphs

RDF = W3C recommendation (since 98)

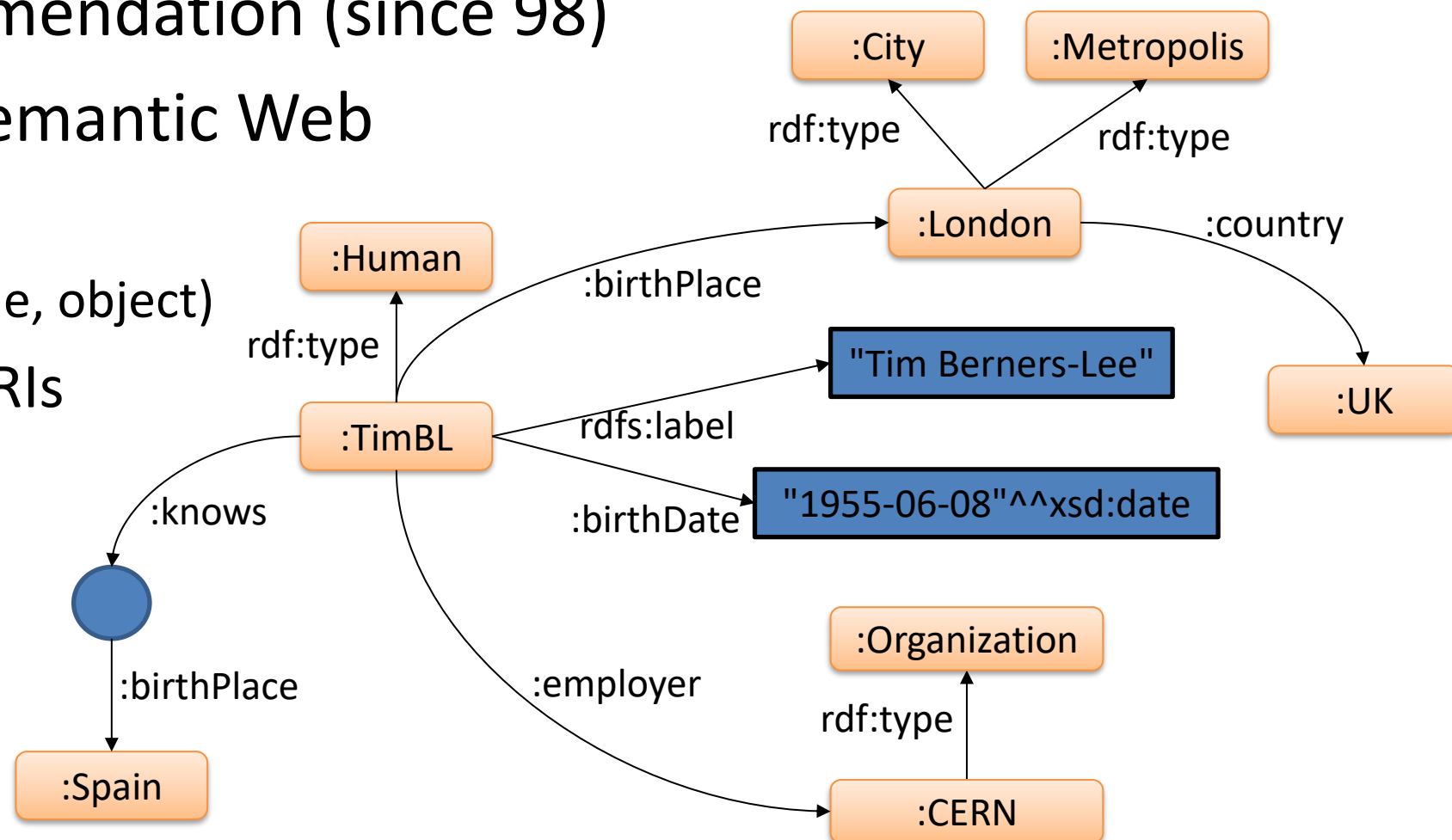
*Lingua franca* of Semantic Web

Based on triples

(subject, predicate, object)

Most nodes are URIs

Interoperability







# RDF ecosystem

One data model, several syntaxes: Turtle, N-Triples, JSON-LD

Vocabularies: RDF Schema, OWL, SKOS, etc.

