What are the ten largest cities with a female mayor?
What are the ten largest cities with a female mayor?

<table>
<thead>
<tr>
<th>cityLabel</th>
<th>mayorLabel</th>
<th>population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tokyo</td>
<td>Yuriko Koike</td>
<td>13784212</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>Carrie Lam</td>
<td>7336585</td>
</tr>
<tr>
<td>Baghdad</td>
<td>Zekra Alwach</td>
<td>6960000</td>
</tr>
<tr>
<td>Surabaya</td>
<td>Tri Rismaharini</td>
<td>4975000</td>
</tr>
<tr>
<td>Yokohama</td>
<td>Fumiko Hayashi</td>
<td>3731706</td>
</tr>
<tr>
<td>Rome</td>
<td>Virginia Raggi</td>
<td>2873494</td>
</tr>
<tr>
<td>Paris</td>
<td>Anne Hidalgo</td>
<td>2206488</td>
</tr>
<tr>
<td>Havana</td>
<td>Marta Hernández Romero</td>
<td>2141652</td>
</tr>
<tr>
<td>Caracas</td>
<td>Helen Fernández</td>
<td>1943901</td>
</tr>
<tr>
<td>Bucharest</td>
<td>Gabriela Firea</td>
<td>1883425</td>
</tr>
</tbody>
</table>
Where are people born who travel to space?

(colour-coded by gender)
Which days of the week do disasters occur?

<table>
<thead>
<tr>
<th>Date</th>
<th>Mon</th>
<th>Tue</th>
<th>Wed</th>
<th>Thu</th>
<th>Fri</th>
<th>Sat</th>
<th>Sun</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>25</td>
<td>33</td>
<td>22</td>
<td>18</td>
<td>26</td>
<td>28</td>
<td>23</td>
</tr>
<tr>
<td>2</td>
<td>24</td>
<td>26</td>
<td>23</td>
<td>23</td>
<td>22</td>
<td>32</td>
<td>12</td>
</tr>
<tr>
<td>3</td>
<td>24</td>
<td>27</td>
<td>21</td>
<td>31</td>
<td>23</td>
<td>28</td>
<td>38</td>
</tr>
<tr>
<td>4</td>
<td>24</td>
<td>25</td>
<td>33</td>
<td>25</td>
<td>26</td>
<td>26</td>
<td>24</td>
</tr>
<tr>
<td>5</td>
<td>37</td>
<td>23</td>
<td>32</td>
<td>18</td>
<td>19</td>
<td>17</td>
<td>29</td>
</tr>
<tr>
<td>6</td>
<td>25</td>
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<td>32</td>
<td>20</td>
<td>24</td>
<td>33</td>
<td>22</td>
</tr>
<tr>
<td>7</td>
<td>18</td>
<td>22</td>
<td>25</td>
<td>16</td>
<td>22</td>
<td>18</td>
<td>17</td>
</tr>
<tr>
<td>8</td>
<td>32</td>
<td>26</td>
<td>19</td>
<td>25</td>
<td>22</td>
<td>23</td>
<td>19</td>
</tr>
<tr>
<td>9</td>
<td>20</td>
<td>25</td>
<td>29</td>
<td>29</td>
<td>27</td>
<td>21</td>
<td>23</td>
</tr>
<tr>
<td>10</td>
<td>20</td>
<td>20</td>
<td>19</td>
<td>14</td>
<td>25</td>
<td>25</td>
<td>29</td>
</tr>
<tr>
<td>11</td>
<td>30</td>
<td>34</td>
<td>28</td>
<td>23</td>
<td>22</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>12</td>
<td>41</td>
<td>33</td>
<td>27</td>
<td>30</td>
<td>20</td>
<td>20</td>
<td>23</td>
</tr>
<tr>
<td>13</td>
<td>35</td>
<td>26</td>
<td>29</td>
<td>21</td>
<td>25</td>
<td>24</td>
<td>25</td>
</tr>
<tr>
<td>14</td>
<td>24</td>
<td>23</td>
<td>27</td>
<td>23</td>
<td>22</td>
<td>28</td>
<td>17</td>
</tr>
</tbody>
</table>

Markus Krötzsch, 13th Nov 2018

Knowledge Graphs
Which 19th century paintings show the moon?
Which films co-star more then one future head of government?

