Practical Linked Data Access via SPARQL: The Case of Wikidata

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Also reporting on joint work with
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For the eponymous LDOW 2018 paper, see https://iccl.inf.tu-dresden.de/web/Inproceedings3196/en

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Wikidata, the knowledge graph of Wikipedia,
uses SPARQL as its main query API

- Who is using this?
- What are those SPARQL queries like?
- What can we learn from them?

Wait! – Wikidata uses RDF?!

Louis Néel (Q155781)

French physicist

Louis Neel | Louis Eugène Felix Néel

award received	Nobel Prize in Physics	edit
	point in time	1970
	together with	Hannes Alfvén
	prize money	200,000 Swedish krona

2 references

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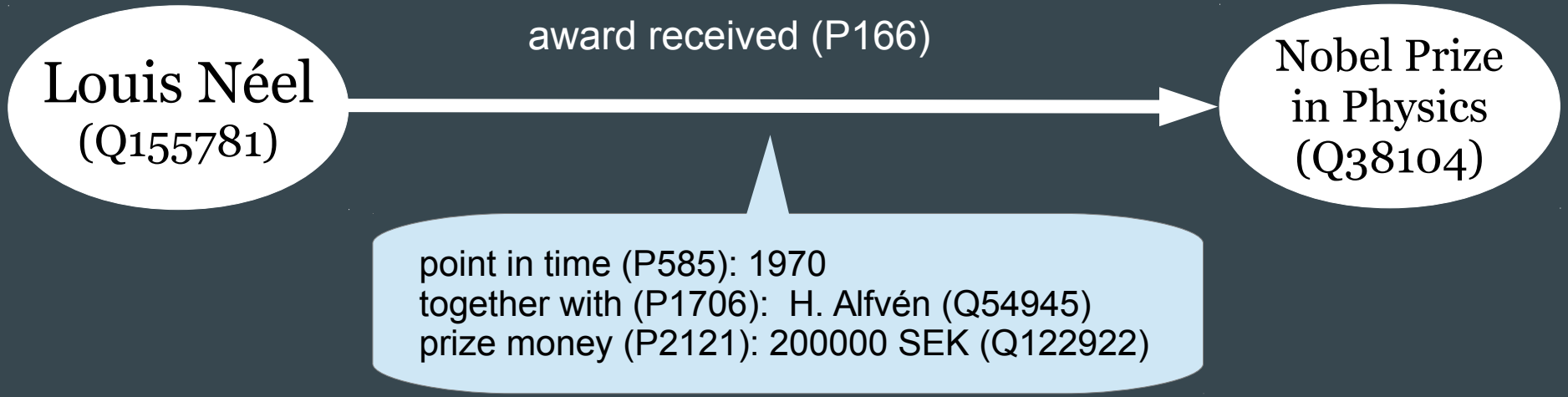
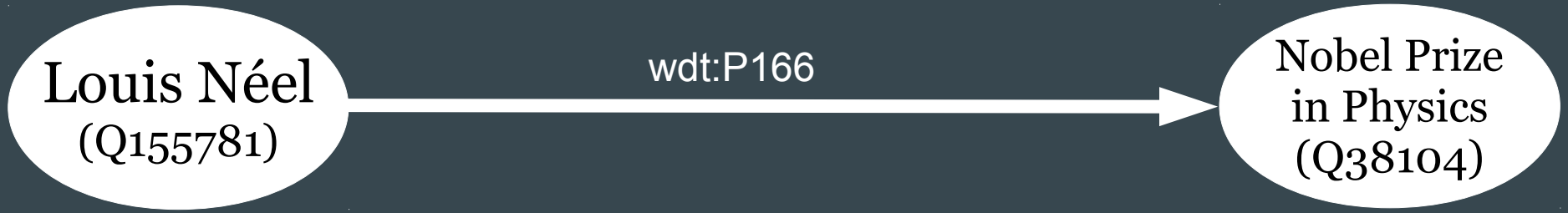
Wait! – Wikidata uses RDF?!



How does Wikidata's rich graph model relate to RDF?

Wait! – Wikidata uses RDF?!

Official RDF version follows Erxleben et al. [ISWC 2014]:



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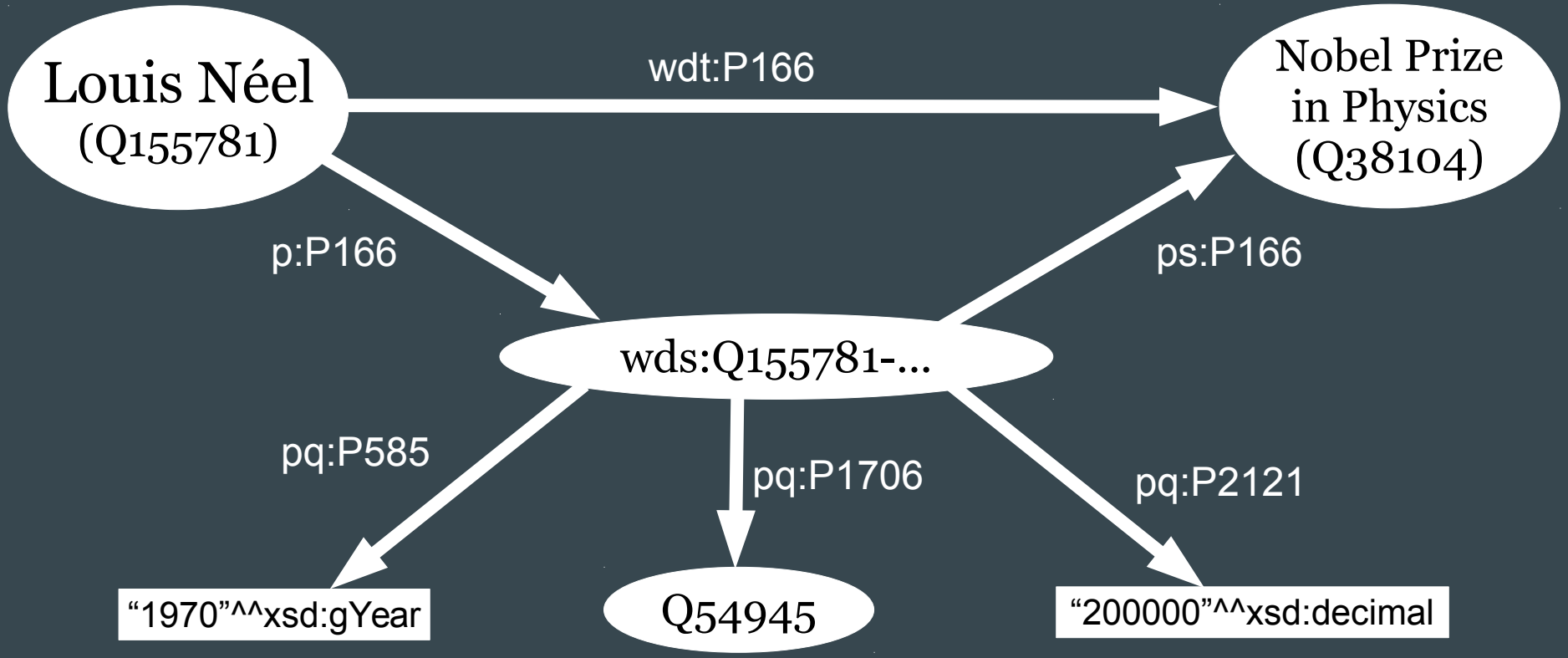