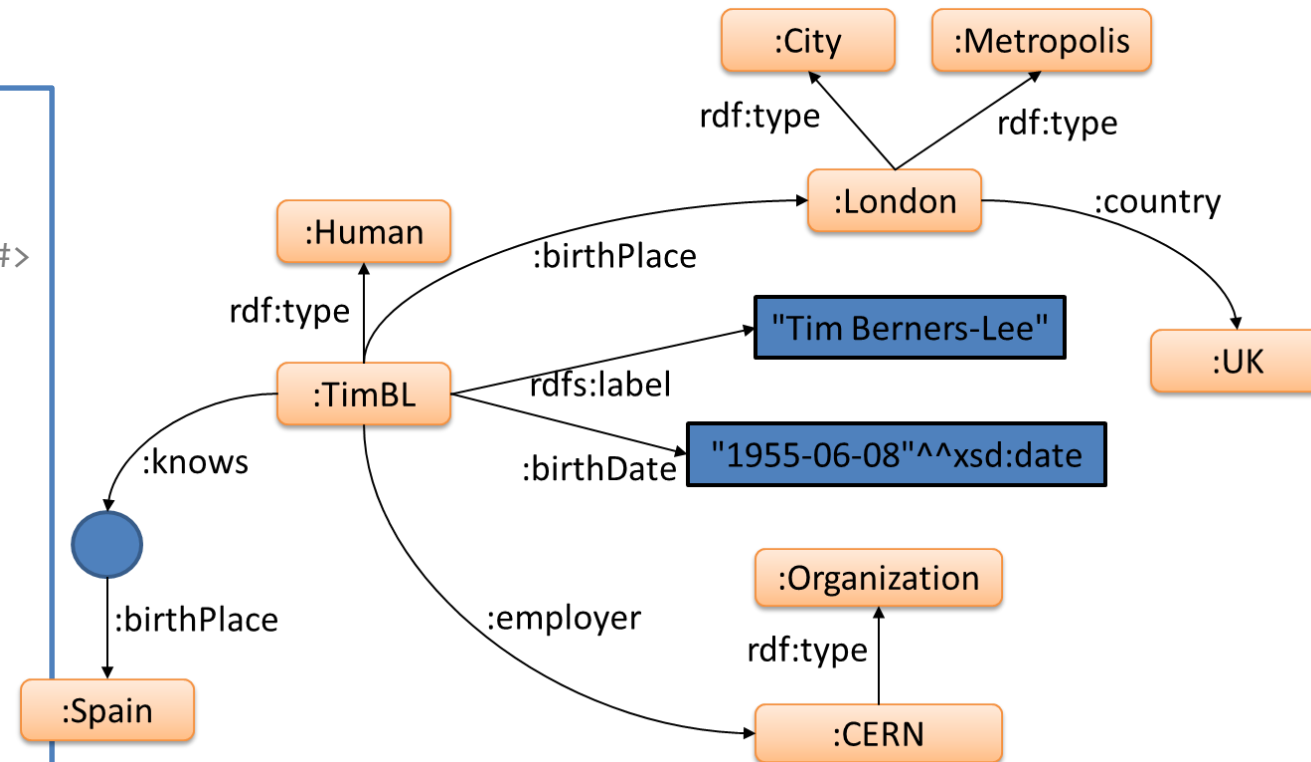
## Turtle

```
prefix :      <http://example.org/>
prefix rdfs:  <http://www.w3.org/2000/01/rdf-schema#>
prefix xsd:   <http://www.w3.org/2001/XMLSchema#>
prefix rdf:   <http://www.w3.org/1999/02/22-rdf-syntax-ns#>

:timbl rdf:type      :Human ;
       :birthPlace  :london ;
       rdfs:label   "Tim Berners-Lee" ;
       :birthDate   "1955-06-08"^^xsd:date ;
       :employer    :CERN ;
       :knows       _:1 .

:london rdf:type     :City, :Metropolis ;
       :country      :UK .

:CERN   rdf:type     :Organization .
_:1     :birthPlace  :Spain .
```



