A Closer look at DBpedia

- DBpedia and Wikidata are the two largest semantic knowledge graphs of general background knowledge
- Both are extremely useful for many tasks and have complementary strengths
- We'll look at some of DBpedia's details today
- Some material here is adapted from a **tutorial** by Milan Dojchinovski at the 2022 Knowledge Graph Conference. A video of an earlier tutorial is available **here**

DBpedia Mission

2007: A crowd-sourced community effort to **extract structured information from Wikipedia** and make this information available on the Web.

- benefit: query Wikipedia as a Database

2022: Current mission: **Global and Unified Access to Knowledge Graphs**

- Original definition still holds true, moreover ...
- **Global DBpedia -> data beyond Wikipedia**
  1. offer **links** to other sources
  2. **platform** (i.e. databus) to integrate your data with all other data

DBpedia Milestones

2007
formation of the Linked Data Cloud

2010
Open editing of DBpedia Ontology
A new type of Cyc?

2012-2016
Covering all 140 Wikipedias, Commons, Wikidata
14.4 B facts extracted

2018

2020 - 22 B facts per month

Huge Linked Data - derived Open Knowledge Graphs (OKG)

2007 2015 2020

2007
first Wikipedia extraction, SPARQL Linked Data

2009
Major boost in KG and Linking Research

2011
Industry adoption

2014
Foundation of DBpedia Association Leipzig

2017
SHACL W3C Standard by Uni Leipzig Test-driven KG development

2019
DBpedia Innovation Platform - Central hub for Linked Data Technology and Ecosystem

2020 - FAIR Linked Data

Findable
Accessible
Interoperable
Reusable

DBpedia is a hub for Linked Open Data

- Tim Berners Lee coined the term Linked Data in 2006 as one of the motivations for RDF and the semantic web
- RDF data enables easy linking though the **owl:sameAs** and **rdfs:seeAlso** links connecting URIs
  - dbr: University_of_Maryland,_Baltimore_County **owl:sameAs** wikidata:University of Maryland, Baltimore County
- The links are transitive, but DBpedia and Wikidata are hubs, with many links
- Other useful links are in the skos ontology

DBpedia is a hub

- Tim Berners Lee
one of the motiv
- RDF data enable
ar
  - dbr: Univers y_of
wikidata:Universit
- The links are tra
hubs, with many
- Other useful link

sameAs links from DBpedia

- yago-res:University of Maryland, Baltimore County
- freebase:University of Maryland, Baltimore County
- http://viaf.org/viaf/145133422
- dbpedia-commons:University of Maryland, Baltimore County
- http://d-nb.info/gnd/5304456-3
- wikidata:University of Maryland, Baltimore County
- geodata:University of Maryland, Baltimore County
- dbpedia-ar:University of Maryland, Baltimore County
- http://arz.dbpedia.org/resource/جامعة_مارپلاند
- http://azb.dbpedia.org/resource/بالتیمورده_کی_مریلند_پیلیمبوردو
- dbpedia-de:University of Maryland, Baltimore County
- dbpedia-fa:University of Maryland, Baltimore County
- dbpedia-fr:University of Maryland, Baltimore County
- dbpedia-lb:University of Maryland, Baltimore County
- dbpedia-simple:University of Maryland, Baltimore County
- http://tl.dbpedia.org/resource/Unibersidad_ng_Maryland,_Baltimore_County
- http://ur.dbpedia.org/resource/یونیورسٹی_آف_میری_لینڈ،_بالٹیمور_کاؤنٹی
- dbpedia-zh:University of Maryland, Baltimore County
- https://global.dbpedia.org/id/4uE9S

DBpedia is a hub for Linked Open Data

- Tim Berners Lee coi
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  and **rdfs:seeAlso** lin
  - dbr: University_of_Mar
    wikidata:University of M
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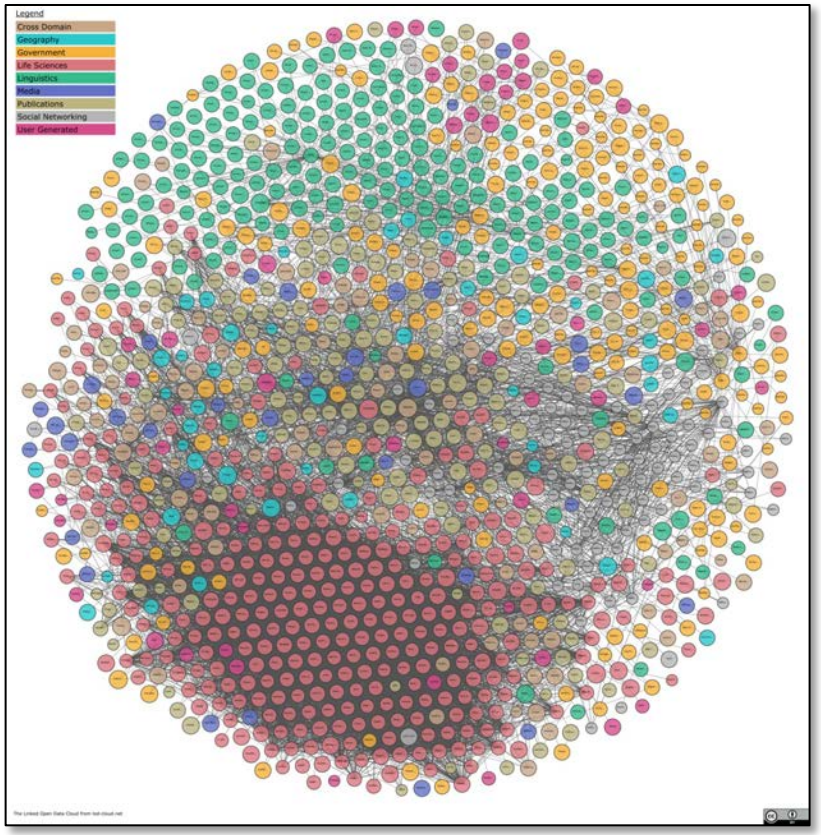
  hubs, with many link
- Other useful links are in the skos ontology