<table>
<thead>
<tr>
<th>Star in the Dust</th>
<th>1956 film by Charles F. Haas</th>
<th>2</th>
<th>Clint Eastwood, mayor; George Wallace, Governor of Alabama</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Two Who Stole the Moon</td>
<td>1962 Polish film by Jan Batory</td>
<td>2</td>
<td>Jarosław Kaczyński, Prime Minister of Poland; Lech Kaczyński, Mayor of Warsaw</td>
</tr>
<tr>
<td>Ragasíya Police 115</td>
<td>1968 film by B. R. Panthulu</td>
<td>2</td>
<td>M. G. Ramachandran, Chief Minister of Tamil Nadu; Jayalalithaa, Chief Minister of Tamil Nadu</td>
</tr>
<tr>
<td>Québec : Duplessis et après...</td>
<td>documentary</td>
<td>2</td>
<td>Bernard Landry, Premier of Quebec; René Lévesque, Premier of Quebec</td>
</tr>
<tr>
<td>Q3541438</td>
<td>1994 film by Claude Lanzmann</td>
<td>2</td>
<td>Ariel Sharon, Prime Minister of Israel; Ehud Barak, Prime Minister of Israel</td>
</tr>
<tr>
<td>Batman &amp; Robin</td>
<td>1997 American superhero film based on the DC Comics character Batman</td>
<td>2</td>
<td>Arnold Schwarzenegger, Mr. Freeze / Governor of California; Jesse Ventura, Governor of Minnesota</td>
</tr>
</tbody>
</table>
A Free Knowledge Graph

**Wikidata**

- Wikipedia’s knowledge graph
- Free, community-built database
- Large graph
  (October 2018: >570M statements on >50M entities)
- Large, active community
  (October 2018: >230,000 logged-in human editors)
- Many applications

Freely available, relevant, and active knowledge graph
A short history of Wikidata

Prehistory


• September 2005: First release of Semantic MediaWiki software, which since became an active stand-alone software project

• 2006–2011: Many talks and discussions at Wikimanias in Boston, Taipei, Alexandria, Buenos Aires, Gdańsk, and Haifa

• 2011/2012: WMF support and donations for starting Wikidata development are secured

• 1st April 2012: Wikidata development kick-off in Berlin

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A short history of Wikidata

History

- **29th October 2012**: wikidata.org is launched
- **15th Dec 2012**: Item with ID number 1000000 created
- **4th Feb 2013**: The first statements can be created
- **Early 2013**: Most Wikipedia language links relocate to Wikidata
- **Late 2013**: More than 100,000,000 edits on over 15M items
- **Dec 2014**: Google announces the closure of Freebase and migration to Wikidata
- **2014-2018**: A total of >700M edits produce >55M items and >570M statements
- **May 2018**: Wikidata starts storing data about lexemes (=expressions in a language)
- **Oct 2018**: Senses of lexemes become supported
Many applications (1)

As of today, Wikidata content has been used in many ways.

**Wikipedia & the Wikimedia community:**
- Wikipedia inter-language links (see any Wikipedia page)
- Data displays in pages (auto-generated info boxes, article placeholders, result tables, …)
- Quality checks & edit-a-thons

**External re-uses of data:**
- Application-specific data-excerpts (e.g., Eurowings in-flight app)
- Data integration and quality control (e.g., Google checks own KG against Wikidata)
- Authority control & identity provider (VIAF, Open Streetmaps, DBLP, … link their content to Wikidata)
- Data-driven journalism (individual analyses as well as data-driven information portals)
Grover Cleveland
22nd and 24th president of the United States

Stephen Grover Cleveland was an American politician and lawyer who was the 22nd and 24th President of the United States. He won the popular vote for three presidential elections – in 1884, 1888, and 1892 – and was one of two Democrats to be elected president during the era of Republican political domination dating from 1861 to 1933. He was also the first and to date only President in American history to serve two non-consecutive terms in office.