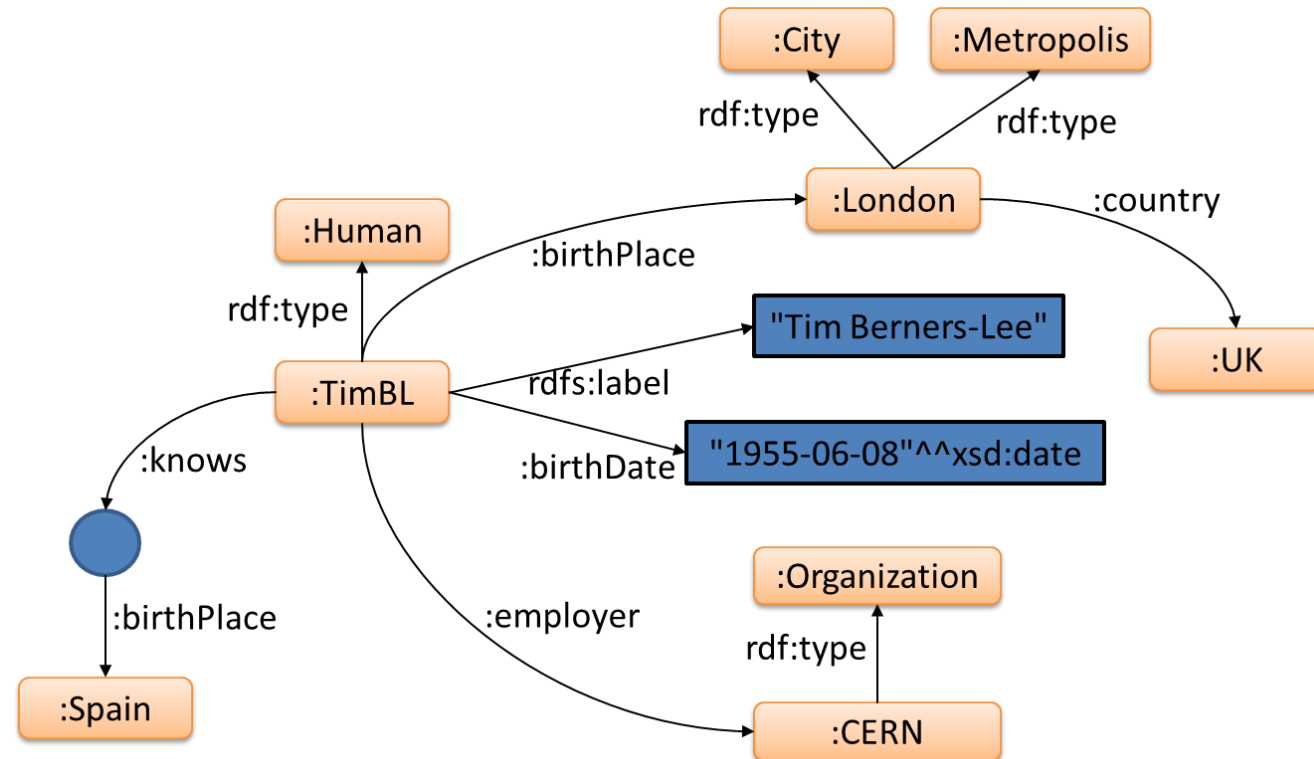


# RDF ecosystem: SPARQL

SPARQL is an RDF query language and protocol  
It enables the creation of SPARQL endpoints

```
select ?person ?date ?country where {  
  ?person :birthDate ?date .  
  ?person :birthPlace ?p .  
  ?p      :country ?country  
}
```