- The **SKOS ontology** is a W3C standard that provides relations to connect RDF concepts
- These are less formal and precise than the RDFS and OWL relations, which is often needed
- Examples:
  skos:related
  skos:narrower
  skos:broader

Linked Open Data Cloud

DBpedia

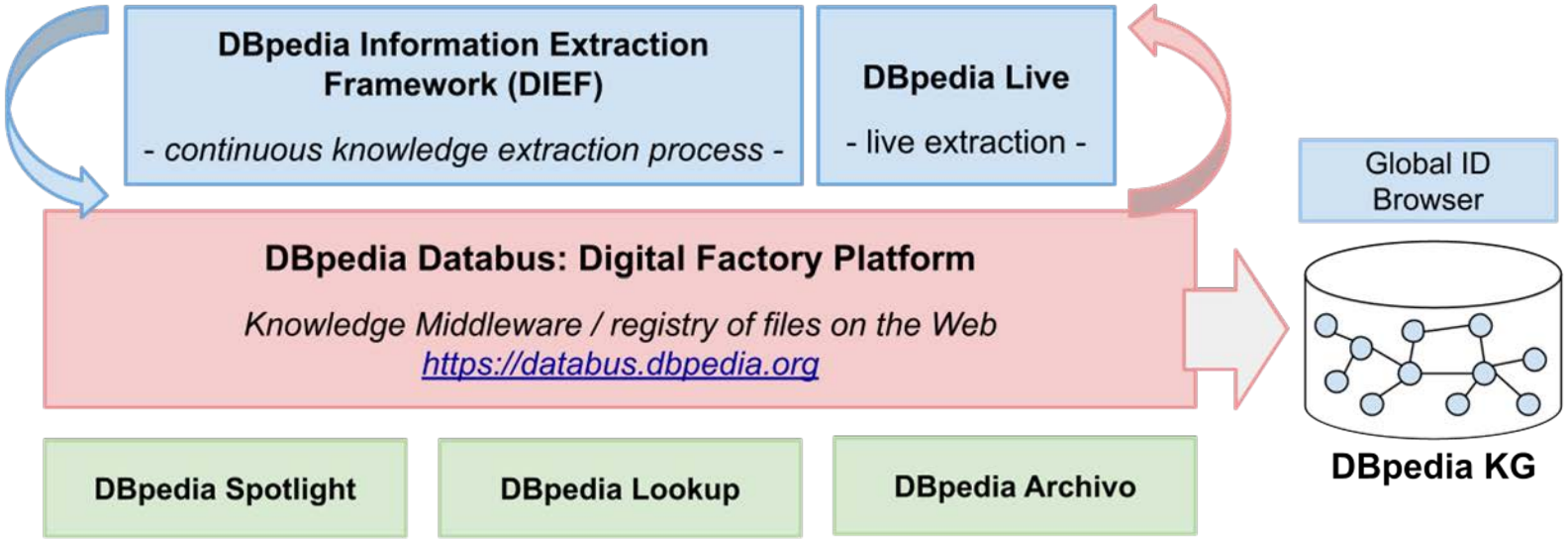
- The **LOD cloud** contains over **1,255** datasets with **16,174** links (as of May 2020)
- Each item in the figure represents one RDF knowledge graph
- DBpedia is at the center as the most commonly linked resource
- **Wikidata** is another commonly linked knowledge graph
- The linking is enhanced since many of the connections are transitive



Dbpedia Organizational Structure in Numbers

- **Around 20 DBpedia Chapters**
  - **language chapters**, English, German, Dutch, Czech, Polish, Hungarian, ...
  - **regional chapters**, e.g. for cities or individual countries
  - **domain chapters**, e.g. for law, medicine, media and science
  - each chapter hosts and maintains localized DBpedia version
  - more about DBpedia chapters at https://www.dbpedia.org/members/chapter-overview/
- **30+ DBpedia members**
  - 41% industry and start-up, 37% non-profit, 22% tiny & self-employed
  - join the network of pioneers to shape the future of knowledge graphs
  - apply via https://www.dbpedia.org/members/membership/