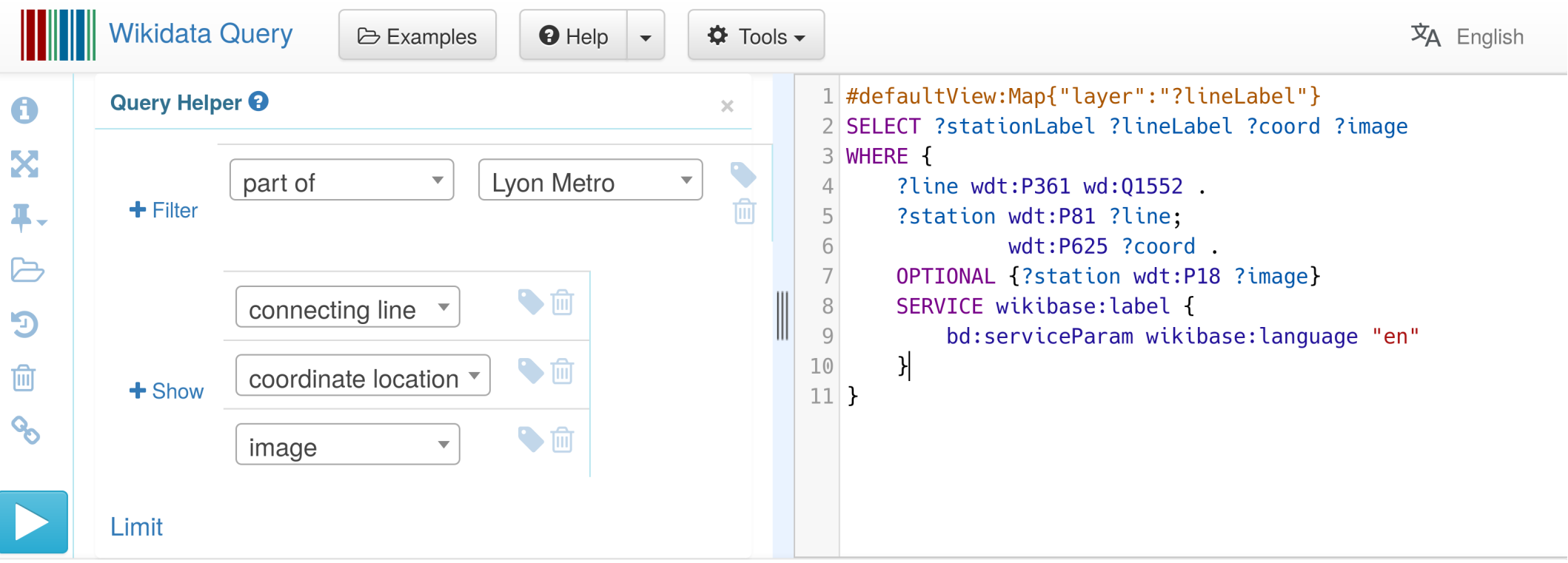
RDF for Wikidata

- Wikidata offers **all of its content** in RDF
  - Linked data live exports
    (Example: https://www.wikidata.org/wiki/Special:EntityData/Q42.nt)
  - Weekly dumps
    (See https://dumps.wikimedia.org/wikidatawiki/entities/)
- Currently **4.9B triples** (as of April 2018)
  - >415M Wikidata Statements
  - 4.5K Wikidata properties → >48K RDF properties
  - >1.5B labels/descriptions/aliases
  - >63M links to Wikipedia and friends

Wikidata SPARQL Query Service

- Official query service since mid 2015
  - User interface at https://query.wikidata.org/
- All the data (4.9B triples), live (latency<60s)
- No limits (well, almost):
  - 60sec timeout
  - No limit on result size (!)
  - No limit on query numbers per IP
  - Clients might be paused after too many parallel requests

