Python programming — Semantic Web

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What is Semantic Web?

Semantic Web =

Triple data structure (representing subject, verb and object)

+ URIs to name elements in the triple data structure

+ standards (RDF, N3, SPARQL, . . .)

for machine readable semi-structured data.

Why the Semantic Web?

IBM's Watson supercomputer destroys all humans in Jeopardy

http://www.youtube.com/watch?v=WFR3lOm_xhE

"[. . .] they can build confidence based on a combination of reasoning methods that operate directly on a combination of the raw natural language, automatically extracted entities, relations and available structured and semi-structured knowledge available from for example the Semantic Web." — http://www.research.ibm.com/deepqa/faq.shtml

Example triples

Subject	Verb	Object
neuro:Finn	a	foaf:Person
neuro:Finn	foaf:homepage	http://www.imm.dtu.dk/~fn/
dbpedia:Charlie_Chaplin	foaf:surname	Chaplin
dbpedia:Charlie_Chaplin	owl:sameAs	fbase:Charlie Chaplin

Table 1: Triple structure

where the the so-called "prefixes" are

```
PREFIX foaf:    <http://xmlns.com/foaf/0.1/>
PREFIX neuro:   <http://neuro.imm.dtu.dk/resource/>
PREFIX dbpedia: <http://dbpedia.org/resource/>
PREFIX owl:     <http://www.w3.org/2002/07/owl#>
PREFIX fbase:   <http://rdf.freebase.com/ns/type.object.>
```

DBpedia

DBpedia extracts semi-structured data from Wikipedias and map and add the data to a triple store.

The data is made available on the Web is a variety of ways: http://dbpedia.org

DBpedia names (URIs), e.g., `http://dbpedia.org/resource/John_Wayne`

Human readable page, e.g., `http://dbpedia.org/page/John_Wayne`

Machine readable, e.g., `http://dbpedia.org/data/John_Wayne.json`

Query DBpedia

SPARQL endpoint for DBpedia:

```
http://dbpedia.org/sparql
```

Get pharmaceutical companies with more than 30'000 employees:

```
SELECT ?Company ?numEmployees ?industry ?page WHERE {
    ?Company dbpprop:industry ?industry ;
             dbpprop:numEmployees ?numEmployees ;
             foaf:page ?page .
    FILTER (?industry = dbpedia:Pharmaceutical_industry ||
            ?industry = dbpedia:Pharmaceutical_drug) .
    FILTER (?numEmployees > 30000) .
}
ORDER BY DESC(?numEmployees)
```