The DBpedia Tech Ecosystem



DBpedia Live vs DBpedia snapshot

- The standard DBpedia website and sparql service uses a **snapshot** released every 3 months & available to download
  - This is why Freeman Hrabowski still shows as UMBC's president
- **DBpedia live** is a version that is continually updated by monitoring changes to Wikipedia
  Wikimedia resources make edits public, e.g., see recent changes to the english **UMBC** page
- **https://live.dbpedia.org/sparql** is DBpedia live's SPARQL endpoint

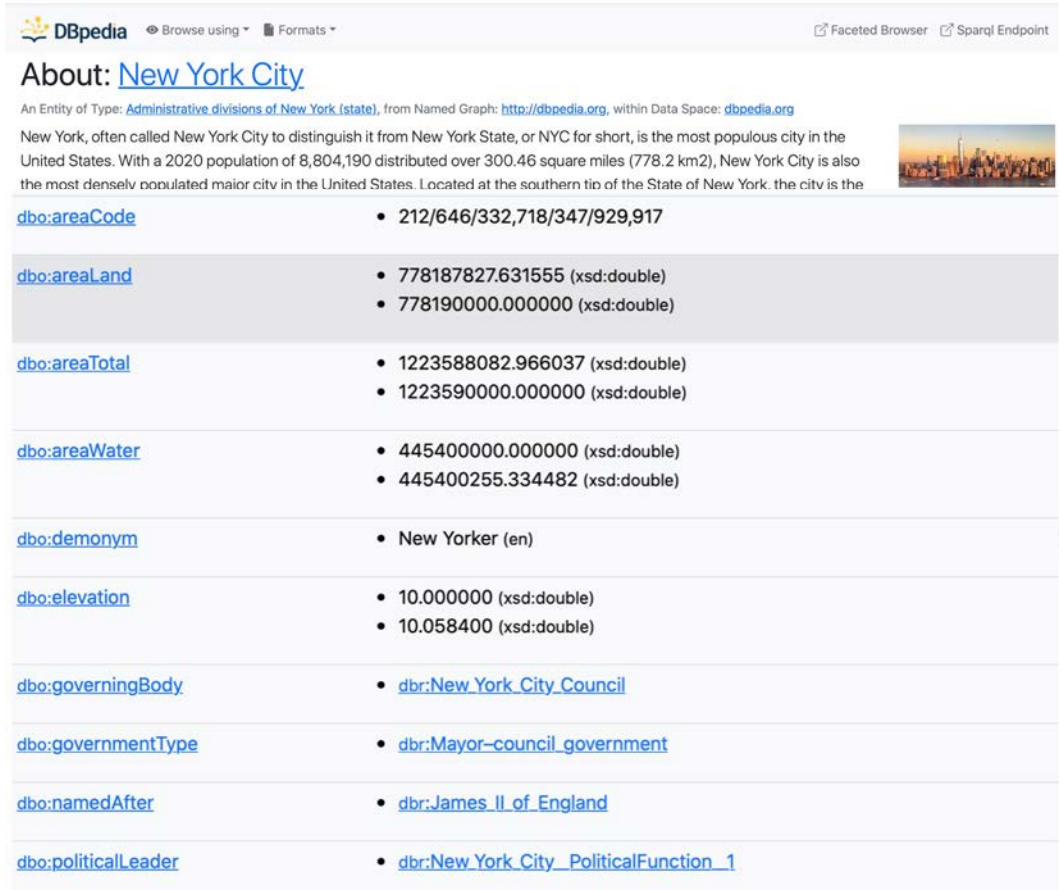
How a DBpedia triple is born?

One easy source is Wikipedia Infoboxes

New York

City

Country	United States
State	New York
Region	Mid-Atlantic
Constituent counties (boroughs)	Bronx (The Bronx) Kings (Brooklyn) New York (Manhattan) Queens (Queens) Richmond (Staten Island)
Historic colonies	New Netherland Province of New York
Settled	1624 (approx)
Consolidated	1898
Named for	James, Duke of York
Government	
· Type	Strong mayor–council
· Body	New York City Council
· Mayor	Bill de Blasio (D)
Area[2]	
· Total	472.43 sq mi (1,223.59 km²)
· Land	300.46 sq mi (778.19 km²)



DBpedia · Browse using · Formats · Faceted Browser · Sparql Endpoint

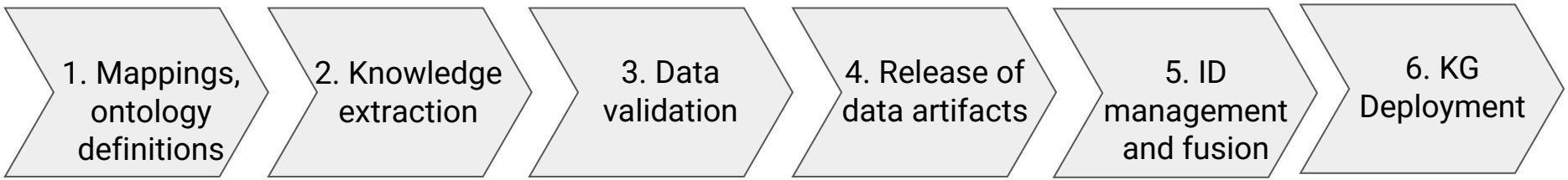
About: New York City

An Entity of Type: Administrative divisions of New York (state), from Named Graph: http://dbpedia.org, within Data Space: dbpedia.org