A simple SPARQL query



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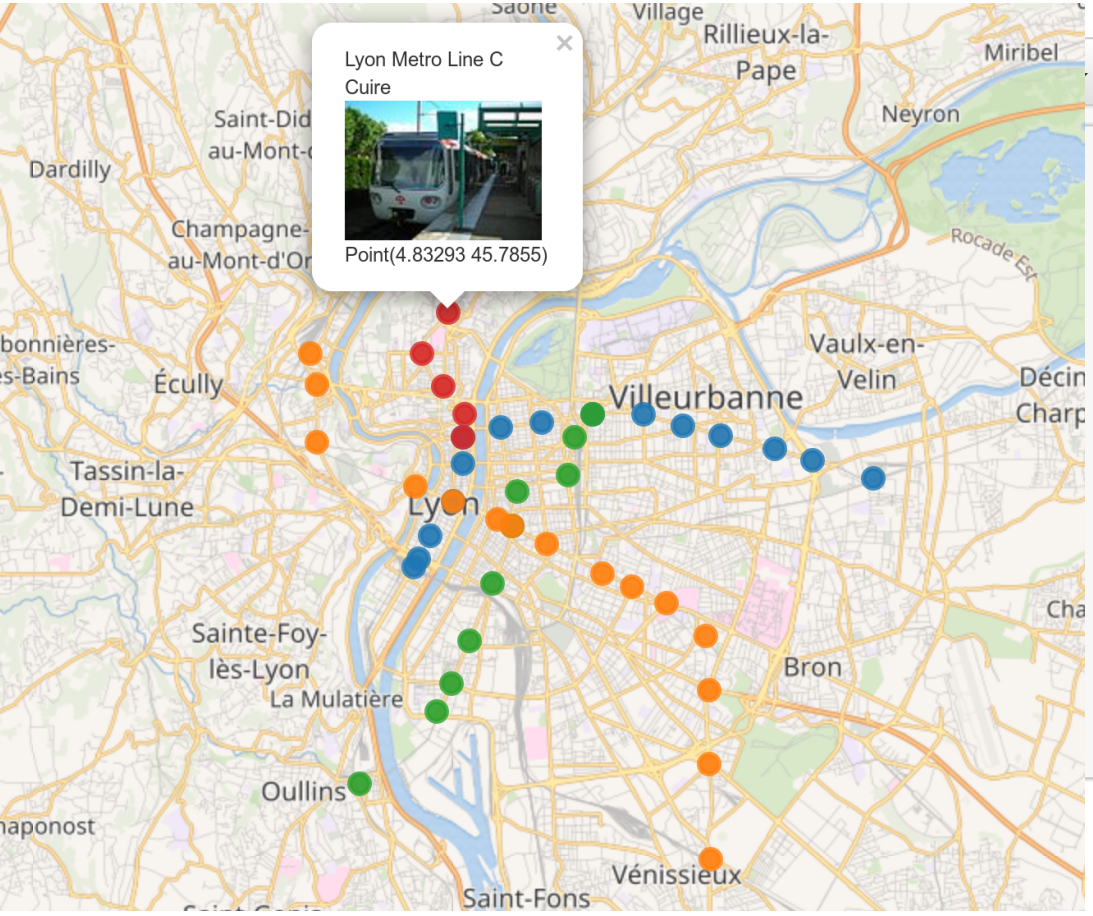
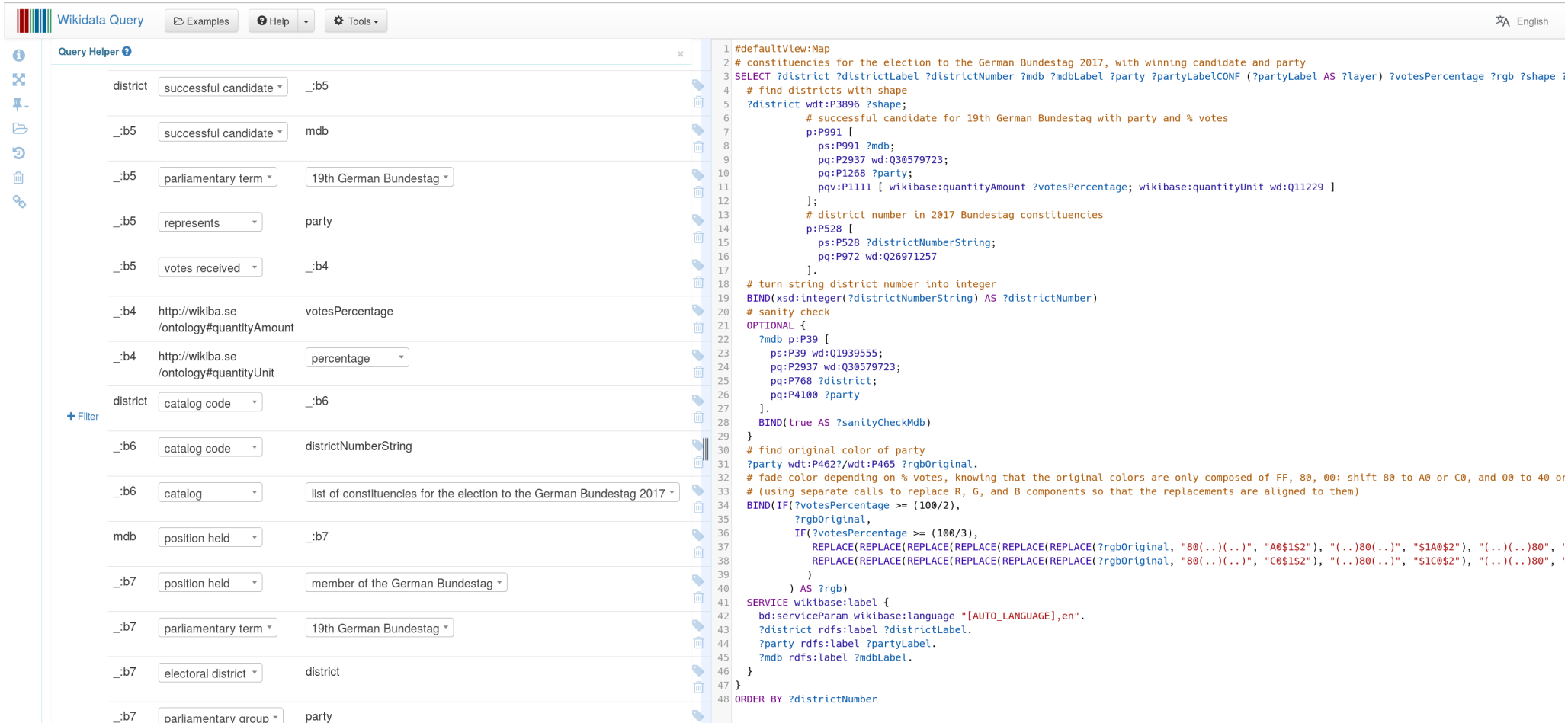


English

```
#defaultView:Map{"layer":"?lineLabel"}
SELECT ?stationLabel ?lineLabel ?coord ?image
WHERE {
    ?line wdt:P361 wd:Q1552 .
    ?station wdt:P81 ?line;
             wdt:P625 ?coord .
    OPTIONAL {?station wdt:P18 ?image}
    SERVICE wikibase:label {
        bd:serviceParam wikibase:language "en"
    }
}
```