<table>
<thead>
<tr>
<th>Date of birth</th>
<th>March 18, 1837</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birthplace</td>
<td>Caldwell</td>
</tr>
<tr>
<td>Date of death</td>
<td>June 24, 1908</td>
</tr>
<tr>
<td>Deathplace</td>
<td>Princeton</td>
</tr>
</tbody>
</table>
As of today, Wikidata content has been used in many ways.

**In research:**
- Test data for KG-related algorithms
- Training data for machine-learning approaches
- Wikidata as a subject of study (social dynamics, internationality, biases, ...)

**Uses by Wikidata community:**
- Software-supported error and vandalism detection
- Feature-based integration with other datasets
- Data-driven statistics as a measure of progress
What is Wikidata?

Wikidata is often described as “the free knowledge base that anyone can edit” or the “knowledge graph of Wikipedia”
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It is useful to distinguish several of these aspects:

**Wikidata is ...**

- ... a **Wikimedia project** like Wikipedia and Wikimedia Commons; represented and supported by the Wikimedia Foundation (WMF)
- ... a **dataset** that can be downloaded and freely used and distributed
- ... a **website** through which the data can be viewed and modified
- ... a **community** of volunteer editors that creates and controls all content
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“And like all uses of the word ‘community,’ you were never quite sure what or who it was.” – Terry Pratchett (Jingo, 1997)
Principles of Wikidata

Several basic principles have guided the design of Wikidata:

- **Open editing:** Anyone can extend or modify content (as in Wikipedia); no user account or special skills needed
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Markus Krötzsch, 13th Nov 2018
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- **Continuous evolution**: Incompleteness of content and technology are embraced; Wikidata remains “work in progress”
Two views on the Wikidata knowledge base

The website and its main data services expose Wikidata as a document-centric knowledge base:

- Data is grouped by subject entity (one page per entity)
- Documents are structured into different sections
- The order of content is (mostly) pre-served and shown

→ Useful for display and management
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Conceptually and for most applications, Wikidata is a **graph-structured knowledge base:**

- Main content are binary relationships (from entities to entities/data values)
- Properties are first-class objects with a global scope and definition
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We will mostly view Wikidata as a knowledge graph.
Tim Berners-Lee (Q80)

British computer scientist

TimBL | Sir Tim Berners-Lee | Timothy John Berners-Lee | TBL | Tim Berners Lee | T. Berners-Lee | T Berners-Lee | Tim Berners-Lee | T.J. Berners-Lee
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instance of human

› 1 reference
Tim Berners-Lee

British computer scientist

instance of

human

› 1 reference

employer

CERN

start time 1984
end time 1994
position held Fellow

› 0 references

+ add reference
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instance of

human

1 reference

employer

CERN

start time 1984

end time 1994

position held Fellow

0 references

award received

Queen Elizabeth Prize for Engineering

point in time 2013

together with Robert Kahn

Vint Cerf

Louis Pouzin

Marc Andreessen

1 reference
The content of Wikidata entity documents

The previous page shows the main kinds of content stored in Wikidata:

**Entity ID:** Entities are identified by language-independent ids (e.g., “Q80” for TimBL)

**Terms header:** Document pages start with a label, short description, and list of aliases in the user’s language (or best available language); terms can be entered for several hundred languages and writing systems

**Statements:** The main part of the page consists of sourced claims for several properties that an entity might have; statements may have a rank (normal, preferred, deprecated) to encode their current significance

**Site links:** Connections to pages on other Wikimedia projects realise entity-level information integration

---

**Property pages** use IDs of the form “P1234” and have an additional datatype declaration but no sitelinks. The other parts of the page are the same.
Wikidata’s IDs

Why does Wikidata use abstract (numeric) QIDs and PIDs rather than something more readable?