New York, often called New York City to distinguish it from New York State, or NYC for short, is the most populous city in the United States. With a 2020 population of 8,804,190 distributed over 300.46 square miles (778.2 km2), New York City is also the most densely populated major city in the United States. Located at the southern tip of the State of New York, the city is the

dbo:areaCode	• 212/646/332,718/347/929,917
dbo:areaLand	• 778187827.631555 (xsd:double) • 778190000.000000 (xsd:double)
dbo:areaTotal	• 1223588082.966037 (xsd:double) • 1223590000.000000 (xsd:double)
dbo:areaWater	• 445400000.000000 (xsd:double) • 445400255.334482 (xsd:double)
dbo:demonym	• New Yorker (en)
dbo:elevation	• 10.000000 (xsd:double) • 10.058400 (xsd:double)
dbo:governingBody	• dbr:New_York_City_Council
dbo:governmentType	• dbr:Mayor–council_government
dbo:namedAfter	• dbr:James_II_of_England
dbo:politicalLeader	• dbr:New_York_City__PoliticalFunction__1

Overarching DBpedia KG Release Process



1. Definition of mappings and ontology definition
2. Execution of the knowledge extraction process over Wikipedia dumps
3. Parsing and validation of the data against strict rules
4. Release of (intermediate) data artifacts
5. ID management & knowledge fusion from all language editions
6. Deployment of the resulting KG

DBpedia Datasets Partitions

Available extractions, 22 billion facts total (500GB without text)

- **Mapping-based** (rule-based)
- **Generic** (automatic)
- **Text**
- **Wikidata**

… bonus:

- **Fusion** - fused version of all wikipedia languages
- **Global IDs** - unique URIs across all languages (https://global.dbpedia.org)

… data derived based on the Wikimedia XML dumps

How a DBpedia triple is born

… using **mappings-based extraction?**

One easy source is Wikipedia Infoboxes

New York

City

Country	United States
State	New York
Region	Mid-Atlantic
Constituent counties (boroughs)	Bronx (The Bronx) Kings (Brooklyn) New York (Manhattan) Queens (Queens) Richmond (Staten Island)
Historic colonies	New Netherland Province of New York
Settled	1624 (approx)
Consolidated	1898
Named for	James, Duke of York
Government	
· Type	Strong mayor–council
· Body	New York City Council
· Mayor	Bill de Blasio (D)
Area[2]	
· Total	472.43 sq mi (1,223.59 km²)
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dbo:areaWater	• 445400000.000000 (xsd:double) • 445400255.334482 (xsd:double)
dbo:demonym	• New Yorker (en)
dbo:elevation	• 10.000000 (xsd:double) • 10.058400 (xsd:double)
dbo:governingBody	• dbr:New_York_City_Council
dbo:governmentType	• dbr:Mayor–council_government
dbo:namedAfter	• dbr:James_II_of_England
dbo:politicalLeader	• dbr:New_York_City__PoliticalFunction__1

Structure of Wikipedia articles

- Wikipedia's Infoboxes use one or more predefined templates with relevant properties
- These specify what the values can be
- By editing a page you can see its Infobox details

WIKIPEDIA
The Free Encyclopedia

Article Talk

View source for New York City

← New York City

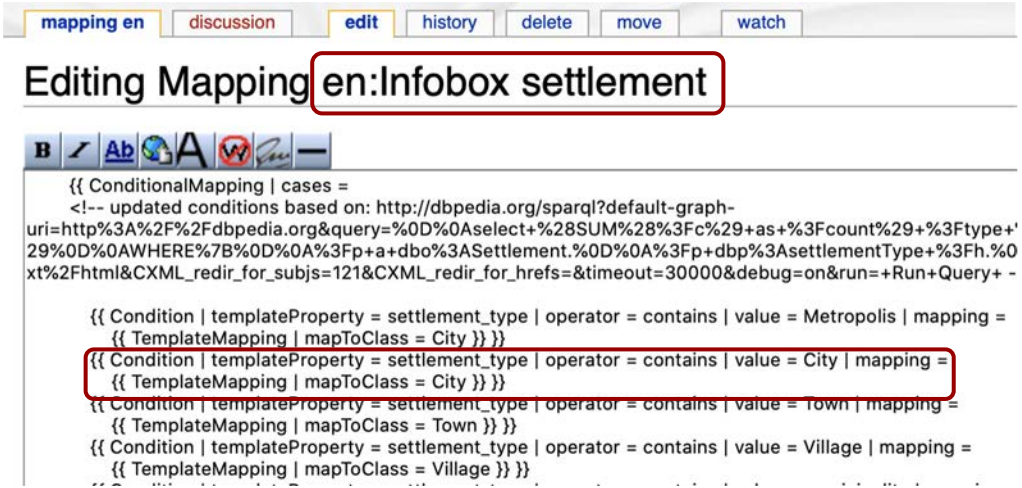
This article is **written in American English**, which has its own spelling conventi… *traveled*) and so…
other varieties of English. According to the relevant style guide, this shou… without broad consensus.

