

Analyzing Wikidata with KGTK



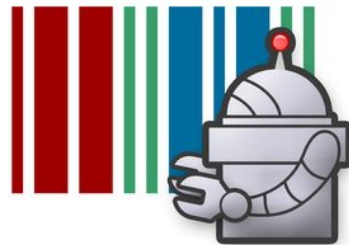
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[@dgarijov](https://twitter.com/dgarijov) 🐦

A short introduction to Wikidata

- Free
- Collaborative
- Multilingual
- A secondary database
- Collecting structured data
- Support for Wikimedia wikis
- For anyone in the world
- With many applications
- A thriving community of contributors

> 90M items
> 8,000 properties
> 2,000,000 classes
> 4,000 external id types
> 1B triples

Public SPARQL endpoint

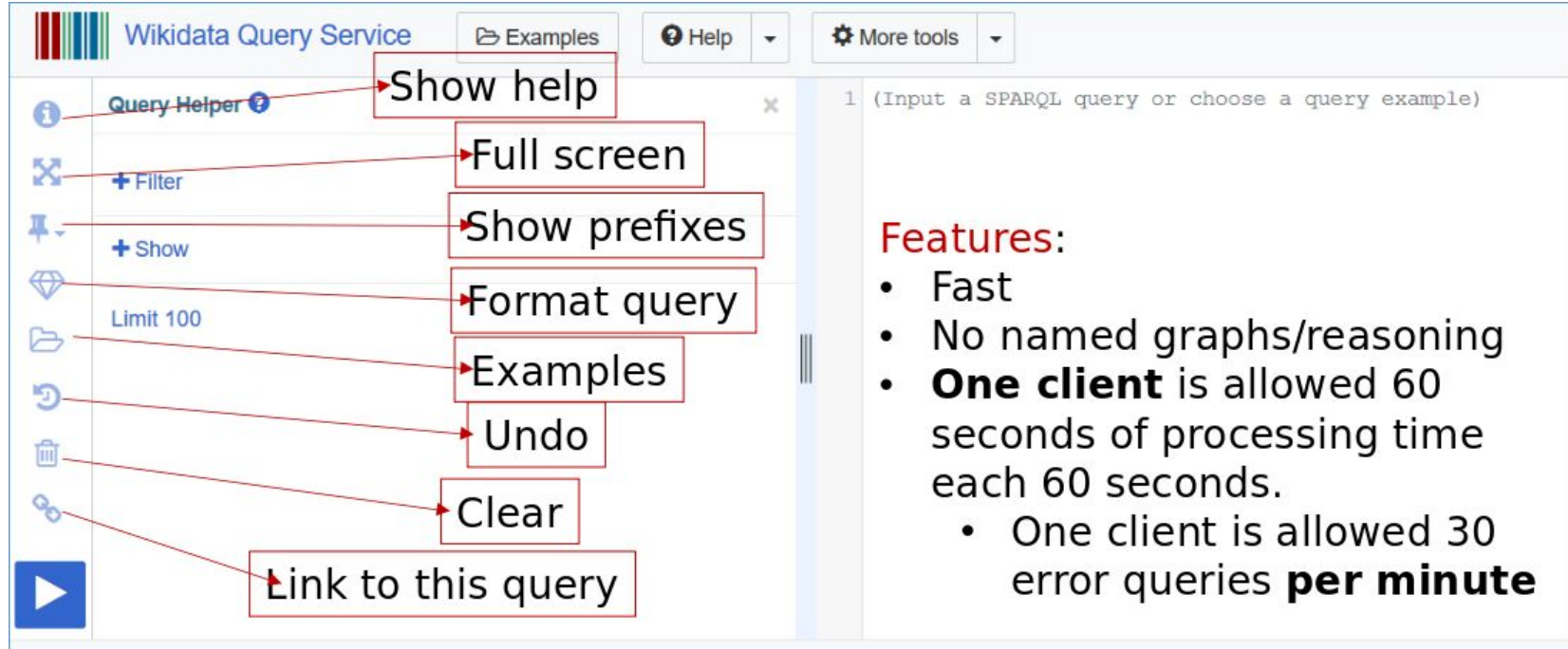


Bots allowed



Working with Wikidata: Endpoint

<https://query.wikidata.org>



The screenshot shows the Wikidata Query Service interface. On the left is a sidebar with icons for various functions. Red boxes with arrows point from these icons to labels on the right. The labels are: 'Show help' (pointing to the 'Query Helper' icon), 'Full screen' (pointing to the 'Filter' icon), 'Show prefixes' (pointing to the 'Show' icon), 'Format query' (pointing to the 'Limit 100' icon), 'Examples' (pointing to the 'Examples' icon), 'Undo' (pointing to the 'Undo' icon), 'Clear' (pointing to the 'Clear' icon), and 'Link to this query' (pointing to the 'Play' icon). The main area on the right contains a text input field with the placeholder '(Input a SPARQL query or choose a query example)' and a list of features.

Wikidata Query Service

Examples Help More tools

Query Helper

1 (Input a SPARQL query or choose a query example)

Features:

- Fast
- No named graphs/reasoning
- **One client** is allowed 60 seconds of processing time each 60 seconds.
 - One client is allowed 30 error queries **per minute**

- + Easy to use and setup
- + Works reasonably well with many results

- Lack of support for complex queries (time outs)

Working with Wikidata: Dumps

<https://dumps.wikimedia.org/wikidatawiki/entities/>

20210929/	02-Oct-2021 09:58	-
20211001/	01-Oct-2021 23:31	-
20211004/	07-Oct-2021 15:21	-
20211006/	09-Oct-2021 05:29	-
20211008/	08-Oct-2021 23:31	-
20211011/	13-Oct-2021 14:58	-
20211013/	13-Oct-2021 03:41	-
dcatap.rdf	09-Oct-2021 05:59	84751
latest-all.json.bz2	07-Oct-2021 01:08	70443187123
latest-all.json.gz	13-Oct-2021 12:41	106349083531
latest-all.nt.bz2	07-Oct-2021 15:21	141076775354
latest-all.nt.gz	06-Oct-2021 21:37	180415076132
latest-all.ttl.bz2	07-Oct-2021 02:56	89873002339
latest-all.ttl.gz	06-Oct-2021 17:15	108204018736
latest-lexemes.json.bz2	13-Oct-2021 03:41	196060822
latest-lexemes.json.gz	13-Oct-2021 03:40	272816734
latest-lexemes.nt.bz2	08-Oct-2021 23:31	557268395
latest-lexemes.nt.gz	08-Oct-2021 23:26	752297082
latest-lexemes.ttl.bz2	08-Oct-2021 23:27	304138275
latest-lexemes.ttl.gz	08-Oct-2021 23:24	385459804
latest-truthy.nt.bz2	09-Oct-2021 05:29	30708742696
latest-truthy.nt.gz	09-Oct-2021 02:38	50187553542

> 100 GB
(compressed)
> 150GB
uncompressed

+ Once loaded, support for complex queries

- Time needed for loadouts (days-week)
- Operations over the data are costly and slow

KGTK to the rescue



import

KGTK pipeline

export



transformation

validate

clean

sort

filter

replace

transformation

query

join

union

intersection

subtraction

network

centrality

page rank

paths

components

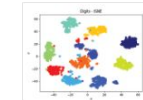
machine learning

embeddings

lexicalization

linking

KGTK commands



Outline

1) Evolution of Wikidata: Analyzing > 300 dumps

- But... why?
- Data collection
- Analysis with KGTK
- Results

2) Wikidata **quality analysis**

- Defining quality in Wikidata
- Anatomy of a constraint
- Constraint validation with KGTK
- Results
- Playing around with the sample KG



Why look at the evolution of Wikidata? (2014-2021)

- How do large KGs (Wikidata) **get populated**:
 - When were classes added
 - When were new properties added?
 - Stable terms (highly used properties and classes)
 - “Complete” classes (few new individuals added)
 - Are highly edited classes more or less connected? (pagerank)
- **Timeliness of large KGs** (propagation of changes)
 - Lag: how much time is there between a qualifier is added to its respective statement?