A not-so-simple SPARQL query



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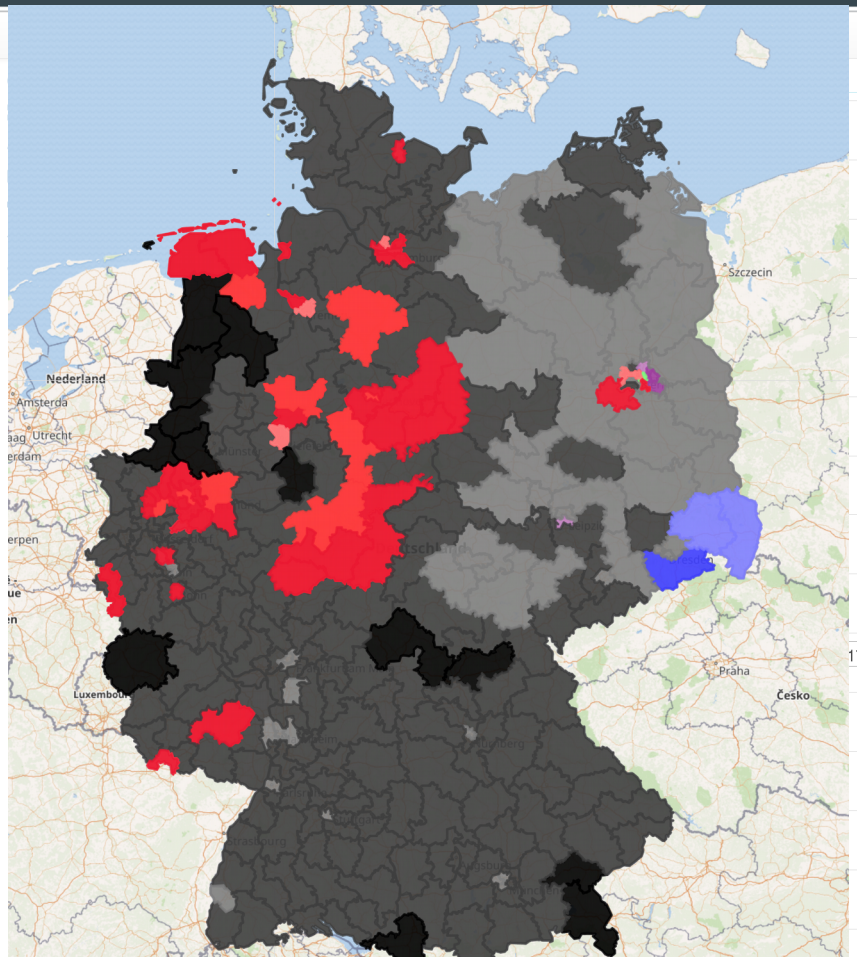

English

```
#defaultView:Map
# constituencies for the election to the German Bundestag 2017, with winning candidate and party
SELECT ?district ?districtLabel ?districtNumber ?mdb ?mdbLabel ?party ?partyLabelCONF (?partyLabel AS ?layer) ?votesPercentage ?rgb ?shape ?
  # find districts with shape
  ?district wdt:P3896 ?shape;
            # successful candidate for 19th German Bundestag with party and % votes
            p:P991 [
              ps:P991 ?mdb;
              pq:P2937 wd:Q30579723;
              pq:P1268 ?party;
              pqv:P1111 [ wikibase:quantityAmount ?votesPercentage; wikibase:quantityUnit wd:Q11229 ]
            ];
            # district number in 2017 Bundestag constituencies
            p:P528 [
              ps:P528 ?districtNumberString;
              pq:P972 wd:Q26971257
            ].
  # turn string district number into integer
  BIND(xsd:integer(?districtNumberString) AS ?districtNumber)
  # sanity check
  OPTIONAL {
    ?mdb p:P39 [
      ps:P39 wd:Q1939555;
      pq:P2937 wd:Q30579723;
      pq:P768 ?district;
      pq:P4100 ?party
    ].
    BIND(true AS ?sanityCheckMdb)
  }
  # find original color of party
  ?party wdt:P462?/wdt:P465 ?rgbOriginal.
  # fade color depending on % votes, knowing that the original colors are only composed of FF, 80, 00: shift 80 to A0 or C0, and 00 to 40 or
  # (using separate calls to replace R, G, and B components so that the replacements are aligned to them)
  BIND(IF(?votesPercentage >= (100/2),
          ?rgbOriginal,
          IF(?votesPercentage >= (100/3),
             REPLACE(REPLACE(REPLACE(REPLACE(REPLACE(REPLACE(?rgbOriginal, "80(..)(..)", "A0$1$2"), "(..)80(..)", "$1A0$2"), "(..)(..)80", "
             REPLACE(REPLACE(REPLACE(REPLACE(REPLACE(REPLACE(?rgbOriginal, "80(..)(..)", "C0$1$2"), "(..)80(..)", "$1C0$2"), "(..)(..)80", "
             )
          ) AS ?rgb)
  SERVICE wikibase:label {
    bd:serviceParam wikibase:language "[AUTO_LANGUAGE],en".
    ?district rdfs:label ?districtLabel.
    ?party rdfs:label ?partyLabel.
    ?mdb rdfs:label ?mdbLabel.
  }
}
ORDER BY ?districtNumber
```

Some metrics

- Running on BlazeGraph database engine
  - 3 servers (+3 as backup) Intel Xeon E5-2620 8 core/128G mem/800G SSD
  - Standard caching (Varnish) and load balancing (LVS)
  - Some custom tools, extension and tunings

  All available online: https://github.com/wikimedia/wikidata-query-rdf

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    All available online: https://github.com/wikimedia/wikidata-query-rdf
- Serving >100M requests/month (3.8M/day)
  - 50% of queries answered in <40ms (95% in <440ms; 99% in <40s)
  - Less than 0.05% of queries time out
  - Service has never been down so far

Analysing SPARQL logs: The Bot Problem

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- Query traffic is **ruled** by a few bots