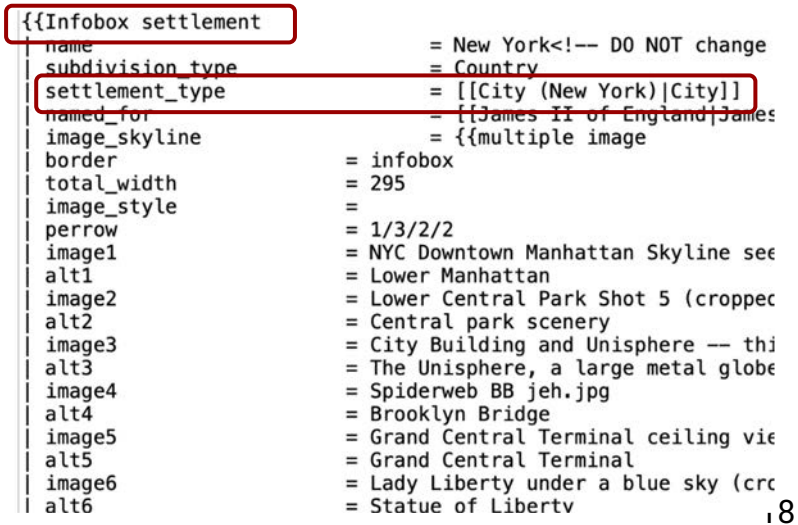
You can view and copy the source of this page:

```
{{short description|Most populous city in the United S
{{redirect2|NYC|New York, New York|4=New York Ci… biguation)|5=and|6=NYC (disambiguation)|7=and|8=New York, New York (disambiguation)}}
{{pp-semi-indef}}
{{Use mdy dates|date=February 2021}}
<!-- Don't add a particular image si… most images of this article; it will be reverted. The images need to be able to customize from personal
preferences. -->
{{Infobox settlement
| name                     = New York<!-- DO NOT change without discussion -->
| subdivision_type         = Country
| settlement_type          = [[City (New York)|City]]
| named_for                = [[James II of England|James, Duke of York]]
| image_skyline            = {{multiple image
| border                 = infobox
| total_width            = 295
| image_style            =
| perrow                 = 1/3/2/2
| image1                 = NYC Downtown Manhattan Skyline seen from Paulus Hook 2019-12-20 IMG 7347 FRD (cropped).jpg
| alt1                   = Lower Manhattan
| image2                 = Lower Central Park Shot 5 (cropped).JPG
| alt2                   = Central park scenery
| image3                 = City Building and Unisphere -- this morning (50155048863) (cropped).jpg
| alt3                   = The Unisphere, a large metal globe sculpture
| image4                 = Spiderweb BB jeh.jpg
```

Triple Generation using Mappings

- Mappings specify how infobox template properties map to DBpedia properties
- Mappings maintained on the mappings server: http://mappings.dbpedia.org/
- Mappings for approx. 40 languages, 6 datasets
- http://mappings.dbpedia.org/index.php/Mapping_en:Infobox_settlement





Mappings Example

```
| unit_pref                    = Imperial
| area_footnotes               = <ref name="C
data/data/gazetteer/2021_Gazetteer/2021_gaz_plac
| area_total_sq_mi             = 472.43
| area_total_km2               = 1223.59
| area_land_sq_mi              = 300.46
| area_land_km2                = 778.19
| area_water_sq_mi             = 171.97
| area_water_km2               = 445.40
| utc_offset1                  = -05:00
| elevation_footnotes          = <ref name="C
|access-date=January 31, 2008 |publisher=[[Unite
| elevation_m                  = 10
| elevation_ft                 = 33
| population_rank              = [[List of Ur
```

Property Mapping (help)	
template property	area_total_km2
ontology property	areaTotal
unit	squareKilometre

Property Mapping (help)	
template property	area_water_km2
ontology property	areaWater
unit	squareKilometre

{{ PropertyMapping | templateProperty = area_total_km2 | ontologyProperty = areaTotal | unit = squareKilometre }}

{{ PropertyMapping | templateProperty = area_water_km2 | ontologyProperty = areaWater | unit = squareKilometre }}

```
dbr:New_York_City
    dbo:areaTotal
                1223590000.000000 ;
    dbo:areaWater
                445400000.000000 .
```