Data collection: Challenges



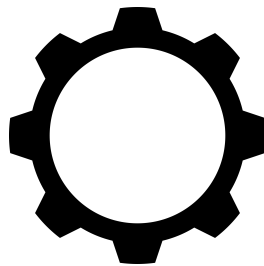
- Weekly dumps in <https://dumps.wikimedia.org/wikidatawiki/entities/> only go back **a few months**
- Internet Archive has many Wikidata dumps
 - Unfortunately, **there are gaps** for many months!
 - Reached out the community for help
- **Size** of dataset
 - First releases of Wikidata are a few GB compressed
 - Last releases are > 100 GB (compressed)
- Total dumps collected: **311** (Oct 2014 - Jan 2021)
 - > 15 TB (compressed)

20170220	https://archive.org
20170227	DOES NOT EXIST
20170306	DOES NOT EXIST
20170313	DOES NOT EXIST
20170320	DOES NOT EXIST
20170329	DOES NOT EXIST
20170403	DOES NOT EXIST
20170410	DOES NOT EXIST
20170417	DOES NOT EXIST
20170424	DOES NOT EXIST
20170501	DOES NOT EXIST
20170508	DOES NOT EXIST
20170515	DOES NOT EXIST
20170522	DOES NOT EXIST
20170529	DOES NOT EXIST
20170605	DOES NOT EXIST
20170612	DOES NOT EXIST
20170619	DOES NOT EXIST
20170626	DOES NOT EXIST
20170703	DOES NOT EXIST
20170710	DOES NOT EXIST
20170717	DOES NOT EXIST
20170724	DOES NOT EXIST
20170731	DOES NOT EXIST
20170807	DOES NOT EXIST
20170814	DOES NOT EXIST
20170821	DOES NOT EXIST
20170828	DOES NOT EXIST
20170904	DOES NOT EXIST

Data analysis with KGTK

For each **dump**

- Import from JSON -> KGTK format
- Sort
- Calculate deltas (external script)
- Count classes and instances (and qualifiers)
- Pagerank, hubs
- Compress results and save them



Challenges:

- Errors on import (JSON format has changed in Wikidata)
- Errors with problematic dumps
 - Problems recognizing some quantities, literals, etc.

Data extraction and analysis: example in KGTK: sh scripts

```
while read -r line ; do
    # Initialize folder, unpack and sort. $line has the full path
    echo "Processing file: $line"
    folder_new_name=$(basename $line)
    folder_new_name="${folder_new_name%%.*}"
    echo "Name of folder: $folder_new_name"

    mkdir $folder_new_name
    echo "Importing file..."
    TEMPDIR=$folder_new_name
    # Import the Wikidata dump file, getting labels, aliases, and descriptions
    # in English and in all languages.
    kgtk --debug --timing --progress import-wikidata \
    -i $line \
    --node ${TEMPDIR}/nodefile.tsv \
    --edge ${TEMPDIR}/edgefile.tsv \
    --qual ${TEMPDIR}/qualfile.tsv \
    --use-mgzip-for-input True \
    --use-mgzip-for-output True \
    --use-shm True \
    --procs 6 \
    --mapper-batch-size 5 \
    --max-size-per-mapper-queue 3 \
    --single-mapper-queue True \
    --collect-results True \
    --collect-seperately True \
    --collector-batch-size 10 \
    --collector-queue-per-proc-size 3 \
    --progress-interval 500000 --fail-if-missing False

    echo "Sorting file ..."
    kgtk sort -i "$folder_new_name"/edgefile.tsv -c 'id' -o "$folder_new_name"/edgefile_sorted.tsv
    # Remove edge file (to save a little space)
    rm "$folder_new_name"/edgefile.tsv
done < dumps_to_import.txt
```