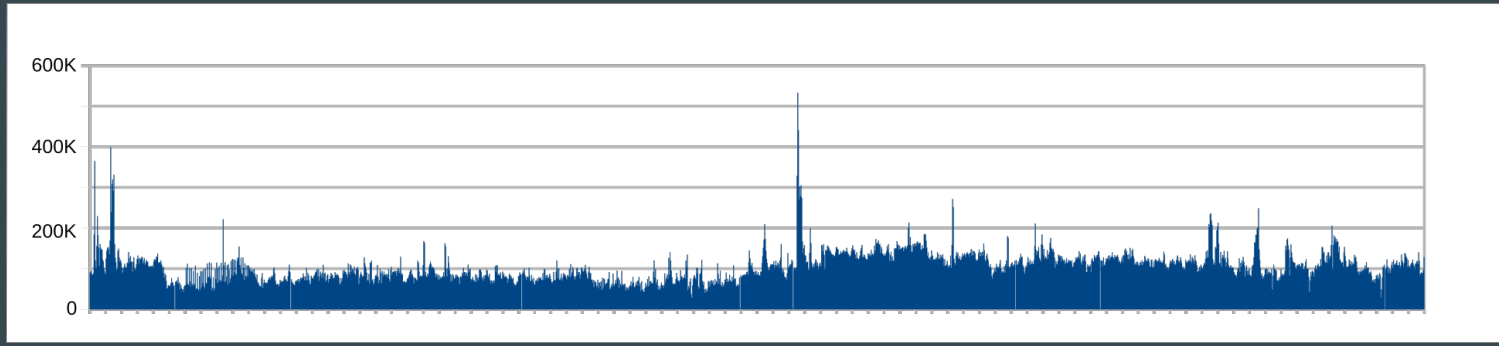

Fig.: Wikidata SPARQL traffic Jun-Sep 2017

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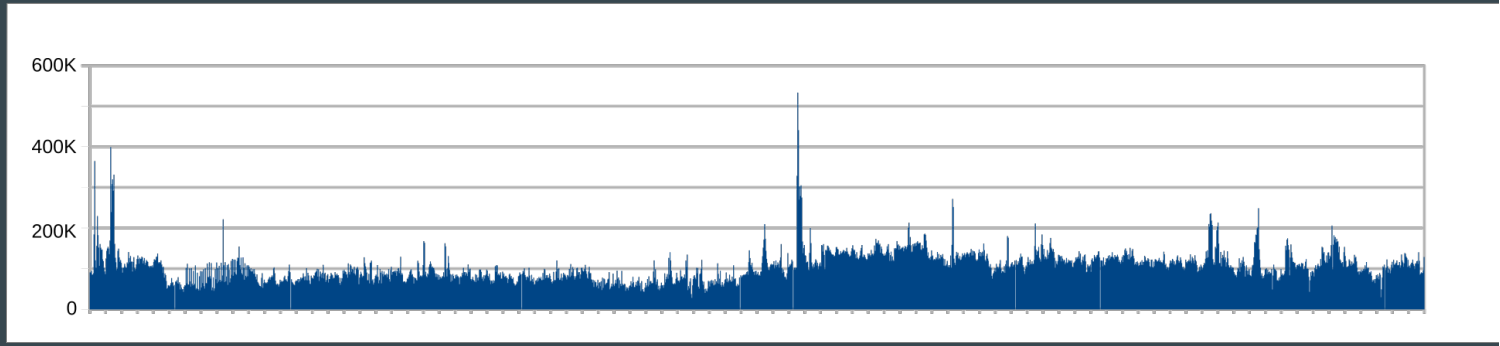

Fig.: Wikidata SPARQL traffic Jun-Sep 2017

- 41% of all Wikidata query traffic from June – September 2017 caused by one super-power user (Magnus Manske)

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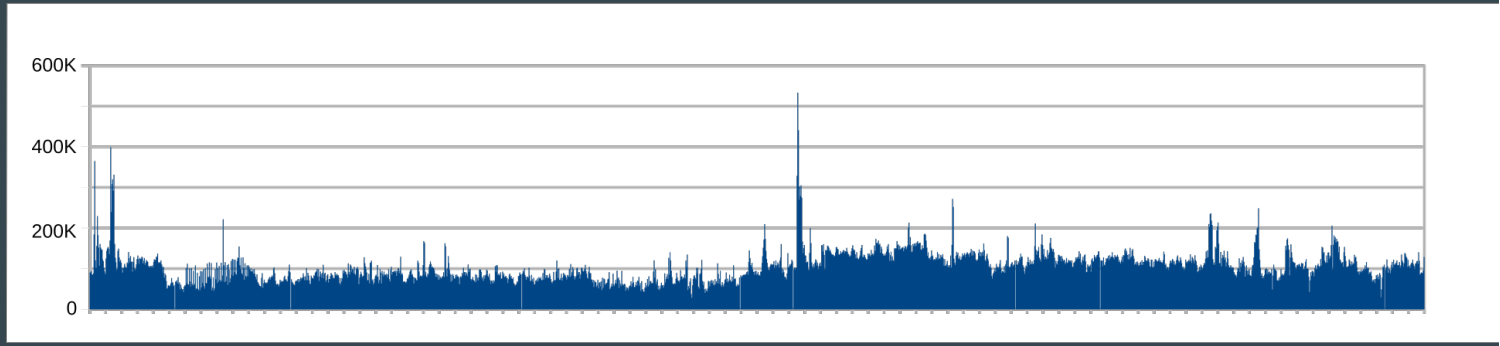
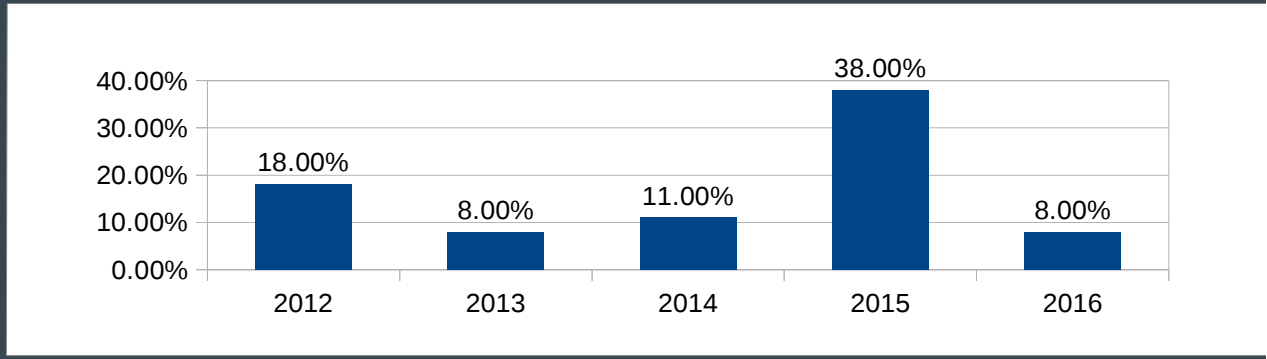