?person	?date	?country
:timbl	1955-06-08	:UK



# RDF1.2 (RDF-Star)

Triple terms

Add statements about triples

Reifiers

```
prefix :      <http://example.org/>

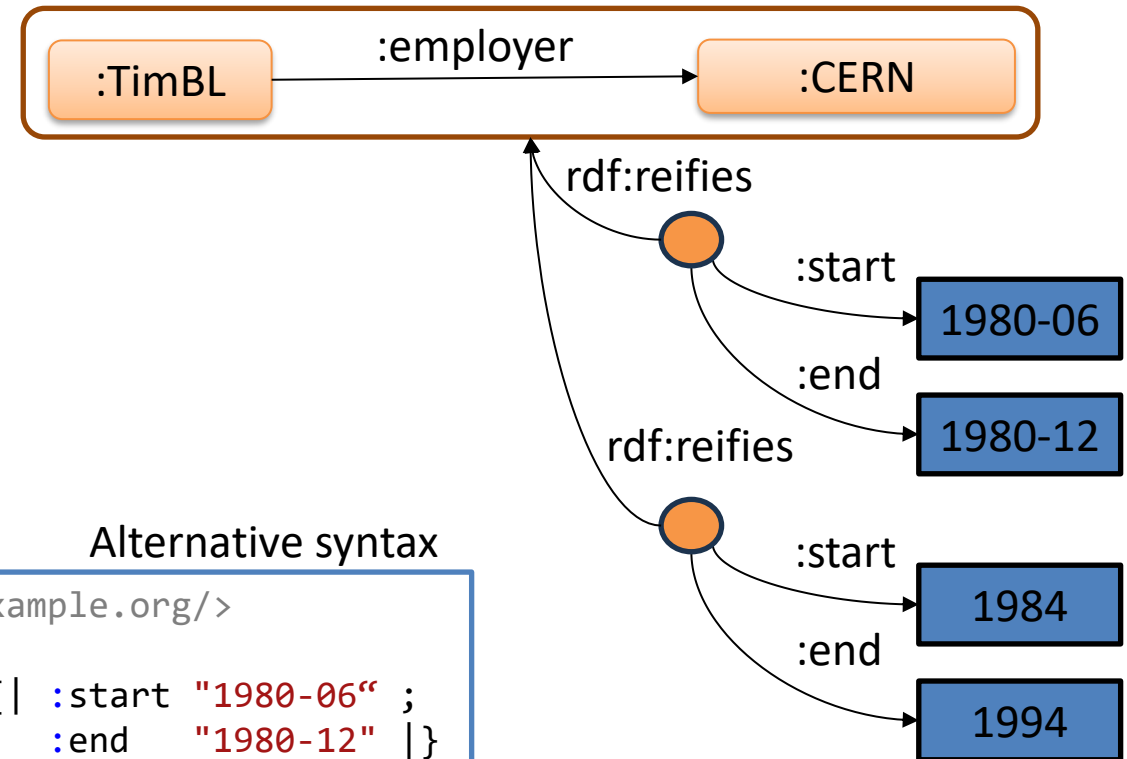
_:r1 rdf:reifies << :timbl :employer :CERN >> .
_:r1 :start "1980-06";
      :end  "1980-12" .

_:r1 rdf:reifies << :timbl :employer :CERN >> .
_:r2 :start "1984";
      :end  "1994" .
```

Alternative syntax

```
prefix :      <http://example.org/>

:timbl :employer :CERN { | :start "1980-06" ;
                           :end  "1980-12" | }
                        { | :start "1984" ;
                           :end  "1994" | } .
```