Import + sort

```
folder=$PWD
for entry in "$folder"/*
do
    #echo "Processing: $entry"
    file_name=$(basename $entry)
    FILE="$entry"/edgefile_sorted.tsv
    if [ -f "$FILE" ]; then
        echo "Processing $FILE"
        kgtk query --debug --graph-cache /wikidata.sqlite3.db -i
"$entry"/edgefile_sorted.tsv -i datatypes.tsv -o "$entry"/claims.wikibase-item.tsv.gz \
--match 'edgefile_sorted: (n1)-[l {label: p}]->(n2), datatypes:
(p)-[:datatype]->(: wikibase-item)`' \
--return 'l as id, n1 as node1, p as label, n2 as node2' \
--order-by 'l'

1

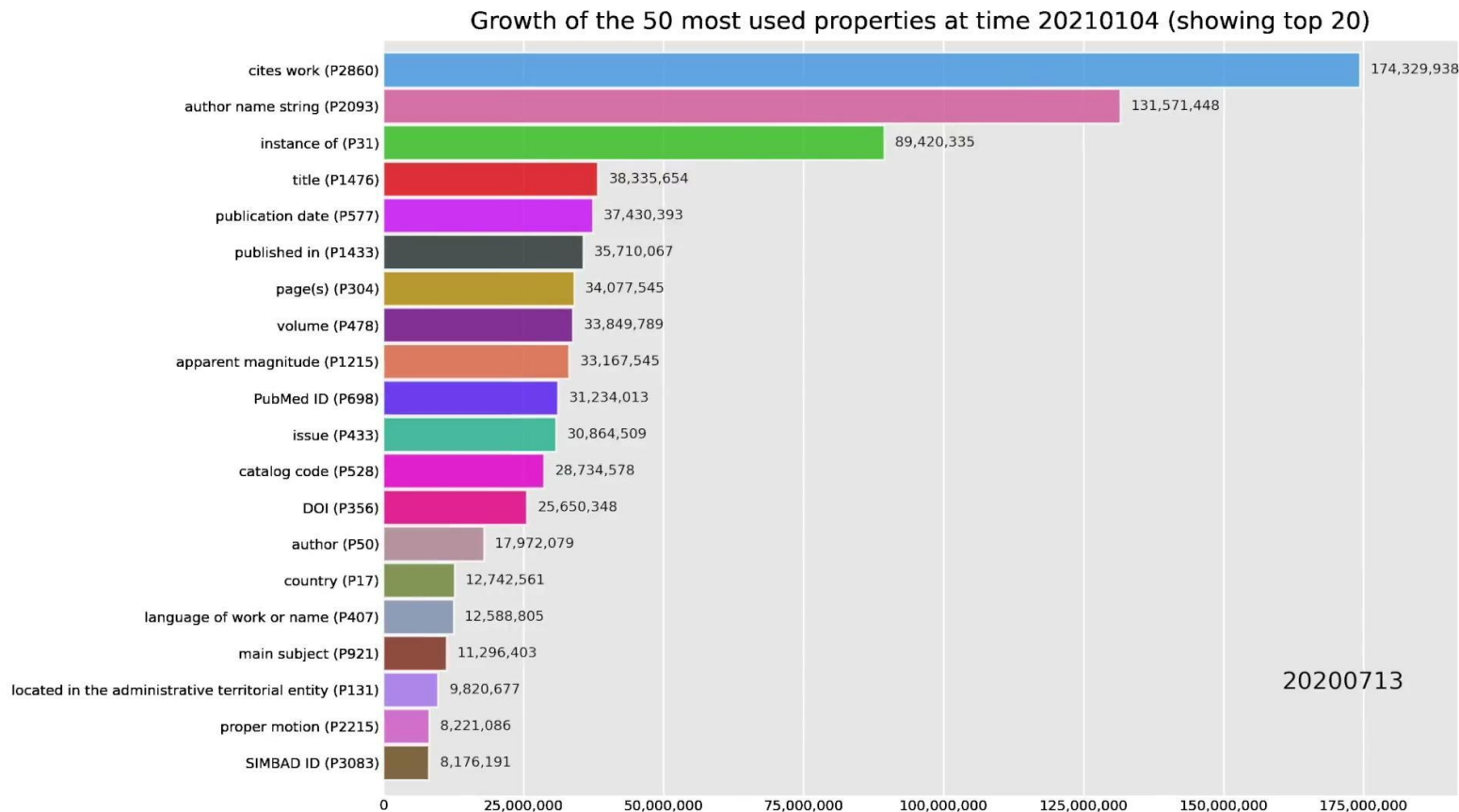
kgtk graph-statistics -i "$entry"/claims.wikibase-item.tsv.gz -o
"$entry"/pagerank.undirected.tsv.gz \
--page-rank-property undirected_pagerank \
--pagerank --statistics-only --hits\
--log "$entry"/pagerank.undirected.summary.txt --print-top-n 100

2

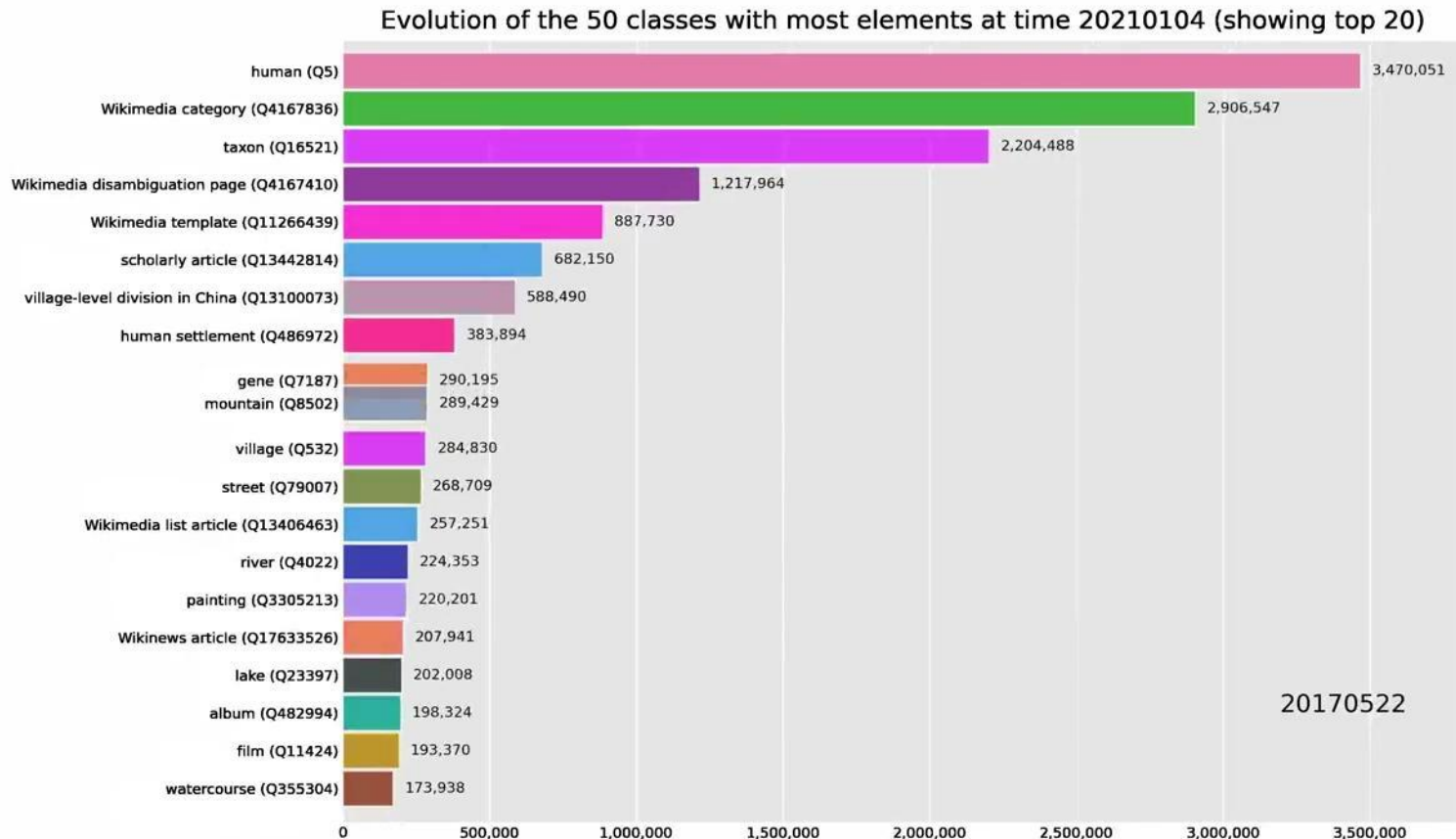
rm /wikidata.sqlite3.db
fi
#cp "$entry"/modified_prop_count.tsv
"$target"/"$file_name"_modified_prop_count.tsv
done
```

1. Retrieve just wikibase items
2. Calculate top 100 entities in the page rank

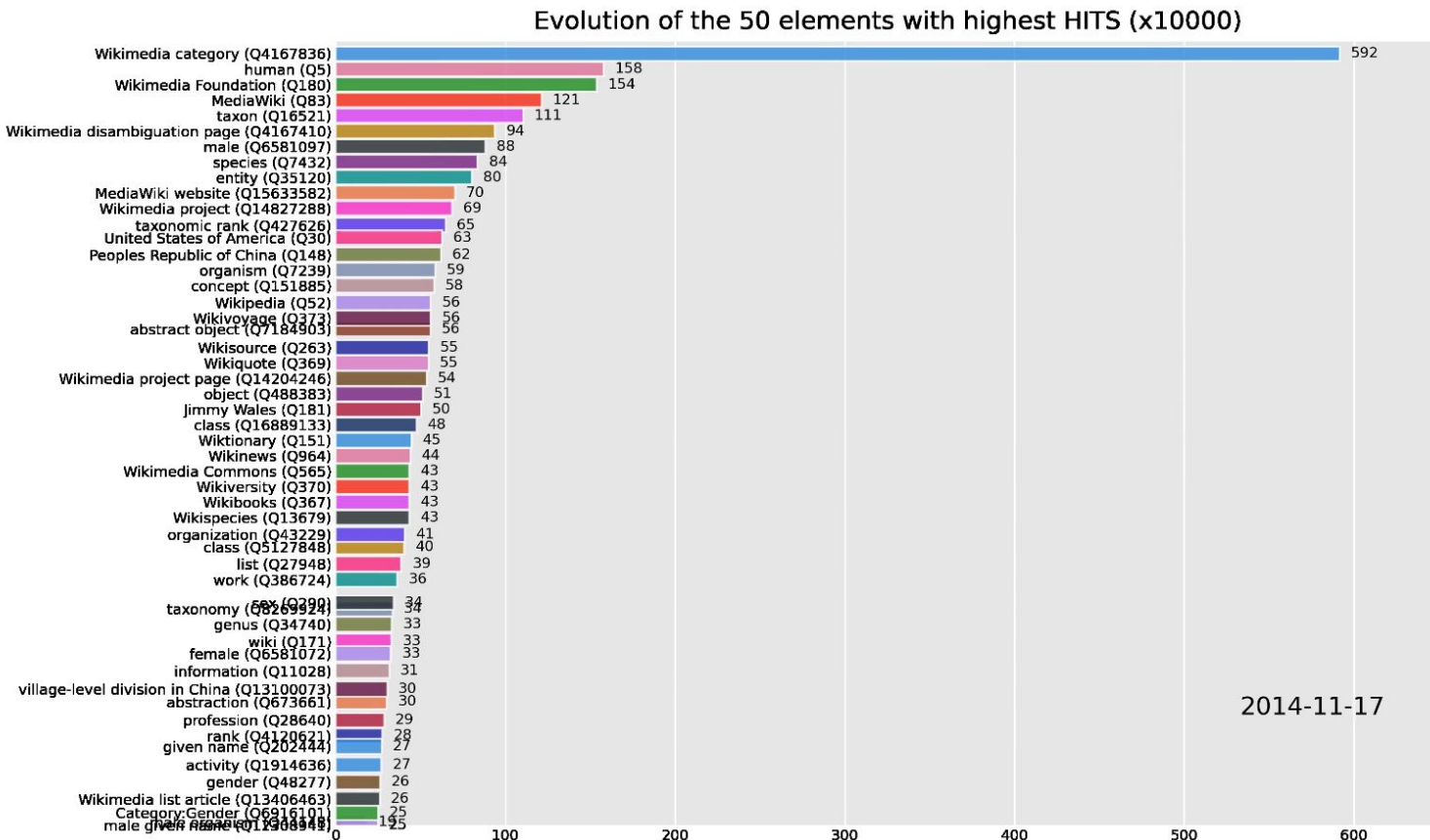
Results: Evolution of the most popular properties