International
• Identifiers work for any language and cultural backgrounds

Stable
• Labels can change without IDs changing
• Multiple entities can have the same label
• IDs of deleted entities are never used again

Convenient
• Numeric IDs are quite short
• Uniform format is practical

How to find the ID of an item?
Main methods:
1. Use the auto-completing search bar on wikidata.org
2. Go to the item’s Wikipedia page and select “Wikdata item” from the sidebar

Several other projects have started to use Wikidata IDs for tagging and inter-linking.

Markus Krötzsch, 13th Nov 2018
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Wikidata’s basic information units

• Built from Wikidata items (“CERN”, “Vint Cerf”), Wikidata properties (“award received”, “end time”), and data values (“2013”)
• Based on directed edges (“Tim Berners-Lee → CERN”)
• Annotated with property-value pairs (“end time: 1994”)
  – same property can have multiple annotation values (“together with: Robert Kahn, Vint Cerf, . . . ”)
  – same properties/values used in directed edges and annotations
• Items and properties can be subjects/values in statements
• Multi-graph
Elizabeth Taylor (Q34851)
Elizabeth Rosemond Taylor | Liz Taylor | Dame Elizabeth Rosemond Taylor
British-American actress

instance of: Elizabeth Taylor is a(n) human

Human relationships

<table>
<thead>
<tr>
<th>Relationship</th>
<th>Person</th>
<th>Description</th>
<th>Start Time</th>
<th>End Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spouse</td>
<td>Larry Fortensky</td>
<td>construction worker and seventh husband of Elizabeth Taylor</td>
<td>1991-10-06</td>
<td>1996-10-31</td>
</tr>
<tr>
<td></td>
<td>John Warner</td>
<td>Republican politician and Secretary of the Navy from the United States</td>
<td>1976-12-04</td>
<td>1982-11-07</td>
</tr>
<tr>
<td></td>
<td>Richard Burton</td>
<td>Welsh actor</td>
<td>1975-10-10</td>
<td>1976-07-29</td>
</tr>
<tr>
<td></td>
<td>Richard Burton</td>
<td>Welsh actor</td>
<td>1954-03-15</td>
<td>1974-06-26</td>
</tr>
<tr>
<td></td>
<td>Eddie Fisher</td>
<td>American entertainer and singer</td>
<td>1959-05-12</td>
<td>1964-03-06</td>
</tr>
<tr>
<td></td>
<td>Mike Todd</td>
<td>American theatre and film producer</td>
<td>1957-02-02</td>
<td>1958-03-22</td>
</tr>
<tr>
<td></td>
<td>Michael Wilding</td>
<td>English television and film actor</td>
<td>1952-02-21</td>
<td>1957-01-30</td>
</tr>
</tbody>
</table>
Each Wikidata property has a datatype that defines which values it may take.

**Available types (as of 2018):**

- Entities of a fixed type (item, property, lexeme, sense, form)
- Quantities (including integers and numbers with units)
- Points in time (including imprecise dates and times in the distant past/future)
- Geographic coordinates (possibly on other astronomic bodies) and shapes
- URLs (actually including IRIs)
- Strings, and special strings (external identifier, media file name on Wikimedia Commons, tabular data file name on Wikimedia Commons, mathematical formula)
- Texts in a specific language (similar to language-tagged RDF strings)

**Property types cannot be changed once created.**
Wikidata, RDF, and SPARQL
Wikidata in RDF

Wikidata is internally stored in the document-centric form using a JSON format

Data is converted to RDF for several purposes:

- Offering complete data dumps for external uses
- Providing entity-specific linked data exports via a Web API
- Importing data into Wikidata’s SPARQL query service
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**Wikidata’s graph view has many commonalities with RDF:**

- Based on directed, labelled, multi-graph
- Properties have own identity in graph
- Order and in-page context of statements does not matter
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- Based on directed, labelled, multi-graph
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- Order and in-page context of statements does not matter

However, there are also some important differences:
- Wikidata statements can have annotations and references
- Wikidata property types do not correspond to XML Schema types
- Wikidata IDs are not immediately IRIs
Encoding statements in RDF (1)
Encoding statements in RDF (1)

**Tim Berners-Lee** (Q80)

British computer scientist

Where to store the annotations?

