SPARQL on Wikidata

MPRI 2.26.2: Web Data Management

Antoine Amarilli

General presentation

- SPARQL: query language for RDF graphs
- Many KBs have a SPARQL endpoint with a Web interface
  - Wikidata `https://query.wikidata.org/`:
    - → latest statistics: serves around 10M requests per day
    - → of which around 1M are by humans
  - DBpedia `https://dbpedia.org/sparql`
  - YAGO `https://yago-knowledge.org/sparql`
  - INSEE `https://rdf.insee.fr/sparql`
  - BNF `https://data.bnf.fr/sparql/`

Basic shape of a query

Prefixes are declared with `PREFIX` (like in Turtle)

```
SELECT ?x ?y ?z WHERE {
  # ... facts about ?x ?y ?z ...
  # syntax is similar to Turtle
}
```

- `SELECT ... WHERE {...}`, most queries
- `ASK WHERE {...}`, for Boolean queries
- `CONSTRUCT {...} WHERE {...}`, to build a graph (see later)
- `DESCRIBE <entity>`: return an implementation-defined description of an entity (set of facts about the entity)

Facts in the query body

- You can put facts in the body of the query, using
  - variables (selected in the query or not)
  - constants (from any namespace, or raw URIs)
  - literals (in any format)
  - blank nodes (e.g., with brackets; anonymous variables)
- For every way to assign the variables such that the pattern holds, produce a result

Exercise: Finding all dogs

How to find all dogs in Wikidata?

Exercise: Finding all dogs

How to find all dogs in Wikidata?

```
SELECT DISTINCT ?dog ?dogLabel
WHERE
{
  ?dog wdt:P31 wd:Q144.
  SERVICE wikibase:label { bd:serviceParam
      wikibase:language "[AUTO_LANGUAGE],en". }
}
```

Property paths

Property paths allow us to use regular expressions in facts:

```
SELECT ?descendant
WHERE
{
  ?descendant (wdt:P22|wdt:P25)+ wd:Q1339.
}
```

Exercise: More dogs

How to find all dogs missed in the previous question?

Exercise: More dogs

How to find all dogs missed in the previous question?

(Hint: instances of subclasses of dogs are also dogs)

Exercise: More dogs

How to find all dogs missed in the previous question?

(Hint: instances of subclasses of dogs are also dogs)

```
SELECT DISTINCT ?dog ?dogLabel WHERE
{
  ?dog wdt:P31/wdt:P279* wd:Q144.
}
```

Wikidata-specific techniques

- To avoid typing entity and property numbers in the query, you can use `Ctrl+Space` to search by name
- To avoid them in the results, you can use the label service:

```
SERVICE wikibase:label
  { bd:serviceParam wikibase:language "[AUTO_LANGUAGE],en". }
```

- You can get this incantation with `Ctrl-Space`
- Automatically creates a variable `?xLabel` for every variable `?x`
- This is done late in the evaluation (e.g., cannot filter on them)

LIMIT and ORDER

- To avoid returning **too many results**, you can use `LIMIT`
- Also useful to **speed up the query**

```
SELECT * WHERE {
  ?s ?p ?o .
} LIMIT 1000
```

- We can also **sort** (using the implicit order on types)

```
SELECT DISTINCT ?country ?population WHERE
{
  ?country wdt:P31/wdt:P279* wd:Q3624078;
           wdt:P1082 ?population.
}
ORDER BY DESC(?population)
LIMIT 10
```

OPTIONAL

- SPARQL has an **open-world semantics** on missing data
- Extend results **if possible** and **keep them as-is** otherwise

```
SELECT ?book ?title ?publisher
WHERE {
  ?book wdt:P50 wd:Q35610.
  ?book wdt:P1476 ?title.
  OPTIONAL { ?book wdt:P123 ?publisher. }
}
```

- **Semantics:**
  - Consider **every solution** of what precedes
  - For each solution, **run the optional query**
  - If it produces outputs, **combine them** with the solution
  - If it does not, leave the solution **as-is**

OPTIONAL subtleties

- The order of patterns matter!

```
# selects people, which may have an image
SELECT * WHERE {
  ?person rdf:type ex:Person
  OPTIONAL { ?person ex:image ?image }
}
# selects only people with an image
SELECT * WHERE {
  OPTIONAL { ?person ex:image ?image }
  ?person rdf:type ex:Person
}
```

- Makes the computational complexity much worse (query evaluation is PSPACE-complete in combined complexity)
  https://arxiv.org/abs/0812.3788

Exercise: Gendered dogs

How to find all dogs in Wikidata and their gender if known?

