RDF Explorer

A Visual SPARQL Query Builder

Hernán Vargas, Carlos Buil-Aranda, Aidan Hogan and Claudia López
What currently endangered animals are related to extinct ones?
Whaaaat?!
Let’s use Wikidata

The Linked Open Data Cloud [1]
The problem
Data consumption - SPARQL endpoints

Virtuoso SPARQL Query Editor

```
select distinct ?concept where { ?a ?con ?c }
LIMIT 100
```

Concepts:
- http://www.w3.org/2002/07/owl#FunctionalProperty
- http://www.w3.org/1999/02/22-rdf-syntax-ns#Property
- http://www.w3.org/2002/07/owl#Thing
- http://www.w3.org/2002/07/owl#Class
- http://www.w3.org/2002/07/owl#ObjectProperty
- http://www.w3.org/2002/07/owl#DataProperty
- http://xmlns.com/foaf/0.1/Organization
- http://dbpedia.org/ontology/Company
- http://xmlns.com/foaf/0.1/Person
- http://dbpedia.org/ontology/Activity
- http://dbpedia.org/ontology/Name
- http://dbpedia.org/ontology/Person
- http://dbpedia.org/ontology/Actor
- http://dbpedia.org/ontology/Place
- http://dbpedia.org/ontology/Publisher
- http://dbpedia.org/ontology/Genre
- http://dbpedia.org/ontology/Language
- http://dbpedia.org/ontology/Location
- http://dbpedia.org/ontology/Software
- http://dbpedia.org/ontology/School
- http://xmlns.com/foaf/0.1/Document

Virtuoso SPARQL Query Editor
Data consumption - Explorers

Tabulator: Exploring and analyzing linked data on the semantic web [2]
Data consumption - Explorers

Experimenting with explorator: a direct manipulation generic rdf browser and querying tool [3]
Data consumption - Faceted Search

FACETED SEARCH OVER RDF-BASED KNOWLEDGE GRAPHS [4]
Data consumption - Visual Query Builders
Data consumption - Visual Query Builders
Data consumption - Visual Query Builders
User interfaces and mental models

Data model: RDF

External structure: Visualization tool

Mental model: User's own ideas about how the visualization tool works

Data model — Representation — Mental model
What users believe they know about a UI strongly impacts how they use it.

The internal representation is created from the external representation.

Most visualization tools do not allow users to see the graph behind.

Visual query builders do not provide enough information for the user to understand the system.
Our proposal
Visual Query Language

Visual Query Graph ($VQG$) is defined as a directed edge-labelled graph $G = (N, E)$ with nodes $N \subseteq I \cup L \cup V$ and edges $E \subseteq I \cup V$.

Letting $VQG = (N, E)$ denote the current VQG; the visual query language (VQL) is defined through the following four atomic operations:

- Initialize a new variable node: $\eta(G) = (N \cup \{v\}, E)$ where $v \notin var(G)$.

- Add a new constant node: $\eta(G, x) = (N \cup \{x\}, E)$ where $x \in (I \cup L)$.

- Initialize a new edge between two nodes with a variable edge-label:
  $\varepsilon(G, n_1, n_2) = (N, E \cup \{(n_1, v, n_2)\})$ where $\{n_1, n_2\} \subseteq N$ and $v \notin var(G)$.

- Add a new edge between two nodes with an IRI edge-label:
  $\varepsilon(G, n_1, x, n_2) = (N, \cup\{(n_1, x, n_2)\})$ where $\{n_1, n_2\} \subseteq N$ and $x \in I$. 
Our proposal

We want to create a visualization tool that, by reducing the gap between the data model and the external structure, helps lay users to explore RDF datasets and create SPARQL queries.

https://www.rdfexplorer.org
https://dbpedia.rdfexplorer.org

https://gitlab.com/imfd-public/rdfexplorer
Study design
Study design

Test subjects use two different user interfaces to complete a set of tasks of increasing complexity.

*Wikidata query service v/s RDF Explorer*

We perform a task-driven user study. Ideal for technique-driven works.

We evaluate the idiomatic level of the application, which verifies whether the representation used and the interactions within the interface are appropriate.

The same users will use both user interfaces (*within subject study*) balancing the user interface that was used for the first time (*counterbalancing*)
Independent variables

- User interface used
- Task difficulty

Dependent variables

- Completeness ratio
- Correct RDF resources obtained (ratio)
- Correct query shape
- Time
Baseline: **Wikidata Query Helper (WQH)**

```
# Humans without children
# added before 2016-10
# demonstrates "no value" handling

SELECT ?human ?humanLabel
WHERE
{
  ?human wdt:P31 wd:Q5 .  # find humans
  ?human rdf:type wdn:o:P40 .  # with at least one P40 (child) statement defined to be "no value"
  SERVICE wikibase:label { bd:serviceParam wikibase:language "[AUTO_LANGUAGE],en" }
}
```

<table>
<thead>
<tr>
<th>human</th>
<th>humanLabel</th>
</tr>
</thead>
<tbody>
<tr>
<td>wd:Q15846920</td>
<td>Marie de Bretagne</td>
</tr>
<tr>
<td>wd:Q16117325</td>
<td>Saša Broz</td>
</tr>
<tr>
<td>wd:Q16322530</td>
<td>Ingeborg Wern Bugge</td>
</tr>
<tr>
<td>wd:Q18475398</td>
<td>Jan Opaliński</td>
</tr>
</tbody>
</table>
## Tasks in the study