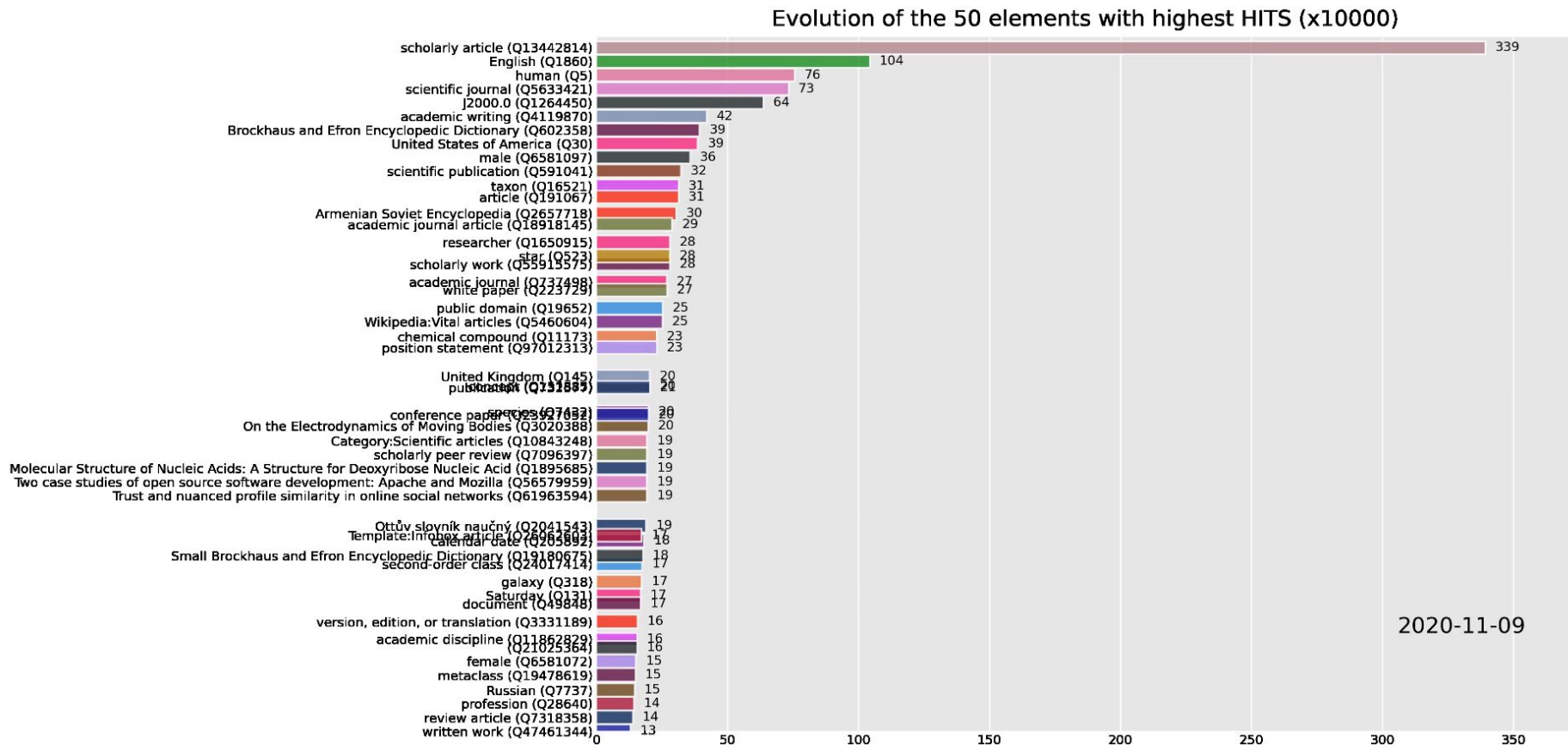
Results: Evolution of the most popular classes