Linked Data cloud

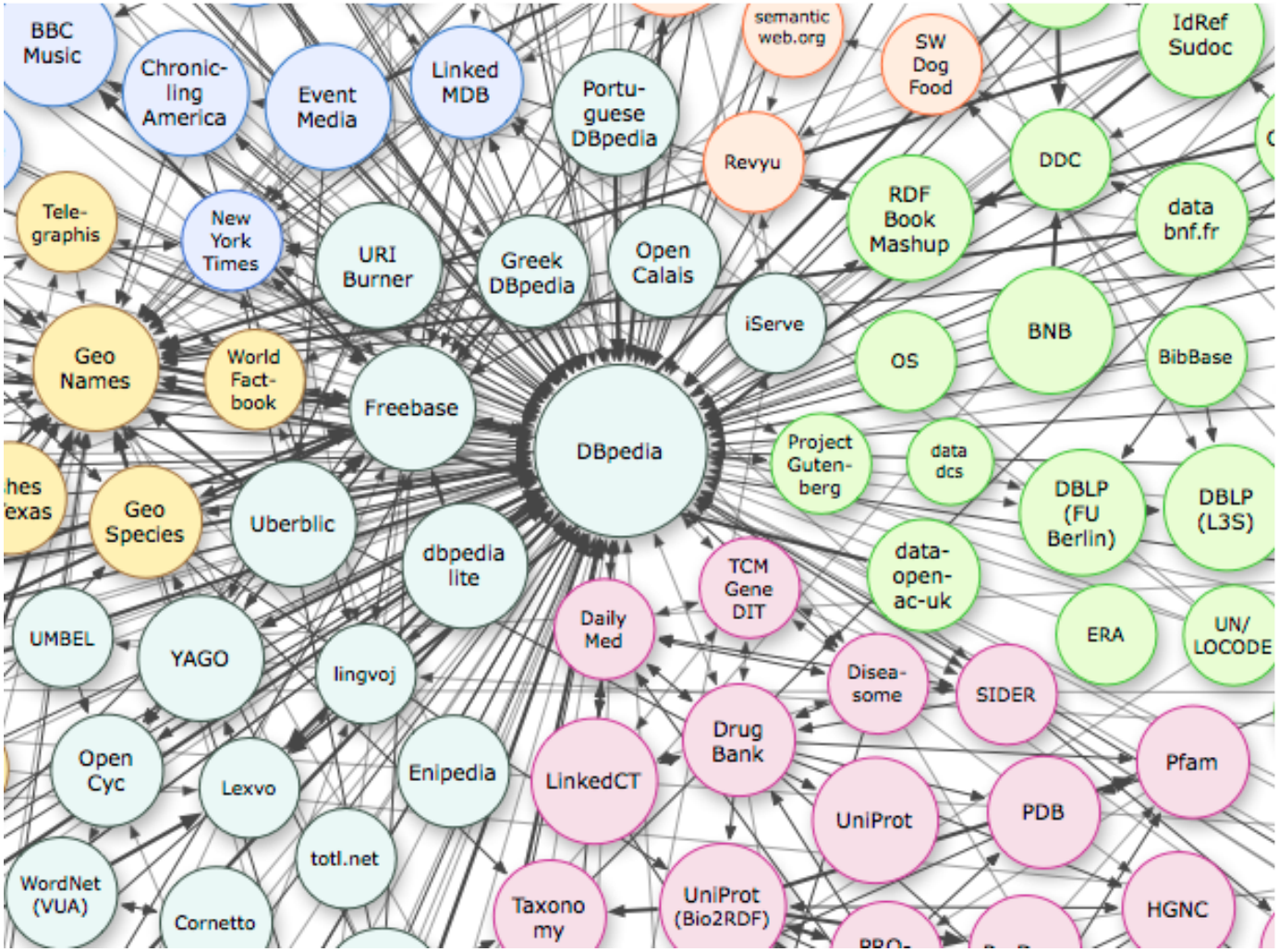


Figure 1: Part of Linking Open Data cloud diagram, by Richard Cyganiak and Anja Jentzsch. CC-BY-SA.

Huge amount of interlinked data where DBpedia is central

Media, geographical, publications, user-generated content, government, cross-domain, life sciences.

And what can Python do with this Semantic Web?

Python

Query existing triple stores, e.g., DBpedia

Setup a triple store

Getting data from DBpedia

URI for municipality seats in Denmark:

```
url = "http://dbpedia.org/resource/Category:Municipal_seats_of_Denmark"
```

Get the data in JSON with "Content-Type" negotiation:

```
import urllib2, simplejson
opener = urllib2.build_opener()
opener.addheaders = [('Accept', 'application/json')]
seats = simplejson.load(opener.open(url))
```

Get the URIs for the municipality seats:

```
uris = [k for k,v in seats.items()
              if "http://purl.org/dc/terms/subject" in v]
```

Getting data from DBpedia

URI for municipality seats in Denmark:

```
url = "http://dbpedia.org/resource/Category:Municipal_seats_of_Denmark"
```

Get the data in JSON with "Content-Type" negotiation using the more elegant requests module:

```
import requests
```

```
seats = requests.get(url, headers={'Accept': 'application/json'}).json()
```

Get the URIs for the municipality seats:

```
uris = [k for k,v in seats.items()
                if "http://purl.org/dc/terms/subject" in v]
```