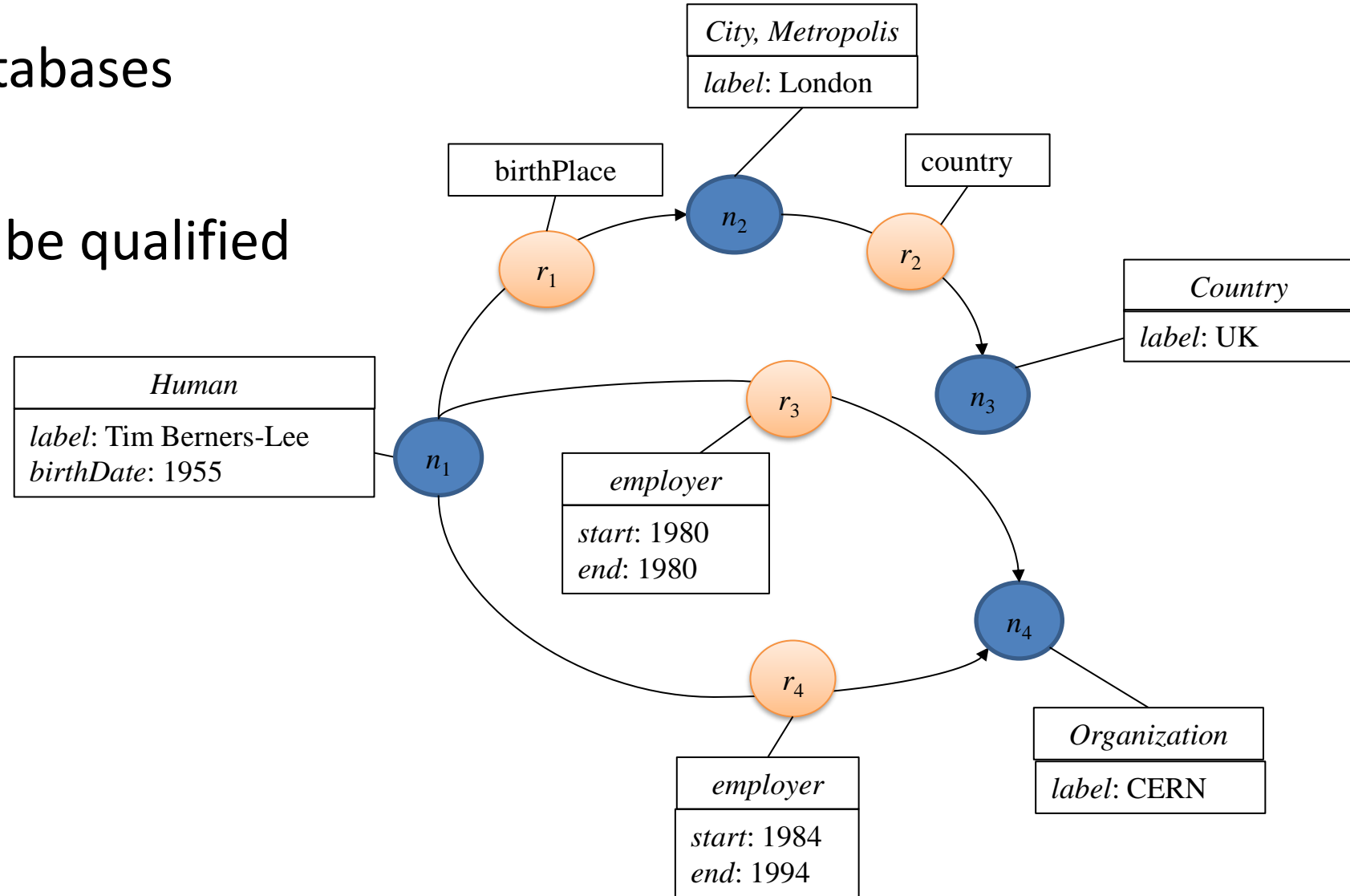
# Property graphs

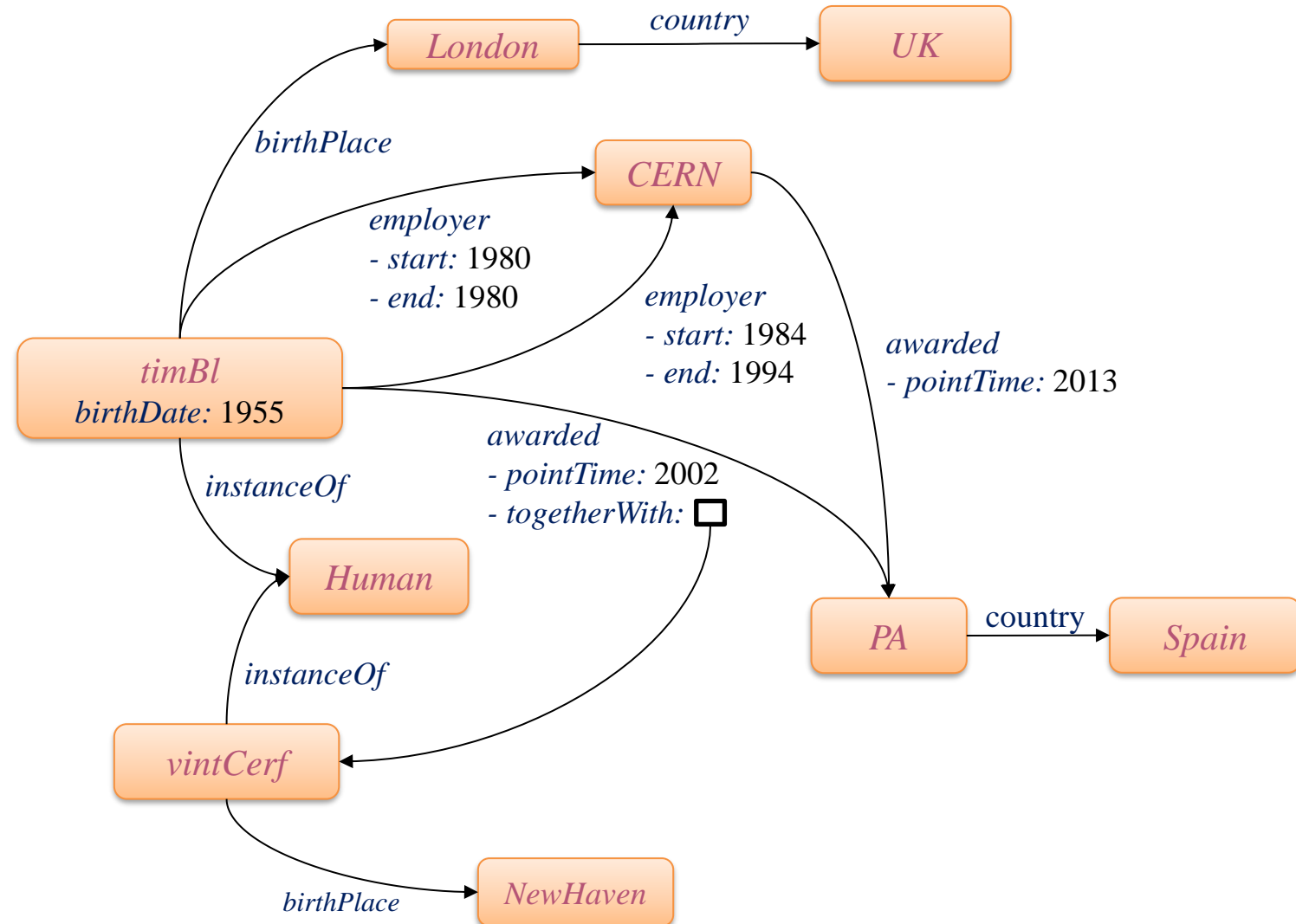
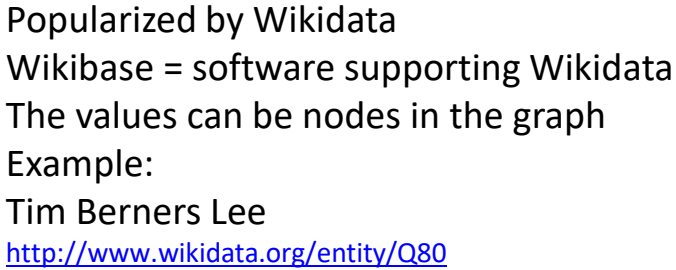
Popularized by graph databases

Example: Neo4j

Nodes and relations can be qualified

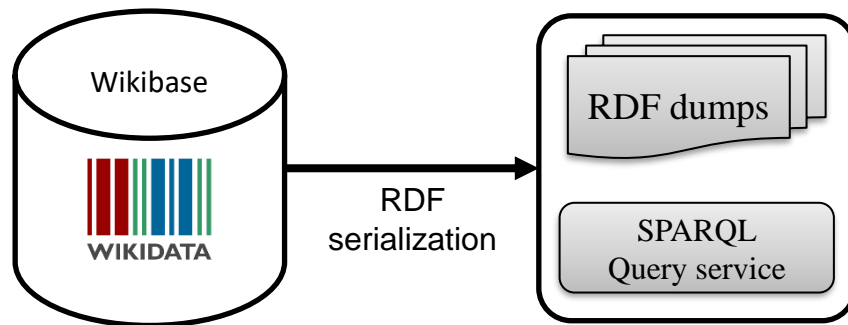
Nodes can have types





# Wikibase graphs and SPARQL

Wikibase graphs generate RDF serializations for each item  
SPARQL endpoint and Query service available



```
select ?name ?date ?country where {  
  wd:Q80 wdt:P1559 ?name .  
  wd:Q80 wdt:P569 ?date .  
  wd:Q80 wdt:P19 ?place .  
  ?place wdt:P17 ?country  
}
```

?name	?date	?country
Tim Berners-lee	1955-06-08	:UK

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