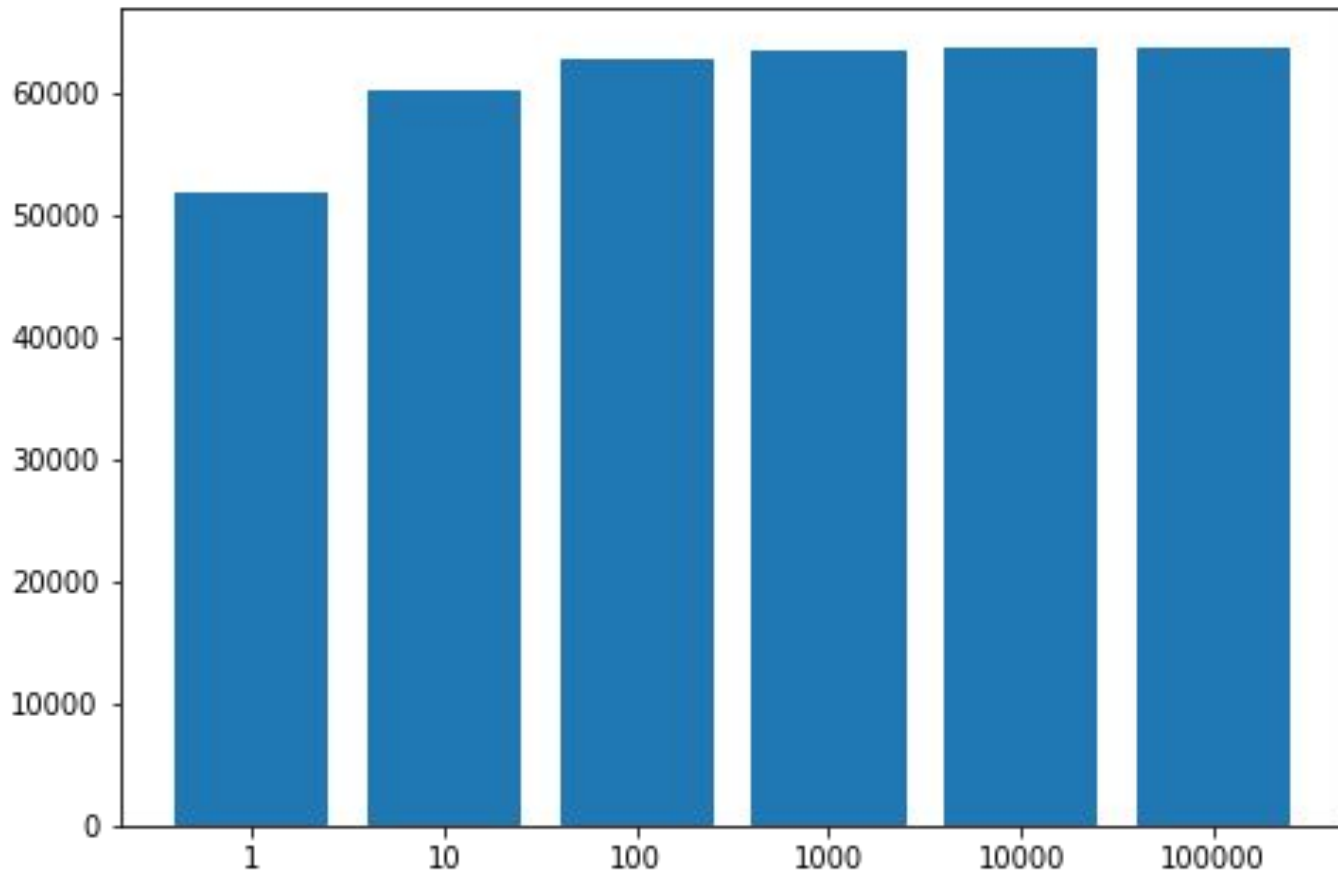
Results: Evolution of the entities with biggest page rank



Results: Evolution of the entities with biggest page rank



Results: How “stable” are Wikidata classes?

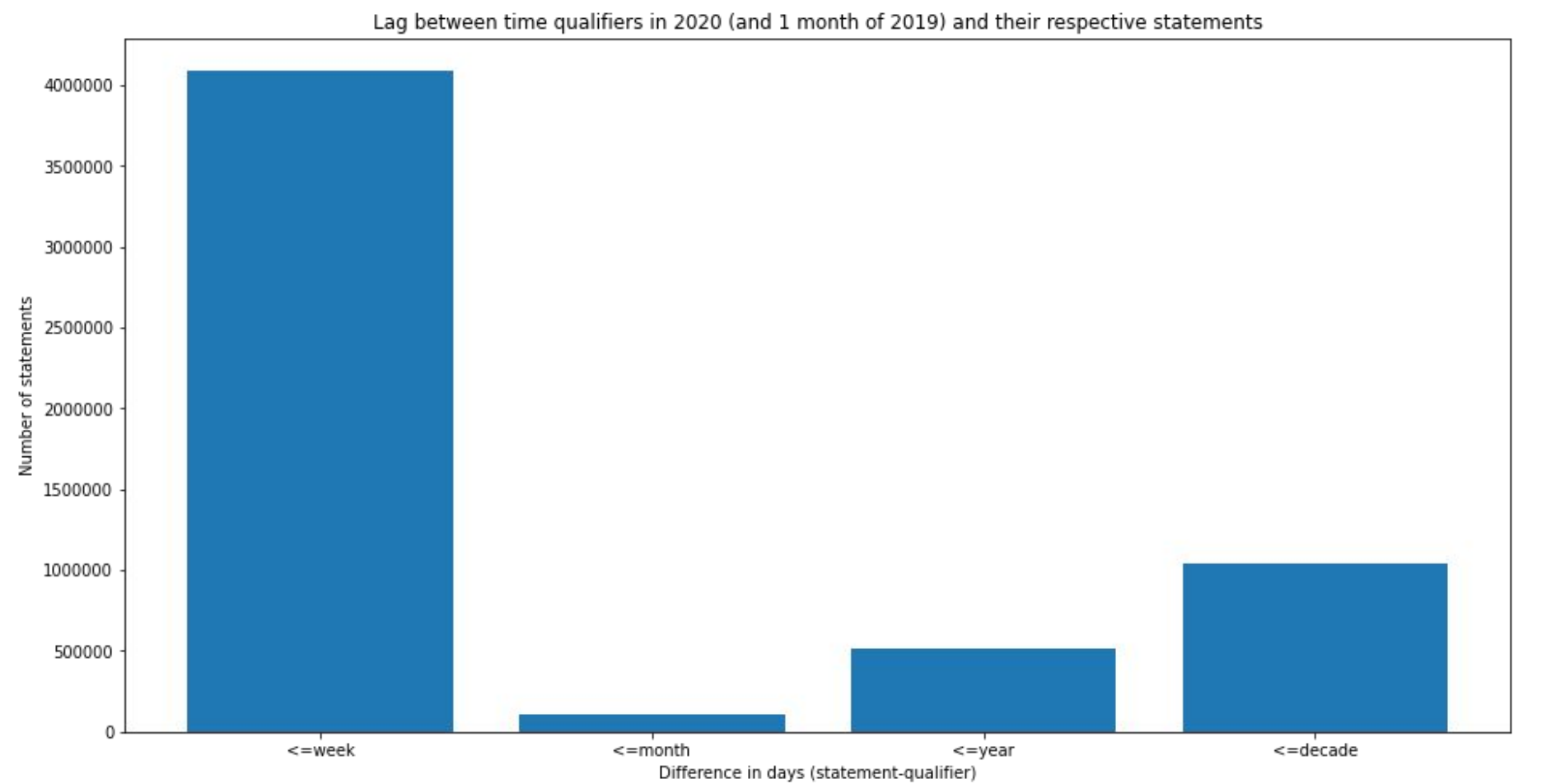


X axis: variance
Y axis: number of
classes with that
variance.

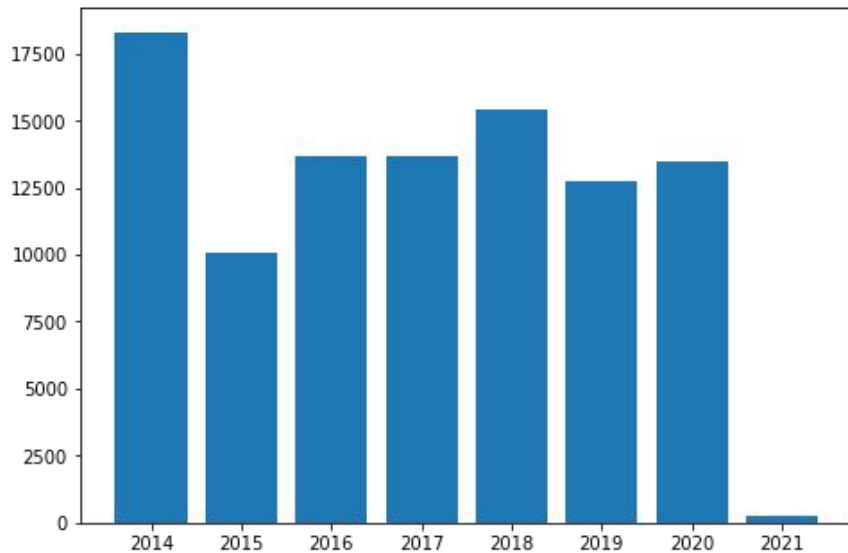
e.g., number of classes
that had a difference of
10 **or less** instances with
respect the previous
week for any week
(some weeks could be 0)
during 2020 is 60292
(very stable).