DBpedia

How a DBpedia triple is born

… using **generic extraction?**

Generic Extraction Example

```
| image7                = The United Nations Secretariat Bu
| alt7                    = United Nations headquarters bui
| image8                 = Greenpoint Houses.JPG
| alt8                    = Rowhouses in Brooklyn
}}
| image_caption          = '''From top, left to right''':
[[Grand Central Terminal]]; the [[Statue of Liberty]]; the [
| image_flag             = Flag of New York City.svg
| image_seal             = Seal of New York City BW.svg
| image_blank_emblem     = NYC Logo Wolff Olins.svg
| blank_emblem_type      = [[Wordmark]]
| nicknames              = ''[[The Big Apple]]'', ''[[The
York City to 1898|Gotham]]'', and [[Nicknames of New York Ci
| image_map              = {{Maplink|frame=yes|plain=y|fra
City|marker=city|type2=shape|stroke-width2=2|stroke-color2=#
| subdivision_name       = {{flag|United States}}
| map_caption            = Interactive map of New York Cit
| coordinates            = {{coord|40|42|46|N|74|00|22|W|r
```

dbp:name	• New York (en)
dbp:namedFor	• dbr:James_II_of_England
dbp:nicknames	• The Big Apple, The City That Never Sleeps, Gotham, and others (en)
dbp:perrow	• 2 (xsd:integer)
dbp:populationAsOf	• 2020 (xsd:integer)
dbp:populationDemonym	• New Yorker (en)
dbp:populationDensityKm	• 11313.680000 (xsd:double)
dbp:populationDensitySqMi	• 29302.370000 (xsd:double)
dbp:populationMetro	• 23582649 (xsd:integer)
dbp:populationRank	• 1 (xsd:integer)
dbp:populationTotal	• 8804190 (xsd:integer)

Output triples:

dbr:New_York_City
dbp:nicknames "The Big Apple, The City That Never Sleeps, Gotham, and others"

Generic Extraction

- Automatic extraction and export of information
  - Covers 130+ languages and exports 30 different datasets
  - https://databus.dbpedia.org/dbpedia/generic/
- Extraction of:
  - unmapped information in infoboxes
  - other structured information found on the Wikipedia pages

1. **Automatic extraction of unmapped properties from infoboxes**
   - covers all infobox types along with their attributes
   - http://dbpedia.org/property/ + the name of the infobox attribute
   - e.g. http://dbpedia.org/property/birthplace for the Wikipedia attribute “birthplace”
   - objects are created from the attribute values
2. **Automatic extraction of other structured information**
   - set of extractors
   - https://github.com/dbpedia/extraction-framework/tree/master/core/src/main/scala/org/dbpedia/extraction/mappings
   - categories, interlanguage links, labels, and many others

Text Extraction

- Extract data from Wikipedia articles‘ text
- https://databus.dbpedia.org/dbpedia/text/
- 132 languages, 8 datasets
  - Short and long abstracts
  - content/text + structure
    - sections, sub-sections, paragraphs
    - links
- Information modeled using the NIF Format
- Use cases
  - Training data for text mining
  - Fact extraction

20th century [edit]

First Czechoslovak Republic [edit]

Main article: First Czechoslovak Republic

World War I ended with the defeat of the Austro-Hungarian Empire and the creation of Czechoslovakia. Prague was chosen as its capi true European capital with highly developed industry. By 1930, the population had risen to 850,000.

Second World War [edit]

Further information: German occupation of Czechoslovakia

Hitler ordered the German Army to enter Prague on 15 March 1939, and from Prague Castle proclaimed Bohemia and Moravia a Germ German and (mostly native German-speaking) Jewish populations.[47] From 1939, when the country was occupied by Nazi Germany, H the Germans. In 1942, Prague was witness to the assassination of one of the most powerful men in Nazi Germany—Reinhard Heydrich Kubiš. Hitler ordered bloody reprisals.[48]

In February 1945, Prague suffered several bombing raids by the US Army Air Forces. 701 people were killed, more than 1,000 people Vinohrady Synagogue) were destroyed.[49] Many historic structures in Prague, however, escaped the destruction of the war and the da pilots, it was the result of a navigational mistake. In March, a deliberate raid targeted military factories in Prague, killing about 370 peop

On 5 May 1945, two days before Germany capitulated, an uprising against Germany occurred. Several thousand Czechs were killed in the 3rd Shock Army of the Red Army took the city almost unopposed. The majority (about 50,000 people) of the German population of

Extraction executed every 3-4 months.

https://en.wikipedia.org/wiki/Prague

Text Extraction

- Extract data from Wikipedia article text every 3-4 months
- https://databus.dbpedia.org/dbpedia/text/
- 132 languages, 8 datasets
  - Get short and long abstracts
  - content/text + structure
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    - links
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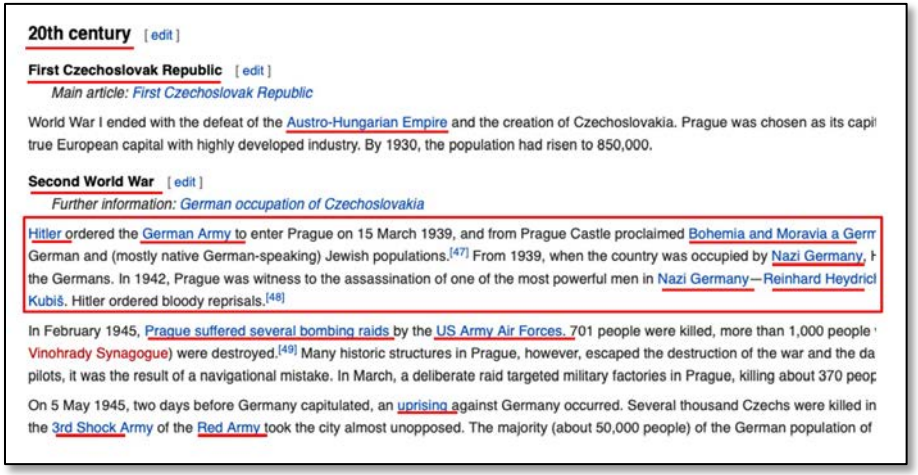