Fig.: Wikidata SPARQL traffic Jun-Sep 2017

- 41% of all Wikidata query traffic from June – September 2017 caused by one super-power user (Magnus Manske)
- The effect does **not** average out, and it affects other sites too



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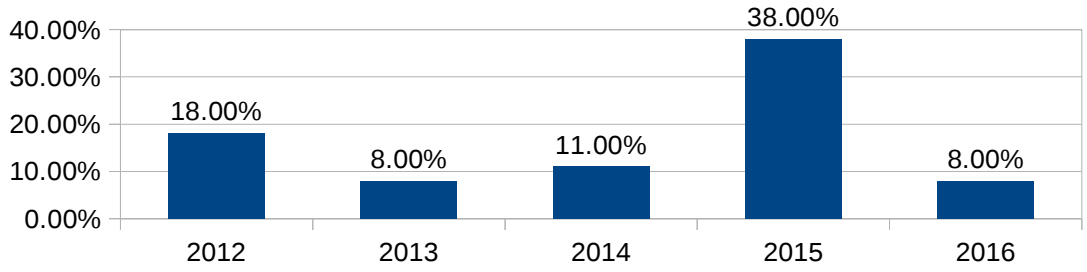

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No trends!
No predictability!
No insights!

Are SPARQL queries interesting after all?

- Observation: Robotic traffic dominates
  - May not represent any real interest
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Are SPARQL queries interesting after all?

- Observation: Robotic traffic dominates
  - May not represent any real interest
  - Governed by very few sources
  - Random changes – not uniform on any observed scale
- Hypothesis: Organic traffic also exists
  - Representing human information need during some interaction
  - Composed of many diverse sources
  - Continuous change over months

Note: “Organic” ≠ “hand-written SPARQL” (user apps might use SPARQL to get user-requested data without users actually writing queries)

Extracting organic traffic

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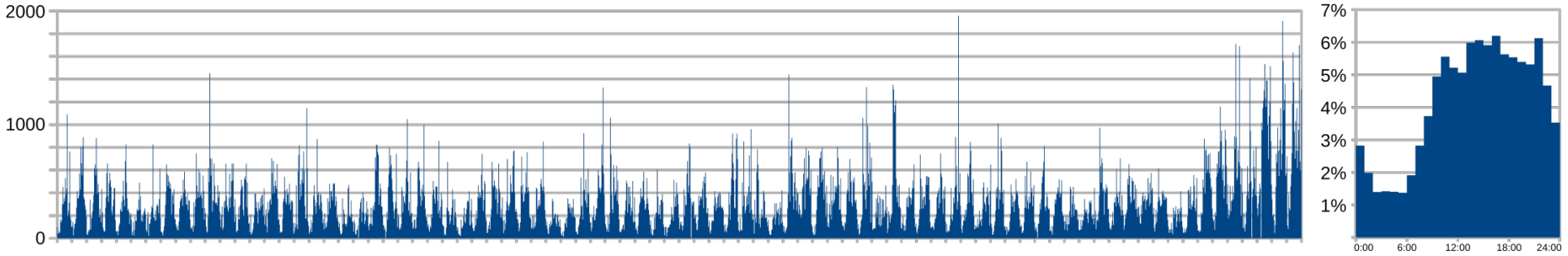
  - Assumption: organic traffic generally from browser-like agents
- 2nd signal: query comments
  - Some browser-based tools mark queries using comments
- 3rd signal: activity spikes
  - Group queries by query pattern (following [Raghuveer, USEWOD'12])
  - Find agent-pattern pairs that spike (>2K requests/month)
  - Manually inspect these queries to decide if organic or robotic

→ About 300 further browser-based sources classified "robotic"

Results: Organic component

- Jun–Sep 2017: 658,890 queries (<0.5%)
- More triples
  organic 17%: 1, 97%: ≤11 vs. robotic 57%: 1, 96%: ≤7
- More varied (vocabulary, SPARQL features)

Temporal distribution of organic queries (12 weeks / time of day)



Insights on SPARQL Usage

- General: more features than reported elsewhere
- Typically organic: LIMIT, DISTINCT, OPTIONAL, ORDER BY, subqueries, aggregates, services
- Typically robotic: BIND, UNION, VALUES
- Conjunctive regular path queries with converse (C2RPQs)
  - Main query fragment for robotic queries (75% when allowing VALUES)
- OPTIONAL:
  - Important mostly for organic queries
  - Recent data (2018) also shows shift to C2RPQ+OPTIONAL (up to 82%)

Insights on Wikidata Usage

- Robotic traffic:
  - Mainly information integration bots (comparing database contents)
  - Potentially also selective data download (spider-like)
  - Most queries from a few dominant bots (>60% from top-three bots)
- Organic traffic:
  - Data browsers (often general-purpose)
  - Mobile apps (often topical)
  - Most queries from of unidentified “small” sources
- Reified statements in 4%–10% of queries