Depopulated classes
have not been included

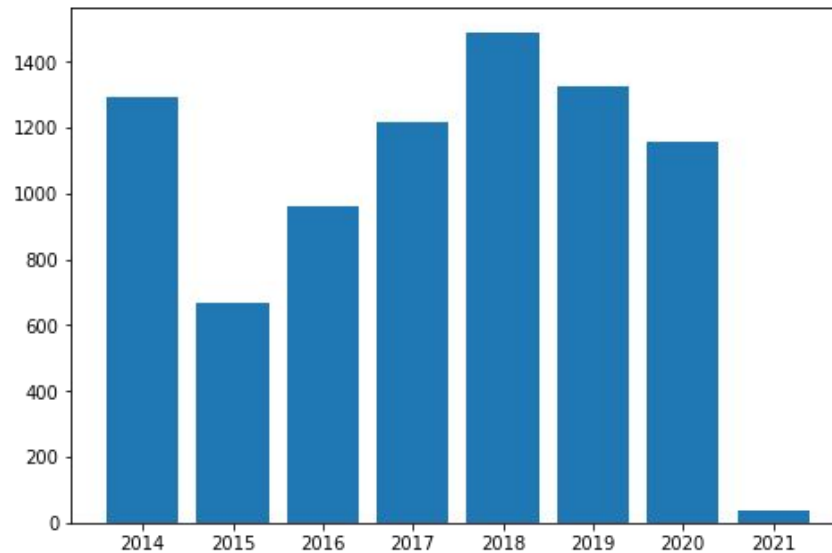
Results: Lag between qualifiers and the entity they describe (2020)



Results: How **alive** is Wikidata (new terms)



When were classes first populated?



When were properties first used?

More results soon (ongoing paper)

Outline

1) **Evolution of Wikidata**: Analyzing > 300 dumps

- But... why?
- Data collection
- Analysis with KGTK
- Results

2) **Wikidata quality analysis**

- Defining quality in Wikidata
- Anatomy of a constraint
- Constraint validation with KGTK
- Results
- Playing around with the sample KG

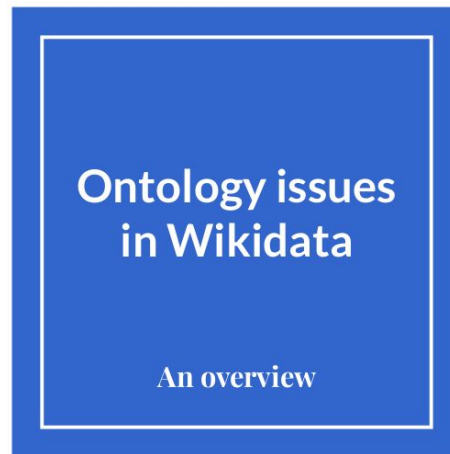


Data Quality in Wikidata

Crowdsourced data is great, but:

- **Conceptual** issues
 - Conflicting real-world models
 - Mixup of meta-levels
 - Conceptual ambiguity
 - Subclass of cycles
 - Entity vs class distinction
 - Messy upper ontology
- **Constraint violations**
 - Inconsistent modeling
- **Duplicate** entities
- ...

Based on



By [lydia.pintscher](#)

What questions did we want to explore regarding quality?

- Q1: Are entities being **deduplicated**?
- Q2: Can the community distinguish **classes from instances**?
- Q3: Are **property types and value types** respected?
- Q4: Can we detect **missing triples**?
- Q5: Are constraints **correct and complete**?
- Q6: What statements get **deprecated**?
- Q7: Are constraint violations **getting fixed**?

KGTK Analysis: Three indicators of low quality statements

Sources:



- **Permanently deleted statements (76.5 M)**
 - Q1 (calculate redirections in entity deduplication)
 - Q2 (which entities have switched from class to instance?)
 - Q7 (constraint violation correction)
- **Deprecated statements (10 M)**
 - Q6 (what statements get deprecated)
- **Constraint violations (symmetric, inverse, etc.)**
 - Q3 (property types getting respected)
 - Q4 (infer new triples)
 - Q5 (number of constraint violations)
 - Q7 (constraint violation correction)



KGTK Analysis: Data sources

Permanently deleted statements: extracted from the evolution analysis

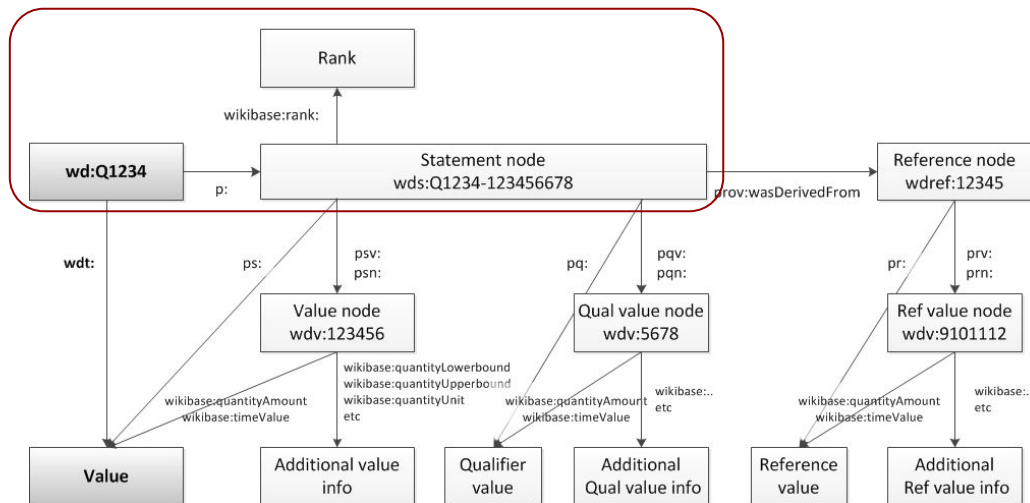
```
kgtk ifnotexists -i $removed --filter-on "$entry"/added.tsv -o $removed_aux  
# Aggregate the difference into the deleted file  
echo "Concatenating statements at the end of $removed"  
kgtk cat -i $removed_aux "$entry"/deleted.tsv -o $removed
```

Deprecated terms

- **Filter** by rank “deprecated”

Constraint violations

- **Kgtk query**



Anatomy of a Wikidata constraint

occupation (P106)

occupation of a person; see also "field of work" (Property:P101), "position held" (Property:P39)
profession | job | work | career | employment | craft | employ

The screenshot shows the Wikidata constraint editor for the property 'occupation' (P106). The interface is divided into several sections:

- type constraint**: A section with a dropdown menu currently set to 'class'. Below it, a list of classes is shown: 'person', 'narrative entity', 'fictional character', 'animal', 'human', 'robot', 'group of humans', and 'group of fictional characters'. Red arrows point from this section to the text 'Constraint type (there are over 30). Similar to rdfs:domain' and 'Described entity should be instance of one of these classes'.
- relation**: A section with a dropdown menu currently set to 'instance of'. A red arrow points from this section to the text 'Described entity should be instance of one of these classes'.
- exception to constraint**: A section with a dropdown menu currently set to 'prescriber'. A red arrow points from this section to the text 'Exceptions to the rule (either classes or instances)'.
- 0 references**: A section at the bottom indicating the number of references.