Get one of the geographical coordinates associated with the first municipality seat by querying DBpedia again, now with a URI for the seat:

```
seat = simplejson.load(opener.open(uris[0]))
geo = "http://www.w3.org/2003/01/geo/wgs84_pos#"
lat = seat[uris[0]][geo + 'lat'][0]['value']
long = seat[uris[0]][geo + 'long'][0]['value']
```

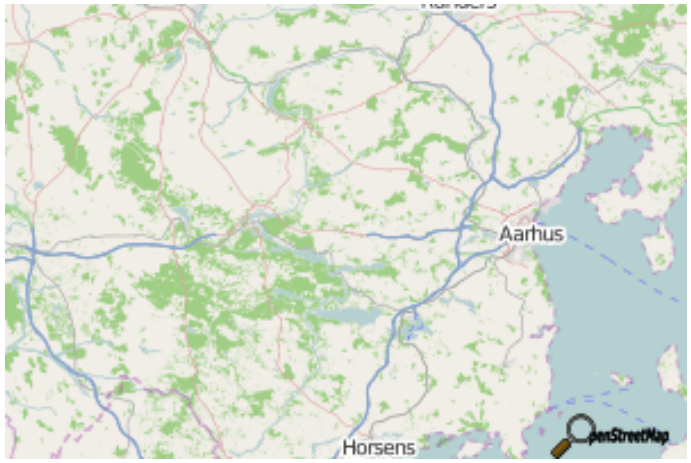
Show the coordinate on an OpenStreetMap map:

```
url_map = ('http://staticmap.openstreetmap.de/staticmap.php?center=%f,%f'
           '&zoom=8&size=300x200&maptype=mapnik"') % (lat, long)
import PIL.Image
import StringIO
buf = urllib2.urlopen(url_map).read()
im = PIL.Image.open(StringIO.StringIO(buf))
im.show()
```

In this case the first municipality seat returned from DBpedia was Hvorslev:

```
>>> uris[0]
'http://dbpedia.org/resource/Hvorslev'
>>> lat
56.15000152587891
>>> long
9.767000198364258
```

And the generated image:



Construct SPARQL URL for DBpedia

SQL-like *SPARQL* is the query language in Semantic Web web services.

As an example, formulate a query in SPARQL language for information about pharmaceutical companies with more than 30'000 employees:

```
>>> query = """
SELECT  ?Company ?numEmployees ?revenue ?industry ?name ?page WHERE {
    ?Company dbpprop:industry ?industry ;
             dbpprop:numEmployees ?numEmployees ;
             dbpprop:revenue ?revenue ;
             foaf:name ?name ;
             foaf:isPrimaryTopicOf ?page .
    FILTER (?industry = dbpedia:Pharmaceutical_industry ||
            ?industry = dbpedia:Pharmaceutical_drug) .
    FILTER (?numEmployees > 30000) .
    FILTER (?numEmployees < 30000000) .
} """
```

Query the DBpedia so-called "endpoint" for data in CSV format:

```
>>> import urllib
>>> param = urllib.urlencode({'format': 'text/csv',
                              'default-graph-uri': 'http://dbpedia.org',
                              'query': query})
>>> endpoint = 'http://dbpedia.org/sparql'
>>> csvdata = urllib.urlopen(endpoint, param).readlines()
```

Read the csv data into an array of dictionaries:

```
>>> import csv
>>> columns = ['uri', 'employees', 'revenue',
               'industry', 'name', 'wikipedia']
>>> data = [dict(zip(columns, row)) for row in csv.reader(csvdata[1:])]
```

There is an non-uniqueness issue because of multiple foaf:names

```
>>> data = dict([(d['uri'], d) for d in data])
```

Now we got access to the information about the companies, e.g., number of employees:

```
>>> [d['employees'] for d in data][:6]
['90000', '111400', '110600', '99000', '40560', '40560']
```