Exercise: Gendered dogs

How to find all dogs in Wikidata and their gender if known?

```
SELECT ?dog ?dogLabel ?genderLabel WHERE {
  ?dog wdt:P31/wdt:P279* wd:Q144.
  OPTIONAL {
    ?dog wdt:P21 ?gender.
  }
  SERVICE wikibase:label { bd:serviceParam
      wikibase:language "[AUTO_LANGUAGE],en". }
}
```

FILTER

We can also **filter** query results based on conditions that cannot easily be expressed as a pattern of triples:

- Order **comparisons** on a value (e.g., “after 2015”); beware of **types**!
- String comparison and **regexps**
- Testing if a string is **in some set** (also: `VALUES`)
- Booleans, arithmetic operations, etc.

```
SELECT ?item ?bblid
WHERE {
    ?item wdt:P212 ?bblid .
    FILTER(!REGEX(STR(?bblid),
      "^[-.0-9A-Za-z]{1,}$"))
}
```

Exercise: Finding old dogs

How to find all dogs born before 1800?

Exercise: Finding old dogs

How to find all dogs born before 1800?

```
SELECT ?dog ?dogLabel ?dob WHERE
{
  ?dog wdt:P31/wdt:P279* wd:Q144.
  ?dog wdt:P569 ?dob.
  SERVICE wikibase:label { bd:serviceParam
      wikibase:language "[AUTO_LANGUAGE],en" }
  FILTER (YEAR(?dob) <= 1800)
}
ORDER BY DESC(?dob)
```

Aggregates

- Like in SQL:
  - Group the results according to the value of some variables
  - Compute some aggregate within each group

```
SELECT ?country (MAX(?population) AS ?maxPop)
WHERE
{
  ?city wdt:P31/wdt:P279* wd:Q515;
        wdt:P17 ?country;
        wdt:P1082 ?population.
}
GROUP BY ?country
```

- Can use `HAVING` to filter out some groups
- Can be useful with nested queries

Exercise: Most common breeds

How to find the most common dog breeds?

Exercise: Most common breeds

How to find the most common dog breeds?

```
SELECT ?breed ?breedLabel (COUNT(?dog) AS ?count) WHERE
{
  ?dog wdt:P31/wdt:P279* wd:Q144.
  ?dog wdt:P4743 ?breed.
  SERVICE wikibase:label { bd:serviceParam
      wikibase:language "[AUTO_LANGUAGE],en" }
}
GROUP BY ?breed ?breedLabel
ORDER BY DESC(?count)
```

DISTINCT

- We can get **duplicate results**, e.g.,
  - When **projecting away** variables
  - When **multiple paths** exist

```
SELECT ?class WHERE {
  wd:Q6602 wdt:P31/wdt:P279* ?class .
}
```

- We can **remove duplicates** with `SELECT DISTINCT`

MINUS

- We can substract a set of results from another with `MINUS`
- Often, what we really want is `FILTER NOT EXISTS`, i.e., testing that a match cannot be extended

Exercise: Finding colorless dogs

How to find dogs without a known color?

Exercise: Finding colorless dogs

How to find dogs without a known color?

```
SELECT ?dog ?dogLabel WHERE
{
  ?dog wdt:P31/wdt:P279* wd:Q144.
  FILTER NOT EXISTS {
    ?dog wdt:P462 ?color.
  }
  SERVICE wikibase:label { bd:serviceParam
      wikibase:language "[AUTO_LANGUAGE],en" }
}
```

Reified triples: quantifiers, sources, etc. (Wikidata-specific)

- The default way to talk about Wikidata facts does **not** talk about ranks, qualifiers, sources
- By default, only shows the facts with the **highest available rank**
- To talk about ranks, qualifiers, sources, you need to **reify** and use a different namespace

```
wd:Q12418 p:P186 ?stmt1.    # Mona Lisa: material used: ?stmt1
?stmt1 ps:P186 wd:Q296955.  # value: oil paint

wd:Q12418 p:P186 ?stmt2.    # Mona Lisa: material used: ?stmt2
?stmt2 ps:P186 wd:Q291034.  # value: poplar wood
?stmt2 pq:P518 wd:Q861259.  # qualifier: applies to part: painting surface

wd:Q12418 p:P186 ?stmt3.    # Mona Lisa: material used: ?stmt3
?stmt3 ps:P186 wd:Q287.     # value: wood
?stmt3 pq:P518 wd:Q1737943.# qualifier: applies to part: stretcher bar
?stmt3 pq:P580 1951.        # qualifier: start time: 1951 (pseudo-syntax)
```

- This is **not** the same as usual RDF reification!