**Note:** For prefix declarations, see
We can encode statements in the style of **reification**:

- wd:Q80 Tim Berners-Lee
- p:P166 award received
- wds:Q80-... (statement node)
- psv:P166 award received
- wd:Q4273323 Queen Elizabeth Prize...
We can encode statements in the style of reification:

wd:Q80  Tim Berners-Lee

p:P166  award received

wds:Q80-... (statement node)

pq:P585  point in time

"2013"^^xsd:gYear

psv:P166  award received

wd:Q4273323  Queen Elizabeth Prize...

wdref:30b... reference node

prov:wasDerivedFrom

wdt:P166  award received
We can encode statements in the style of reification:

wd:Q80
Tim Berners-Lee

wd:Q4273323
Queen Elizabeth Prize ...

wds:Q80-...
(statement node)

p:P166 award received

psv:P166 award received

pq:P585 point in time

"2013"^^xsd:gYear

pq:P1706 together with

wd:Q214129 Robert Kahn ...

wd:Q92743 Vint Cerf

wdref:30b...

reference node

prov:wasDerivedFrom

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```
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Tim Berners-Lee
```

```
p:P166 award received
```

```
"2013"^^xsd:gYear
```

```
pq:P585 point in time
```

```
wd:Q214129 Robert Kahn
```

```
pq:P1706 together with
```

```
wd:Q92743 Vint Cerf
```

```
pqref:30b9... reference node
```

```
wd:Q4273323 Queen Elizabeth Prize...
```

```
psv:P166 award received
```

```
prov:wasDerivedFrom
```

```
wdt:P166 award received
```

```
... ...
```

We can encode statements in the style of reification:
Encoding statements in RDF (3)

Summary of statement RDF encoding:

- Each statement is represented by a resource in RDF
- Direct single-triple links from subject to value are added for many statements
  
  rule: direct links are generated for statements non-deprecated rank that are top-ranked among statements with the same subject and property
- Each Wikidata property turns into several RDF properties (for different uses in encoding)
- References and complex values are represented using auxiliary nodes (with a generated IRI)
- Values with units are additionally converted to a standard unit (if possible)
  
  the resulting normalised value is stored alongside the given value, using another set of RDF properties
- Order of qualifiers or statements is not represented in RDF

Useful sources:

- The complete Wikidata-to-RDF documentation is available online
  
- Any item can be viewed in RDF in the browser using URLs such as
  
  http://www.wikidata.org/wiki/Special:EntityData/Q80.ttl
Finishing the RDF encoding

Statements in Wikidata:
- Constitute the largest part of the RDF data
- RDF-encoding introduces over 50K RDF properties

Encoding other parts of Wikidata:
- Labels, descriptions, aliases are encoded as RDF literals with language tags, linked from subject with rdfs:label, schema:description, and skos:altLabel, respectively
- Sitelinks are encoded using property schema:about (from article page URL to Wikidata entity IRI)

Available RDF data:
- Full dumps are generated weekly (currently >60B triples, 42GiB gzipped Turtle)
  For download see https://dumps.wikimedia.org/wikidatawiki/entities/
- Linked data exports are provided through content negotiation
  Alternatively, directly use data URLs like http://www.wikidata.org/wiki/Special:EntityData/Q80.nt
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Wikidata SPARQL Query Service (WDQS):

- Official query service since mid 2015
- User interface at https://query.wikidata.org/
  - Query editing support (auto-completion, suggestions, examples)
  - Support for many different result visualisations
- All the data (6.2B triples), live (latency<60s)
- Very liberal configuration:
  - 60sec timeout
  - No limit on result size
  - No limit on parallel queries, but CPU-time budget per client
- Extra SERVICEs in SPARQL (geo, Wikipedia API, labels, ...)

Summary

Wikidata, the knowledge base of Wikipedia, is a freely available knowledge graph.

Wikidata supports a document-centric and a graph-centric perspective.

Content can be converted to RDF and a public SPARQL query service is available.

What’s next?

- More SPARQL query features
- Further background on SPARQL complexity and semantics
- Graphs beyond RDF