However, the DBpedia extraction from Wikipedia might not always be easy to handle, e.g., the revenue has different formats and possible unknown currency:

```
>>> [d['revenue'] for d in data][:12]
['US$30.8 Billion', '3.509E10', 'US$ 67.809 billion', '2.8392E10',
'9.291E9', '9.291E9', 'US$33.27 billion', 'US $50.624 billion',
'US$ 61.587 billion', '4.747E10', 'US$ 18.502 billion',
'\xc2\xa56,194.5 billion']
```

(note here is missing the coding of UTF-8 '\xc2\xa56' to the Yen sign)

Furthermore, information in Wikipedia (and thus DBpedia) is not necessarily correct.

Reading data with Pandas

Reading of the returned data from DBpedia's SPARQL endpoint make the code a bit cleaner:

```
>>> import pandas as pd

>>> data = pd.read_csv(endpoint + '?' + param)
>>> data.drop_duplicates(cols='Company')
>>> data[['Company', 'numEmployees', 'revenue']].head(3)
                                    Company  numEmployees              revenue
0       http://dbpedia.org/resource/Pfizer         91500   US$ 58.98 billion
1  http://dbpedia.org/resource/Merck_&_Co.         86000  US$ 48.047 billion
3     http://dbpedia.org/resource/Novartis        119418  US $58.566 billion
```

Note the data from DBpedia is still dirty, because of the difficulty with extracting data from Wikipedia.

You can also store your own data in Semantic Web-like data structures

Setup up a triple store

See Python Semantic Web book (Segaran et al., 2009)

Simple triple store without the use of URIs:

```
>>> triples = [("Copenhagen", "is_capital_of", "Denmark"),
               ("Stockholm", "is_capital_of", "Sweden"),
               ("Copenhagen", "has_population", 1000000),
               ("Aarhus", "is_a", "city"),
               ("Copenhagen", "is_a", "capital"),
               ("capital", "is_a", "city")]
```

Query the triple store (the Python variable `triples`) for capitals:

```
>>> filter(lambda (s,v,o): v=="is_capital_of", triples)
[('Copenhagen', 'is_capital_of', 'Denmark'),
 ('Stockholm', 'is_capital_of', 'Sweden')]
```

Python Semantic Web package: `rdflib`

Example using `rdflib` (Segaran et al., 2009, Chapter 4+)

```
>>> import rdflib
>>> from rdflib.Graph import ConjunctiveGraph
>>> g = ConjunctiveGraph()
>>> for triple in triples: g.add(triple)
```

Query the triple store with the `triples()` method in the `ConjunctiveGraph()` class:

```
>>> list(g.triples((None, "is_capital_of", None)))
[('Stockholm', 'is_capital_of', 'Sweden'),
 ('Copenhagen', 'is_capital_of', 'Denmark')]
```