Some value, and no value

- Some value (known to be unknown) are represented by blank nodes

  `https://www.wikidata.org/wiki/Wikidata:SPARQL_query_service/queries/examples#Humans_whose_gender_we_know_we_don't_know`

- No value (known not to exist) represented with rdf:type

  `https://www.wikidata.org/wiki/Wikidata:SPARQL_query_service/queries/examples#Humans_without_children`

Other features

- `CONSTRUCT` keyword to build RDF facts to be returned instead of rows
- `UNION`, to union the results of two queries (may have different variables)
- `BIND`, to introduce new variables for arithmetic expressions, etc. (but may harm query optimization)
- `BOUND`, to test if a variable has been bound (e.g., with `OPTIONAL`)
- Renaming variables in the `SELECT` clause with `AS`
- Querying from multiple files (not useful for SPARQL endpoints)
- Many other keywords...

Exercise: It’s raining cats and dogs!

How to find the cats and dogs known in Wikidata?

Exercise: It's raining cats and dogs!

How to find the cats and dogs known in Wikidata?

```
SELECT ?animal ?animalLabel WHERE
{
  {
    ?animal wdt:P31/wdt:P279* wd:Q144.
  } UNION {
    ?animal wdt:P31/wdt:P279* wd:Q146.
  }
  SERVICE wikibase:label { bd:serviceParam
      wikibase:language "[AUTO_LANGUAGE],en" }
}
```

Vizualisations

- BlazeGraph allows different visualizations of the resulting data
- Can change the default visualization with a `#defaultView` comment
- Some possible views (cf links):
  - Map
  - Timeline
  - Dimensions
  - Graph (and way to retrieve deprecated values)
  - Tree

Exercise: Where are the dogs?

How to make a map of the dogs in Wikidata?

Exercise: Where are the dogs?

How to make a map of the dogs in Wikidata?

(Let's use their place of birth.)

Exercise: Where are the dogs?

How to make a map of the dogs in Wikidata?

(Let's use their place of birth.)

```
#defaultView:Map
SELECT ?animal ?animalLabel ?coord WHERE
{
  ?animal wdt:P31/wdt:P279* wd:Q144.
  ?animal wdt:P19 ?place.
  ?place wdt:P625 ?coord.
  SERVICE wikibase:label { bd:serviceParam
      wikibase:language "[AUTO_LANGUAGE],en" }
}
```

Federation

- You can query external SPARQL endpoints with `SERVICE`
- Semantics: the service runs the query for each answer
- Tricky in terms of performance and uptime
- Wikidata allows federation with a specific list of other sources

  `www.mediawiki.org/wiki/Wikidata_Query_Service/User_Manual/SPARQL_Federation_endpoints`
- Some special services:
  - Get labels of elements `SERVICE wikibase:label`
  - Search around point `SERVICE wikibase:around`
  - Search within box `SERVICE wikibase:box`
  - Query Wikipedia from Wikibase

    `https://www.mediawiki.org/wiki/Wikidata_Query_Service/User_Manual/MWAPI`

    Useful for page links, categories...
  - Another experimental way `https://www.mediawiki.org/wiki/MW2SPARQL`

Performance

- Running SPARQL queries is **often slow**
- Main reasons:
  - SPARQL engines are not as **mature** as, e.g., relational databases
  - No **fixed schema** makes it hard to leverage properties of the data
  - No fixed choice of **indexes**
  - Cardinality estimation is complicated

→ SPARQL endpoints such as the Wikidata Query Service impose a **timeout** (60 seconds)

Optimizing SPARQL queries

- Complicated issue, and depends on the underlying engine!
- Blazegraph has support for some optimization,
  e.g., reordering the query (sometimes needs to be disabled)
- Explain mode to see the execution plan of a query (ad hoc)
  `https://www.wikidata.org/wiki/Wikidata:SPARQL_query_service/query_optimization`
- Blazegraph supports query hints to the optimizer (very ad hoc)
- Paths of properties and stars are especially problematic

Wikidata Query Lag

- The data on `query.wikidata.org` is a mirror of Wikidata
- Synchronisation is automated but can have delays, e.g., 1 hour
- There can be inconsistencies across mirrors of `query.wikidata.org`, hence inconsistent results!
- `https://grafana.wikimedia.org/d/000000489/wikidata-query-service?orgId=1&panelId=8&fullscreen`

Alternatives to SPARQL

- SPARUL: support for modifying the dataset (INSERT/DELETE)
- In the property graph model: Cypher (Neo4j) and Gremlin
- GraphQL

Slide acknowledgements

- Slides 9, 10, 13, 15, 20, 6: `https://www.wikidata.org/wiki/Wikidata:SPARQL_tutorial#Qualifiers`
- Slide 11: `https://wiki.blazegraph.com/wiki/index.php/SPARQL_Order_Matters`
- Slide 24: `https://www.wikidata.org/wiki/Wikidata:SPARQL_query_service/queries/examples`
- Many thanks to Thomas Pellissier-Tanon for his helpful feedback