Constraint type (there are over 30).
Similar to rdfs:domain

Described entity should be instance of
one of these classes

Exceptions to the rule (either classes or
instances)

Constraint validation with KGTK

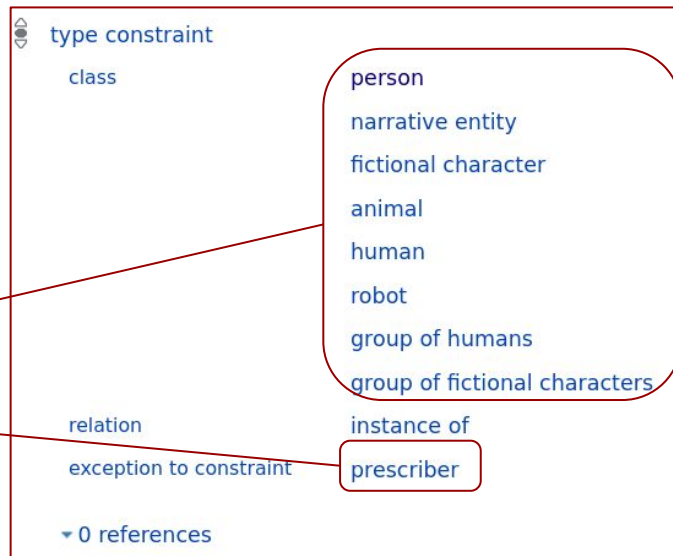
We limited ourselves to five common types of constraints: **type**, **value-type**, **item-requires-statement**, **symmetric** and **inverse**.

Example for **type constraint** template:

kgtk query

```
-i statements_with_property_instance_of_subclass_of_star \  
--match statements: (subject)-[id {label:property}]->(object), \  
    instance_of: (subject)-[]->(class), \  
    subclass_of_star: (class)-[]->(parent)' \  
--where 'parent in expected_parents or subject in exceptions' \  
--return 'distinct id, subject, property, object' \  
-o statements_correct.tsv
```

```
kgtk ifexists -i statements_with_property --filter-on statements_correct.tsv \  
-o statements_incorrect.tsv
```



Result summary

- **Q1: Are entities being deduplicated?**
 - Some are through **redirects**.
 - **2 million redirected nodes**, affecting over 21.3 million statements (27.8% of the removed statements)

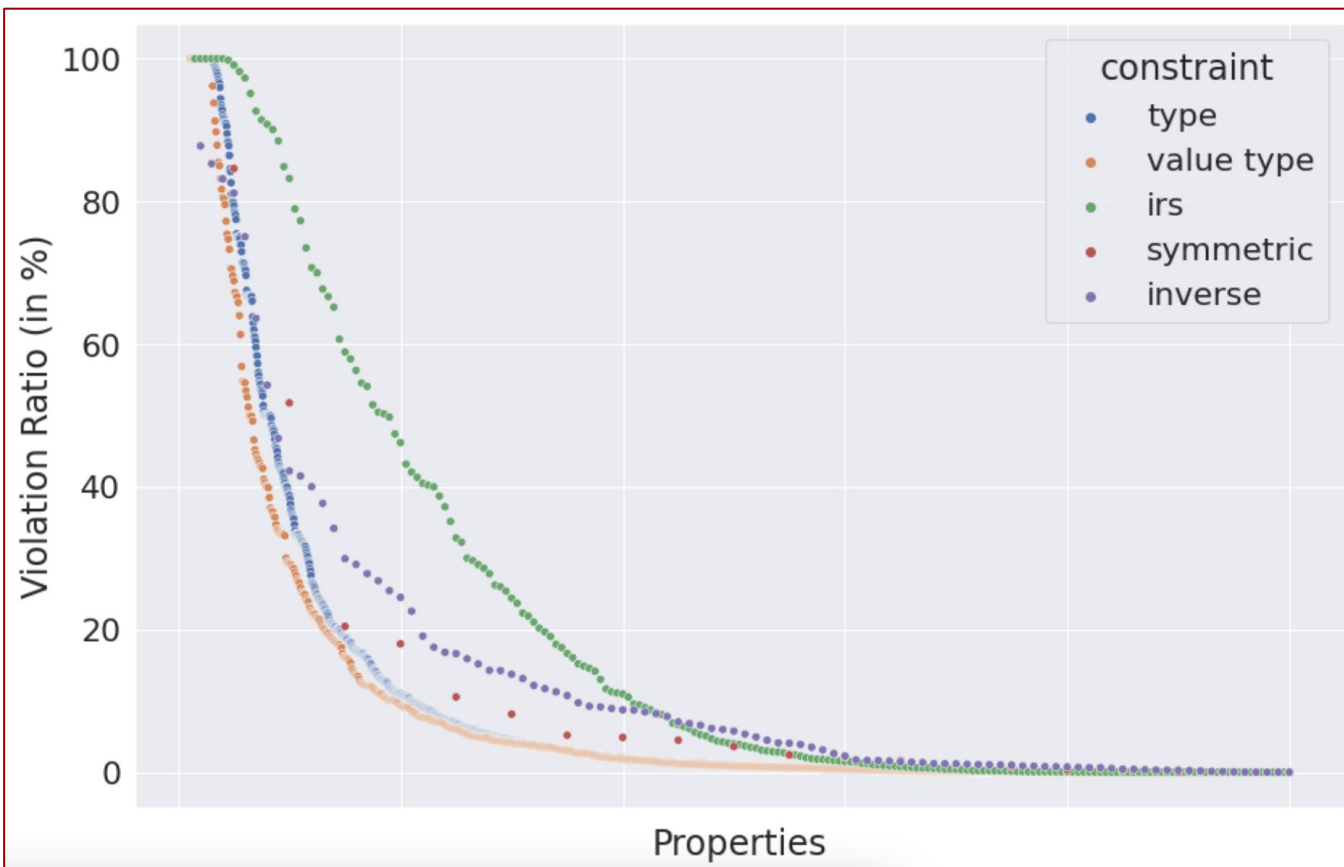
Classes of redirected instances		
Q4167836	Wikimedia category	526,207 (21.38%)
Q5	human	222,809 (9.05%)
Q4167410	Wikimedia disambiguation page	108,583 (4.41%)
Q13442814	scholarly article	101,156 (4.11%)
Q7187	gene	88,231 (3.59%)
Redirected classes		
Q17329259	encyclopedic article	301,359 (12.25%)
Q4423781	dictionary entry	53,671 (2.18%)
Q17143521	village of Poland	51,581 (2.09%)
Q15917122	rotating variable star	50,642 (2.06%)
Q20900710	painting	23,482 (0.99%)

Result summary

- **Q2: Can the community distinguish **classes from instances**?**
 - More than **500.000 changes** (class -> instance or vice versa)
 - 440k go from class -> instance
- **Q3: Are **property types and value types** constraints respected?**
 - Most violation ratios are on “suggested” constraints (20%)
 - Small number of violation ratios for **mandatory constraints** (1%, but more than 40K statements!)

constraint type	mandatory		VR%
	correct	incorrect	
type	44.99M	37.67k	0.08
value type	11.44M	5.38k	0.03
I.R.S.	3.98M	767	0.02
inverse	6.56k	133	1.99
symmetric	7.43k	42	0.56

Constraint violation ratios



Q4: Can we detect **missing triples**?

Item-require-statement and inverse property violations can be used **to suggest candidates**.

Q5: Are constraints **correct and complete**?