Wikidata

Wikidata/Wikibase

Recent effort to structure Wikipedia's semistructured data

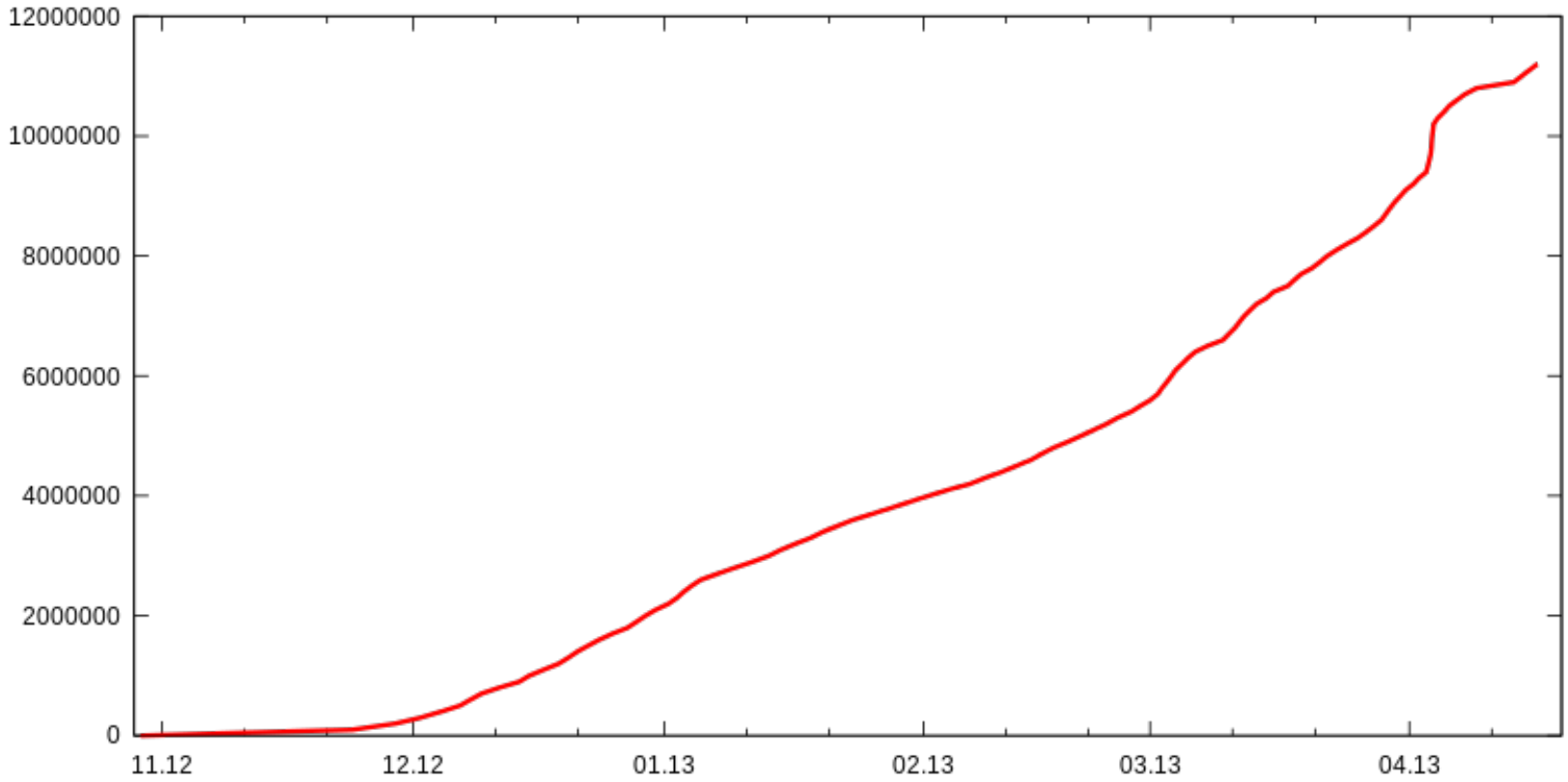
Multilingual so each label and description may be in several languages.

Wikibase is the program for MediaWiki

Instance on wikidata.org under Wikimedia Foundation for Wikipedia

Wikidata have more pages than Wikipedia.

Growth in Wikidata



From Wikidata item creation progress no text (Pyfisch, CC-BY-SA)

Wikidata data model

Entity: Either an "item" (Example: the gene Reelin: Q414043) or a "property"

1. *Item*
   (a) Item identifier, e.g., "Q1748" for Copenhagen
   (b) Multilingual label, e.g., "København", "Copenhagen"
   (c) Multilingual description, "Danmarks hovedstad"
   (d) Multilingual aliases
   (e) Interwikilinks (links between difference language versions of Wikipedia)