Conclusion and Outlook

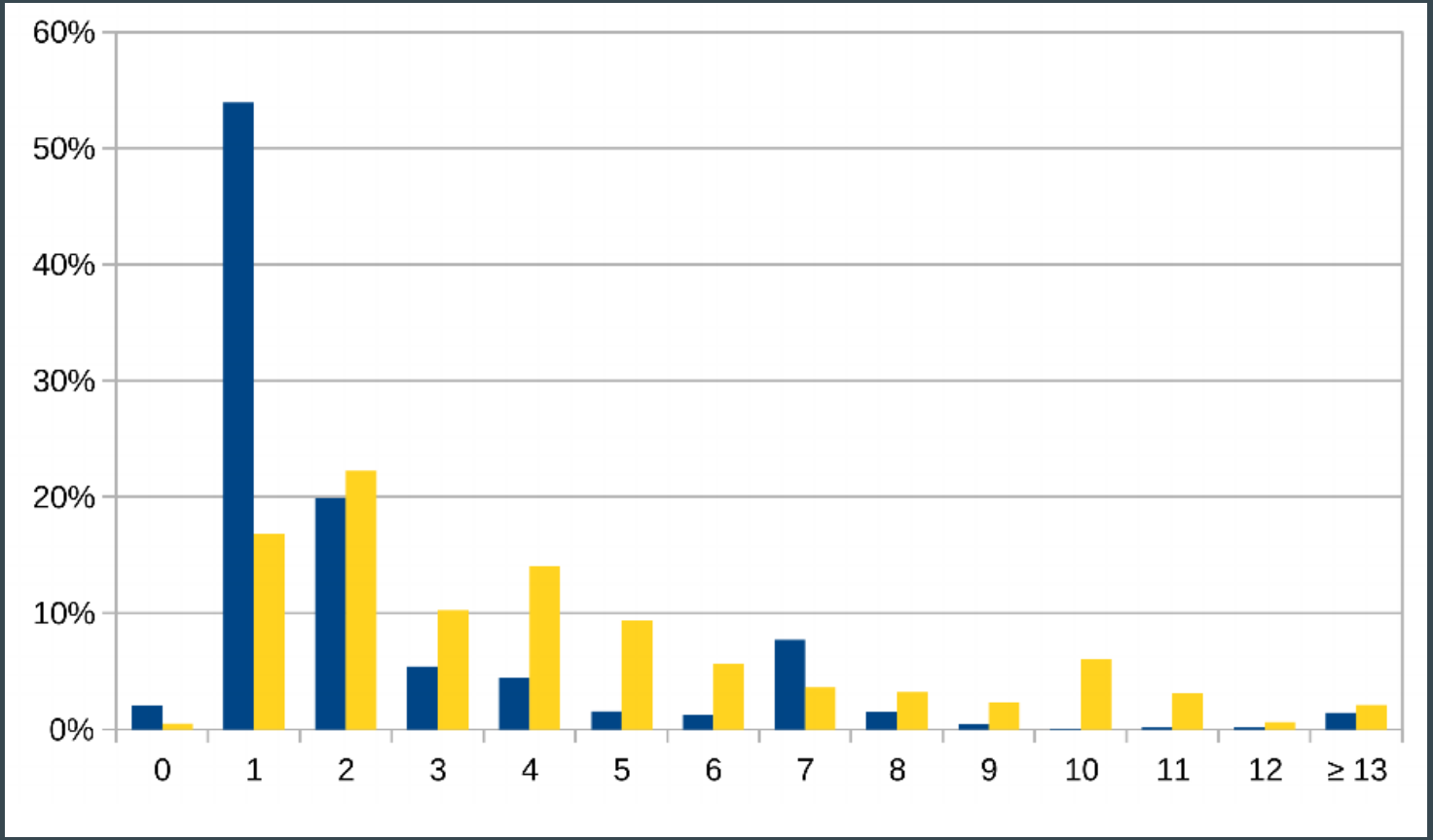
Wikidata relies on RDF and SPARQL for some of its core features – a fascinating use case!

- **Conclusions**
  - SPARQL log analysis is **methodologically difficult**
  - **Organic traffic** can be extracted based on User Agent and timestamps
  - SPARQL queries are **more varied and more complex** than reported elsewhere
  - After Joins, **path queries** are the second most important feature
- **Outlook**
  - Publishing anonymised datasets: under review; stay tuned
  - Documenting Wikidata's SPARQL deployment insights
  - Wikidata will expand further … (Dictionary content! Media meta-data!)

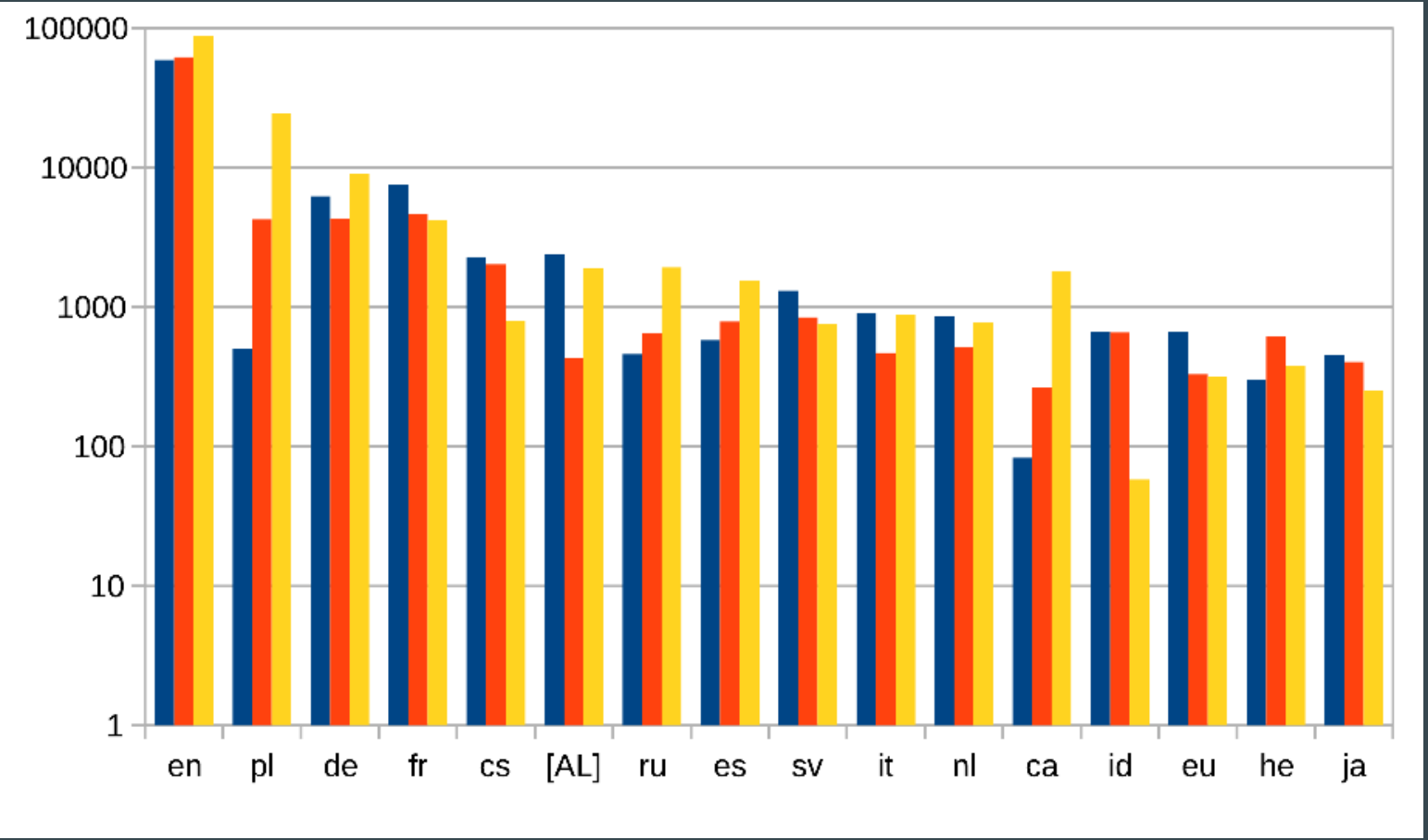
SPARQL Feature Distribution (2017/2018)