Not always. E.g., those constraints with high violation ratios may need to be reviewed

Each dot is a property with that constraint type

Result summary

- **Q6: What statements get deprecated?**
 - Largely, in the **Astronomy** domain
 - **Top 5 classes** with instances and properties being deprecated:

Class	Count	Property	Count
infrared source (Q67206691)	2,546,256	instance of (P31)	3,303,204
star (Q523)	352,194	proper motion (P2215)	2,236,125
near-IR source (Q67206785)	60,055	parallax (P2214)	2,159,860
astronomical radio source (Q1931185)	43,618	radial velocity (P2216)	816,191
galaxy (Q318)	35,768	distance from Earth (P2583)	461,113

Result summary

- **Q7: Are constraint violations getting fixed?**

- Yes. By analyzing the deleted statements, **many included deleted constraint violations**. E.g.,
 - 30% type constraint (mandatory), 15 % (normal), 40% (suggestion)
 - 12% value type constraint (mandatory), 22% (normal), 59% (suggestion)

constraint	mandatory	normal	suggestion
type	763k/2.31M (33.04%)	5.3M/34.87M (15.21%)	920/2.29k (40.12%)
value type	25.4k/211k (12.03%)	198k/8.99M (22.06%)	235/397 (59.19%)
IRS	4.67k/1.28M (0.36%)	192k/4.85M (3.97%)	190k/6.01M (3.17%)
inverse	37/345 (10.72%)	177k/534k (33.13%)	11.7k/160k (7.27%)
symmetric	19/307 (6.19%)	7.52M/10.85M (69.37%)	5.05k/37.5k (13.47%)

How long did it take?

- There are more than 8000 properties, each with different constraints.
- Analysis covered only **wikibase item-based properties**.
- Median of **2 min per constraint**, avg of 5 min.
- Time does not include importing wikidata, generation of filtered files.

constraint type	#properties				#statements	validation time (in sec.)			
	all	M	N	S		min	max	mean	median
type	1,456	165	1,280	11	513,424,170	4.95	5231.15	366.16	174.78
value type	897	106	786	5	182,087,480	11.41	5323.18	352.08	144.15
item requires statement	527	78	418	97	302,642,146	1.89	2199.57	133.51	58.6
inverse	110	6	100	4	9,440,925	8.68	646.22	100.69	54.79
symmetric	38	5	30	3	7,145,197	9.72	527.33	118.44	68.67

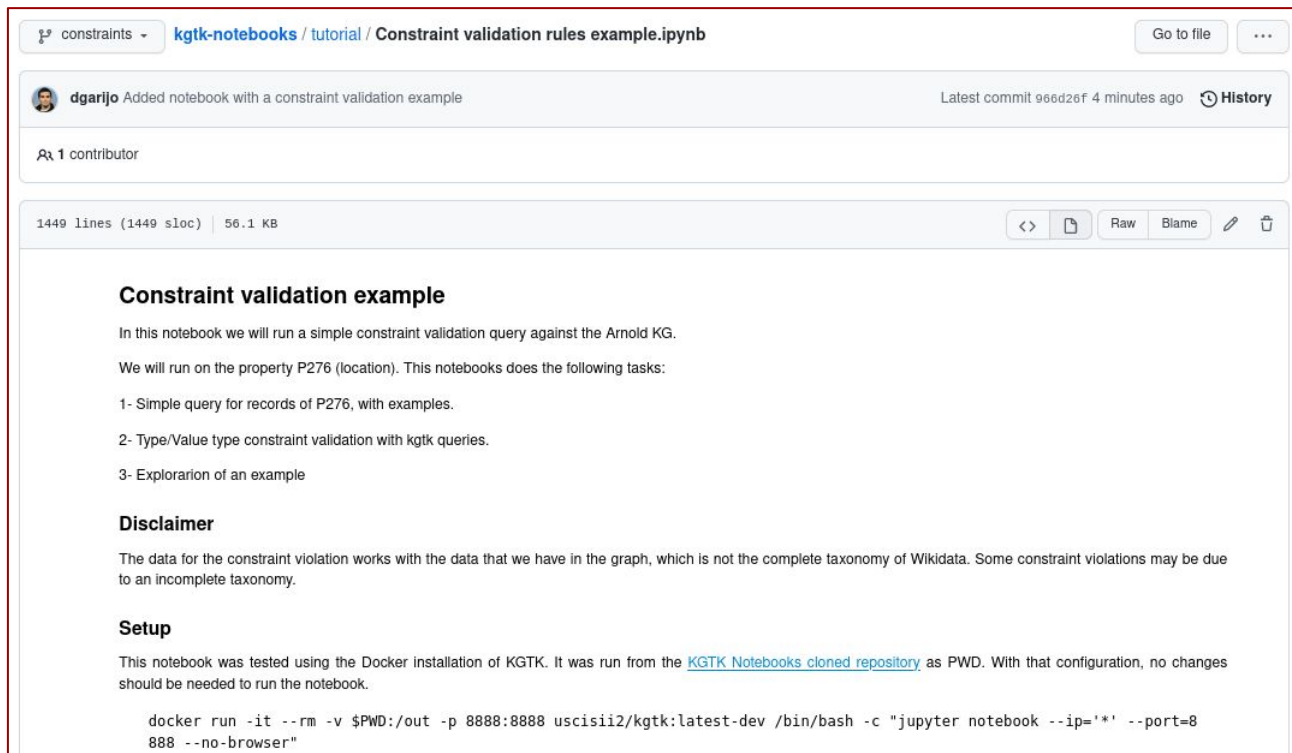
Want to see more details?

Check our paper <https://arxiv.org/abs/2107.00156>

Live example (Notebook)

Let's try and validate one of the constraints in the KG shown in previous sessions (Arnold Schwarzenegger's KG):

<https://github.com/usc-isi-i2/kgtk-notebooks/blob/main/tutorial/07-kg-constraint-validation.ipynb>



The screenshot displays a Jupyter Notebook interface within a web browser. At the top, the breadcrumb navigation shows 'constraints' selected, followed by 'kgtk-notebooks / tutorial / Constraint validation rules example.ipynb'. On the right, there are buttons for 'Go to file' and a menu icon. Below the navigation bar, a message from user 'dgarljo' states 'Added notebook with a constraint validation example', with the latest commit '96ed26f' made '4 minutes ago'. A 'History' button is also present. A search bar indicates '1 contributor'. The notebook's metadata shows '1449 lines (1449 sloc)' and '56.1 KB'. The toolbar includes icons for code, file, raw, blame, edit, and delete. The notebook content begins with the title 'Constraint validation example', followed by an introductory paragraph about running a query against the Arnold KG. It then lists three tasks: a simple query for records of P276, type/value constraint validation, and an exploration of an example. A 'Disclaimer' section follows, noting that the data is incomplete. The 'Setup' section describes the testing environment using Docker and provides a terminal command to run the notebook.

constraints - kgtk-notebooks / tutorial / Constraint validation rules example.ipynb Go to file ...

dgarljo Added notebook with a constraint validation example Latest commit 96ed26f 4 minutes ago History

1 contributor

1449 lines (1449 sloc) | 56.1 KB <> [file icon] Raw Blame [edit icon] [trash icon]

Constraint validation example

In this notebook we will run a simple constraint validation query against the Arnold KG.

We will run on the property P276 (location). This notebooks does the following tasks:

- 1- Simple query for records of P276, with examples.
- 2- Type/Value type constraint validation with kgtk queries.
- 3- Explorariion of an example

Disclaimer

The data for the constraint violation works with the data that we have in the graph, which is not the complete taxonomy of Wikidata. Some constraint violations may be due to an incomplete taxonomy.

Setup

This notebook was tested using the Docker installation of KGTK. It was run from the [KGTK Notebooks cloned repository](#) as PWD. With that configuration, no changes should be needed to run the notebook.

```
docker run -it --rm -v $PWD:/out -p 8888:8888 uscisi2/kgtk:latest-dev /bin/bash -c "jupyter notebook --ip='*' --port=8888 --no-browser"
```