(f) *Claims*

i. *Statement*

A. *Property*, e.g., “GND-type” (P107)

B. *Property value*, e.g., “geographical object”

C. *Qualifiers*

ii. *Reference*

2. *Property*

(a) *Property identifier*

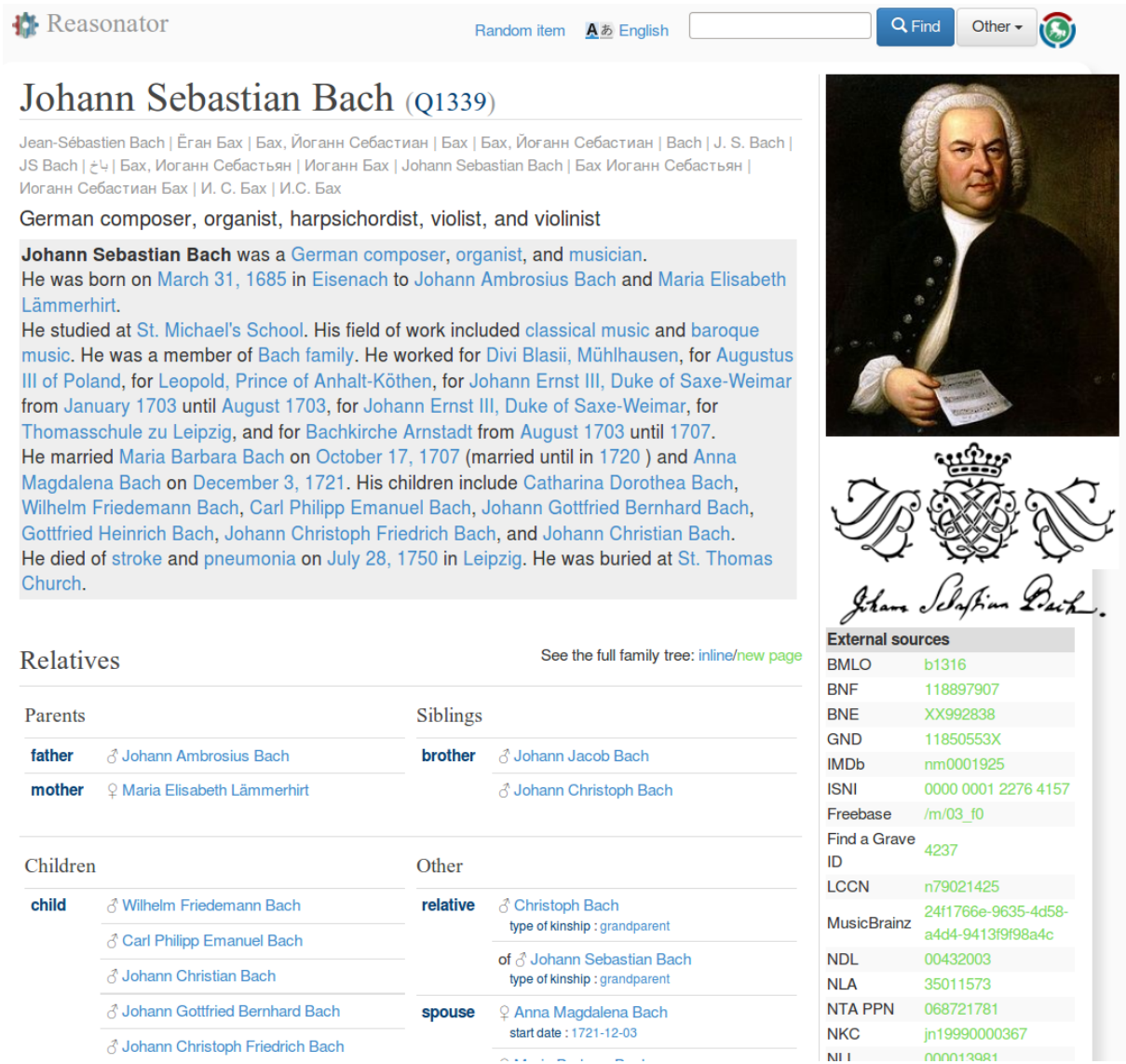
(b) Multilingual label

(c) Multilingual description

(d) Multiplingual aliases

(e) Datatype

Reasonator: Online rendering of Wikidata data



Programmer's interface

Ask for Copenhagen (Q1748), get multilingual element in Danish and JSON:

```
http://wikidata.org/w/api.php?
   action=wbgetentities & ids=Q1748 & languages=da & format=json
```