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https://en.wikipedia.org/wiki/Prague

Wikidata Extraction

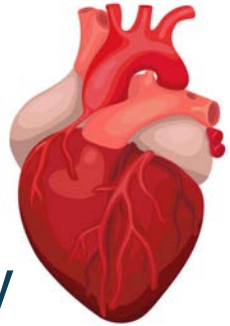
- Same approach as for Wikipedia
- Generic and mappings-based
- Mappings in JSON

https://databus.dbpedia.org/dbpedia/wikidata

Benefit: Unified access over Wikipedia and Wikidata

```
"P279": [
    {
        "rdfs:subClassOf": "$getDBpediaClass"
    }
],
"P625": [
    {
        "rdf:type": "http://www.w3.org/2003/01/geo/wgs84_pos#Spatia
    },
    {
        "geo:lat": "$getLatitude"
    },
    {
        "geo:long": "$getLongitude"
    },
    {
        "georss:point": "$getGeoRss"
    }
],
```

DBpedia Ontology



- The heart of DBpedia
- A shallow cross-domain ontology
  - model information extracted from Wikipedia
  - BUT goes beyond Wikipedia, e.g., uses mappings for the Dutch National KG
- Generated on-the-fly when changes in mappings wiki are introduced
- Over 700 classes and >3,000 properties
- Since v3.7: classes can have multiple superclasses

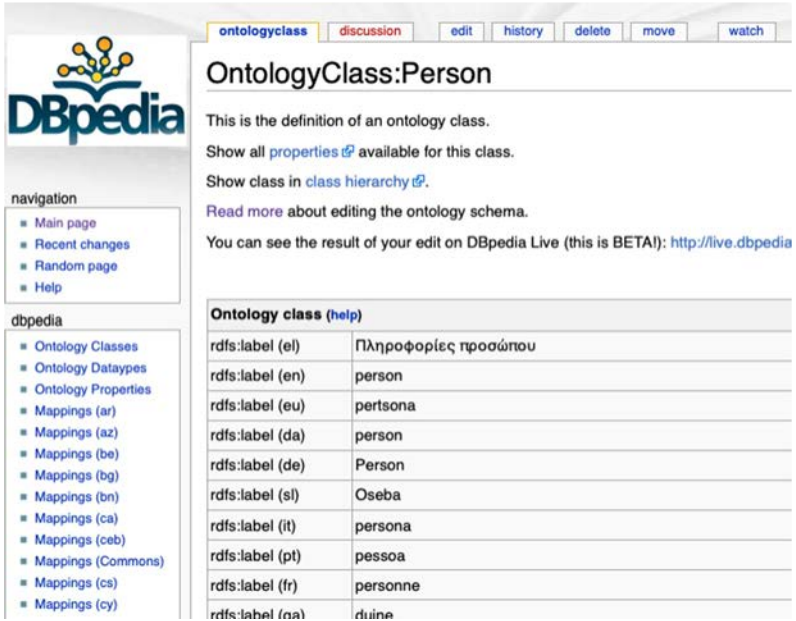
Ontology Classes

- owl:Thing
  - Activity (edit)
    - Game (edit)
      - BoardGame (edit)
      - CardGame (edit)
    - Sales (edit)
    - Sport (edit)
      - Athletics (edit)
      - TeamSport (edit)
  - Agent (edit)
    - Deity (edit)
    - Employer (edit)
    - Family (edit)
      - NobleFamily (edit)
    - FictionalCharacter (edit)
      - ComicsCharacter (edit)
        - AnimangaCharacter (edit)
      - DisneyCharacter (edit)
      - MythologicalFigure (edit)
      - NarutoCharacter (edit)
      - SoapCharacter (edit)
    - Organisation (edit)
      - Broadcaster (edit)
        - BroadcastNetwork (edit)

DBpedia Ontology (2)

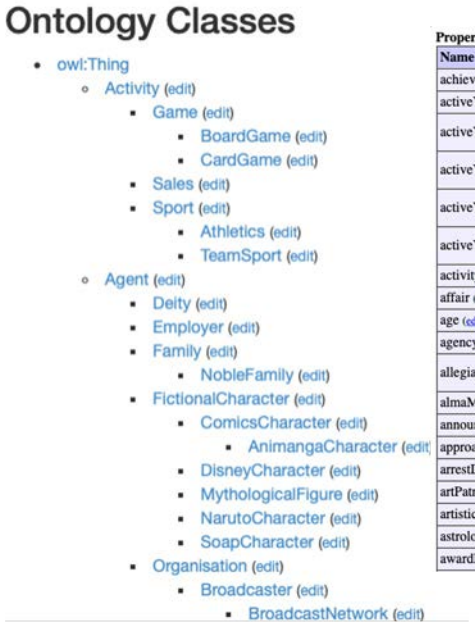
Edit via the mappings server

http://mappings.dbpedia.org/index.php/OntologyClass:Person



Browse the ontology

http://mappings.dbpedia.org/server/ontology/classes/



Properties on *Person*:

Name	Label	Domain	Range
achievement (edit)	achievement	Person	owl:Thing
activeYears (edit)	active years	Person	*xsd:string*
activeYearsEndDateMgr (edit)	active years end date manager	Person	*xsd:string*
activeYearsEndYearMgr (edit)	active years end year manager	Person	*xsd:gYear*
activeYearsStartDateMgr (edit)	active years start date manager	Person	*xsd:date*
activeYearsStartYearMgr (edit)	active years start year manager	Person	*xsd:gYear*
activity (edit)	activity	Person	owl:Thing
affair (edit)	affair	Person	*xsd:string*
age (edit)	age	Agent	*xsd:integer*
agency (edit)	agency	Person	owl:Thing
allegiance (edit)	allegiance	Person	*xsd:string*
almaMater (edit)	alma mater	Person	EducationalInstitution
announcedFrom (edit)	announcedFrom	Person	Place
approach (edit)	approach	Person	owl:Thing
arrestDate (edit)	arrest date	Person	*xsd:date*
artPatron (edit)	patron (art)	Agent	Artist
artisticFunction (edit)	artistic function	Person	*xsd:string*
astrologicalSign (edit)	astrological sign	Person	owl:Thing
awardName (edit)	awardName	Person	*xsd:string*

Three DBpedia SPARQL endpoints

1) DBpedia main SPARQL endpoint
   a) https://dbpedia.org/sparql
   b) hosts the DBpedia latest core release
2) DBpedia Live endpoint
   a) serves live extracted data
   b) http://live.dbpedia.org/sparql
3) Databus SPARQL endpoint
   a) hosts the data artifacts metadata
   b) https://databus.dbpedia.org/repo/sparql

The Power of the DBpedia Knowledge Graph

Main SPARQL endpoint: https://dbpedia.org/sparql

Simple example: *“persons, their names in English, their birth country and country population”*

```
SELECT ?person ?name ?country ?population WHERE {
    ?person a dbo:Person .
    ?person rdfs:label ?name .
    ?person dbo:birthPlace ?country .
    ?country dbo:populationTotal ?population .
    FILTER (langMatches( lang(?name), "en" ) )
}
```

Try It

The Power of the DBpedia Knowledge Graph

Main SPARQL endpoint: https://dbpedia.org/sparql

More complex query:

- *soccer players,*
- *born in a country with more than 10 million inhabitants,*
- *played as goalkeeper*
- *for a club*
- *that has a stadium*
- *with more than 30.000 seats.*

The Power of the DBpedia Knowledge Graph

Main SPARQL endpoint: https://dbpedia.org/sparql

```
SELECT DISTINCT ?personIRI ?name ?countryOfBirth ?population ?team ?stadium ?stadiumCapacity
WHERE {
   ?personIRI a dbo:Person .
   ?personIRI rdfs:label ?name .
   ?personIRI dbo:birthPlace ?countryOfBirth .
   ?countryOfBirth dbo:populationTotal ?population .
   ?personIRI dbo:team ?team .
   ?personIRI dbo:position|dbp:position <http://dbpedia.org/resource/Goalkeeper_(association_football)> .
   ?team dbo:stadium ?stadium .
   ?stadium dbo:seatingCapacity ?stadiumCapacity .

   FILTER (langMatches( lang(?name), "EN" ) )
   FILTER (?stadiumCapacity > 30000)
   FILTER (?population > 10000000)

} ORDER BY DESC(?stadiumCapacity)
```

Try It

Note: SPARQL's syntax doesa not defining prefixes whose URIs have parens or commas

More technical details

The original tutorial continued with more details on different topics…

- Using advanced aspects of the DBpedia technology stack
- Using Dbpedia Spotlight to extract links from entities in text
- Advanced search techniques
- Using DBpedia on your local infrastructure
- And a comment of DBpedia vs Wikidata

DBpedia vs. Wikidata

Complementary but still different projects

- Wikidata not adopted to Wikipedia infoboxes
  - lost of workspace (47k editors vs 13k in Wikidata)
- Is Wikidata up-to-date?
  - some corona related values we found were/are over 1 year old
  - … likely only for stable values such as birth dates, but not for recent data
- Wikidata is growing
  - … but this would require a lot more editors to cover all that and keep it updated
  - similar problem with Freebase
- Live Updates via DBpedia Live
  - whenever something happens, in 30 min in Wikipedia, and then also in DBpedia Live
  - 2 Wikipedia edits every second!
- **DBpedia Global “beyond” Wikipedia**
  - link to recent and authoritative sources