<table>
<thead>
<tr>
<th>Task #</th>
<th>Task Group 1</th>
<th>Task Group 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Find all dogs</td>
<td>Find all actors</td>
</tr>
<tr>
<td>2</td>
<td>Find all popes who are female</td>
<td>Find all German soccer players who participated in FIFA 2014</td>
</tr>
<tr>
<td>3</td>
<td>Find all mountains located in European countries</td>
<td>Find all container ships located in European countries</td>
</tr>
<tr>
<td>4</td>
<td>Find all emperors whose father is also an emperor</td>
<td>Find all physicists whose spouse is also a physicist</td>
</tr>
<tr>
<td>5</td>
<td>Find all Nobel prize winners with a student who won the same Nobel prize</td>
<td>Find all participants of an Olympic sport with a relative who participates in the same sport</td>
</tr>
</tbody>
</table>
## Tasks in the study

<table>
<thead>
<tr>
<th>№</th>
<th>Set 1 (S1)</th>
<th>Set 2 (S2)</th>
</tr>
</thead>
</table>
Tasks in the study

(a) Task 1

(b) Task 2

(c) Task 3

(d) Task 4

(e) Task 5
28 students (only database course taken, no knowledge about semantic web), split into 4 groups by initial interface and tasks.
Results
Completeness ratio

![Bar chart showing the completeness ratio for different tasks. The chart compares two methods: RE and WQH. The x-axis represents the task numbers (1 to 5), and the y-axis represents the ratio correct. The chart shows the performance of RE and WQH across the tasks.]
Correct triples

![Bar chart showing the ratio of correct triples for Task 1 to Task 5. The chart compares RE and WQH methods.]

- Task 1: RE = 0.75, WQH = 0.80
- Task 2: RE = 0.90, WQH = 0.85
- Task 3: RE = 0.80, WQH = 0.75
- Task 4: RE = 0.60, WQH = 0.55
- Task 5: RE = 0.20, WQH = 0.10
Correct query shape

![Bar chart showing ratio correct for tasks]

- Task 1: RE > WQH
- Task 2: RE > WQH
- Task 3: RE > WQH
- Task 4: RE > WQH
- Task 5: RE > WQH
Paired-t validation

\[ t^* = \frac{\bar{d}}{s_d / \sqrt{n}} \]

Parameters:
- \( \bar{d} \): average between averages difference
- \( s_d \): standard deviation
- \( n \): number of measurements (28)
- \( \alpha \): significance level (0.05)
- \( df \): freedom degrees (27)

- Obtaining \( t_{\text{crit}} = 2.052 \)
- If \( t^* \geq t_{\text{crit}} \) we reject null hypothesis

\( H_0: \bar{d} \leq 0 \) (Same results or WQH better).

\( H_A: \bar{d} > 0 \) (RDF Explorer better)
Hypotheses validation

We divided the main hypothesis in three. Null hypothesis is either there is no difference between results among WQH and RDF Explorer or results are better in WQH.

1. **Ha**: Test subject generates more correct queries using RDF Explorer

   **Null hypothesis rejected**, validating alternative hypothesis obtaining a statistically significant result (with $d = 0.1714$, $s_d = 0.2813$, $t^* = 3.22 > t_{crit}$).

2. **Hb**: Test subject finds more correct results using RDF Explorer

   **Null hypothesis is NOT rejected** ($d = 0.06$, $s_d = 0.2609$, $t^* = 1.1947 < t_{crit}$)

3. **Hc**: Test subject generates more correct query graphs using RDF Explorer

   **Null hypothesis rejected**, validating alternative hypothesis obtaining a statistically significant result ($d = 0.1928$, $s_d = 0.2801$, $t^* = 3.643 > t_{crit}$)
Conclusions & Future work
Conclusions

- Using RDF Explorer, users without knowledge about graphs can explore RDF databases and generate SPARQL queries more effectively than with our baseline.

- Drawing queries allows users to solve more complex tasks; however, this affects negatively the tool's learning curve.
Future work

- Add missing SPARQL operators compliant with the language
- Improve query response times
- Show how mental models affect problem resolution using RDF Explorer
- Transform from SPARQL queries to our visual representation
- Federate queries using the interface and actually visually query Linked Data
Thanks!

The authors of this paper, Hernán Vargas, Carlos Buil-Aranda, Aidan Hogan and Claudia López are living on Chile. We are currently on protests against inequality!
IV. References


V. Extra
A mental model is:

The user's internal representation of the user interface with the following characteristics [5]:

1. The system's structural properties and behavior are preserved in the mental model.

2. A mental model can preserve schematic, semantic and specific information about the data represented

3. Given a task, a mental model from an interactive visualization is built and simulated in memory to help reasoning
Time results

(a) Promedio de tiempo gastado por pregunta. (b) Promedio de tiempo gastado por pregunta con respuesta correcta.
Resultados Nasa-TLX

- Frustración: 52.50 (Explorador) / 71.96 (Wikidata)
- Esfuerzo: 56.25 (Explorador) / 66.79 (Wikidata)
- Rendimiento: 48.57 (Explorador) / 61.07 (Wikidata)
- Exigencia Temporal: 60.00 (Explorador) / 63.75 (Wikidata)
- Exigencia Física: 23.57 (Explorador) / 21.61 (Wikidata)
- Exigencia Mental: 52.32 (Explorador) / 73.39 (Wikidata)
User satisfaction results

![Bar chart showing satisfaction results for different criteria: Recomienda, Satisfacción, Confianza. The criteria are rated on a Likert scale of 1-5, with the following scores:
- Recomienda: 2.32
- Satisfacción: 2.57
- Confianza: 2.54
The chart compares results between two platforms: Explorer and Wikidata.]

Scores:
- Recomienda: 3.32
- Satisfacción: 3.99
- Confianza: 3.21

Legend:
- Green: Explorer
- Purple: Wikidata