What is the country of Copenhagen:

```
import requests
url = "http://wikidata.org/w/api.php?" + \
      "action=wbgetentities&ids=Q1748&languages=da&format=json"
response = requests.get(url).json()
property = response['entities']['Q1748']['claims']['P17'][0]
property['mainsnak']['datavalue']['value']['numeric-id']
```

Gives "35" (Q35=Denmark).

pywikibot interface

After setup (of `user-config.py`) you can do:

```
>>> import pywikibot

>>> data = pywikibot.DataPage(42)
>>> dictionary = data.get()
>>> dictionary["label"]["de"]
u'Douglas Adams'
>>> [claim["m"][3]["numeric-id"] for claim in dictionary["claims"]
                                 if claim['m'][1] == 21 ][0]
6581097
>>> print(pywikibot.DataPage(6581097).get()["label"]["ro"])
bărbat
```

Data item number 42 is something called "Douglas Adams" in German which has the sex/gender "bārbat" (male) in Romanian.

pywikibot interface

Note the pywikibot API is unfortunately shaky. You might have to do:

```
>>> import pywikibot
>>> site = pywikibot.Site('en')
>>> repo = site.data_repository()
>>> item = pywikibot.ItemPage(repo, 'Q42')
>>> _ = item.get()              # This is apparently necessary!
>>> item.labels['de']
u'Douglas Adams'
>>> target_item = item.claims['P21'][0].target
>>> _ = target_item.get()
>>> target_item.labels['ro']
u'b\u0103rbat'
```

This is for the branch presently called *core*.

Wikidata tools

Using Magnus Manske's tool to get Danish political parties with a Twitter account

```
>>> import requests
>>> url_base = "https://wdq.wmflabs.org/api?q="
>>> query = "CLAIM[31:7278] AND CLAIM[17:35] AND CLAIM[553:918]"
>>> items = requests.get(url_base + query).json()['items']
>>> items
[25785, 212101, 217321, 478180, 507170, 615603, 902619, 916161]
```

These numbers are Wikidata identifiers for the Danish political parties, e.g., https://www.wikidata.org/wiki/Q25785 is the Red-Green Alliance.

Query to be read: instance of political party and country Denmark and website account on Twitter

Wikidata tools

```
url_base = ('http://wikidata.org/w/api.php?'
            'action=wbgetentities&format=json&ids=Q')
for item in items:
    party = requests.get(url_base + str(item)).json()['entities'].values()[0]
    label = party['labels']['en']['value']
    account = ''
    for claim in party['claims']['P553']:
        if claim['mainsnak']['datavalue']['value']['numeric-id'] == 918:
            # Twitter == 918
            try:
                account = claim['qualifiers']['P554'][0]['datavalue']['value']
            except IndexError, KeyError:
                pass
            break
    print('{}: https://twitter.com/{}'.format(label, account))
```

It gets the parties from the 'ordinary' API and produces the output:

```
Red-Green Alliance: https://twitter.com/Enhedslisten
Social Democrats: https://twitter.com/Spolitik
Venstre: https://twitter.com/Venstredk
...
```

More information and features

Book about Semantic Web and rdflib: (Segaran et al., 2009)

rdflib can read N3 and RDF file formats

rdflib can handle namespaces.

There are dedicated triple store databases, e.g., Virtuoso.

Summary

You can get large amount of background information from the Semantic Web & Co.

References

Segaran, T., Evans, C., and Taylor, J. (2009). *Programming the Semantic Web*. O'Reilly. ISBN 978-0-596-15381-6.