	organic						robotic					
	Jun 2017	Jul 2017	Aug 2017	Jan 2018	Feb 2018	Mar 2018	Jun 2017	Jul 2017	Aug 2017	Jan 2018	Feb 2018	Mar 2018
Limit	31.08%	39.55%	46.56%	52.31%	51.23%	36.87%	21.12%	16.86%	17.42%	20.38%	11.47%	15.17%
Distinct	26.50%	31.40%	19.05%	59.30%	60.42%	63.78%	15.84%	5.48%	4.27%	4.32%	7.54%	12.25%
Order By	17.29%	14.75%	13.22%	46.89%	46.99%	34.53%	12.97%	8.01%	6.78%	8.76%	7.68%	17.46%
Offset	0.40%	2.92%	0.37%	0.09%	0.08%	0.06%	7.73%	6.07%	6.29%	0.10%	0.07%	0.10%
Join	87.59%	87.82%	89.76%	82.50%	91.70%	87.02%	88.48%	78.53%	67.41%	73.26%	61.39%	70.19%
Optional	42.36%	46.24%	55.92%	50.90%	41.30%	41.15%	25.08%	11.63%	11.45%	12.73%	15.41%	30.71%
Filter	25.89%	29.12%	22.24%	12.59%	11.76%	11.76%	21.64%	17.92%	13.79%	14.70%	16.83%	29.02%
Path with *	15.02%	15.59%	12.88%	40.92%	32.43%	30.34%	16.43%	19.19%	14.80%	20.56%	17.26%	24.81%
Subquery	13.09%	15.30%	12.79%	6.45%	5.07%	5.39%	0.34%	0.28%	0.33%	0.09%	0.13%	0.11%
Bind	9.85%	9.23%	8.68%	4.72%	3.99%	4.15%	16.29%	12.07%	9.60%	11.94%	13.79%	24.03%
Union	5.10%	5.76%	12.62%	2.56%	2.07%	3.39%	11.26%	8.63%	7.61%	13.96%	13.05%	18.57%
Values	4.44%	3.07%	10.88%	3.29%	3.23%	3.20%	35.72%	30.74%	28.92%	29.82%	23.80%	11.90%
Not Exists	3.31%	3.37%	2.46%	1.24%	0.94%	0.69%	0.19%	0.21%	0.19%	0.27%	0.29%	0.35%
Minus	2.04%	2.91%	1.60%	0.82%	0.57%	0.71%	0.53%	0.92%	1.07%	1.46%	1.26%	1.78%
Service (lang)	44.63%	42.09%	54.78%	50.88%	41.71%	42.95%	10.40%	6.15%	4.27%	7.15%	7.91%	8.90%
Service (other)	11.49%	10.53%	10.32%	7.30%	13.14%	2.31%	4.51%	0.19%	1.16%	0.17%	0.18%	0.51%
Group By	17.12%	19.93%	13.04%	7.00%	5.40%	5.07%	0.41%	0.37%	0.48%	0.22%	0.23%	0.39%
Sample	8.85%	10.93%	4.60%	1.61%	1.63%	1.69%	0.04%	0.04%	0.06%	0.05%	0.04%	0.10%
Count	7.55%	7.60%	8.15%	5.22%	3.88%	3.73%	1.15%	4.30%	0.30%	1.52%	0.65%	0.89%
GroupConcat	1.80%	2.79%	1.17%	0.86%	0.86%	0.74%	0.06%	0.09%	0.02%	0.03%	0.02%	0.28%
Having	1.17%	1.14%	0.72%	0.65%	0.26%	0.33%	0.01%	0.01%	0.00%	0.00%	0.00%	0.04%

Triples per query: organic (blue)/robotic (yellow)



Languages of labels in organic queries



SPARQL feature co-occurrence

							organic		robotic	
J	**F**	**O**	**U**	**P**	**V**	**S**	I1–I3	I4–I6	I1–I3	I4–I6
		(none)					8.04	9.22	19.67	27.67
J							13.29	31.35	11.26	10.09
	F						1.10	0.98	1.92	1.31
J	F						6.68	2.39	2.61	1.68
J				P			2.98	1.62	13.50	13.94
J	F			P			2.48	0.58	0.39	0.07
J					V		0.39	2.01	30.42	17.47
		O					1.26	1.64	0.11	0.63
J		O					22.32	7.04	1.86	1.95
J		O		P			2.07	29.10	0.35	0.05

							organic		robotic	
J	**F**	**O**	**U**	**P**	**V**	**S**	I1–I3	I4–I6	I1–I3	I4–I6
J	F	O					2.66	1.32	2.13	1.18
J		O	U				3.49	0.25	0.02	0.01
J		O			V		3.38	0.41	0.11	0.43
J		O		P	V		1.01	0.06	0.16	0.07
J						S	2.76	1.41	0.06	0.01
J		O				S	4.78	0.62	0.00	0.01
J	F					S	3.19	2.28	0.03	0.01
J	F	O				S	1.02	0.13	0.00	0.00
J	F	O		P			0.79	0.31	0.64	1.58
J			U	P	V		0.01	0.02	0.05	1.92