Ontologies, Knowledge Bases, Wikidata

MPRI 2.26.2: Web Data Management

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Reminder

- **Ontology:** vocabulary (classes and relations) to describe things
- **Knowledge base:** set of facts in one or several ontologies

→ Focus on **Wikidata**: a general-purpose knowledge base and ontology

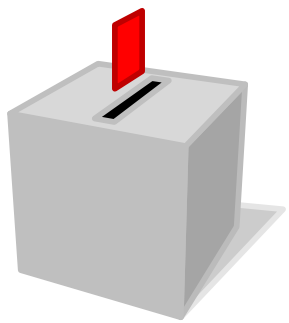
Ontologies

Ontologies

- Various domain-specific vocabularies used across knowledge bases
- One general-purpose ontology used by Google, Microsoft, Yahoo, Yandex: `schema.org`
- Other ontologies that come together with a knowledge base

Examples of ontologies

Which ontologies/knowledge bases do you know about?



Friend of a friend (FOAF)

Describe people, relationship, profiles, activities (social network)

```
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix foaf: <http://xmlns.com/foaf/0.1/> .
<#JW>
    a foaf:Person ;
    foaf:name "Jimmy Wales" ;
    foaf:mbox <mailto:jwales@bomis.com> ;
    foaf:homepage <http://www.jimmywales.com> ;
    foaf:nick "Jimbo" ;
    foaf:depiction <http://www.jimmywales.com/aus_img_small.jpg> ;
    foaf:interest <http://www.wikimedia.org> ;
    foaf:knows [
        a foaf:Person ;
        foaf:name "Angela Beesley"
    ] .
```

Related projects: XHTML Friends Network, hCard

Creative Commons

Describe the **license** and rights on documents

```
<div about="http://lessig.org/blog/"
  xmlns:cc="http://creativecommons.org/ns#">
  This page, by <a property="cc:attributionName"
      rel="cc:attributionURL"
      href="http://lessig.org/">Lawrence Lessig</a>,
  is licensed under a <a rel="license"
      href="http://creativecommons.org/licenses/by/3.0/">
      Creative Commons Attribution License</a>.
</div>
```

- Many **content providers** add this kind of markup (e.g., Flickr)
- **Search engines** can use it (e.g., Google)

Other domain-specific ontologies

- Dublin Core (DC): Describe digital resources (videos, images, etc.) and physical resources (books, CDs, etc.)
- Simple knowledge organization system (SKOS): describe thesauri, taxonomies, etc.
- Open Graph Protocol: metadata for Web pages to be integrated in Facebook's social graph; also Twitter Cards for Twitter
- DOAP (Description of a Project): describe software projects
- VoID (Vocabulary of Interlinked Datasets): describe a linked dataset
- Countless others

Schema.org: a general-purpose ontology

- General-purpose ontology: 797 types and 1457 properties in version 15.0
- Intended to be used on Web pages to annotate the semantics of elements
- Used by search engines for rich search results
- Used in over 10 million sites[1]

[1] Source: `https://schema.org/`

Format: Microdata

```
<div class="event-wrapper" itemscope itemtype="http://schema.org/Event">
  <div class="event-date" itemprop="startDate"
      content="2013-09-14T21:30">Sat Sep 14</div>
  <div class="event-title" itemprop="name">
      Typhoon with Radiation City</div>
  <div class="event-venue" itemprop="location"
      itemscope itemtype="http://schema.org/Place">
    <span itemprop="name">The Hi-Dive</span>
    <div class="address" itemprop="address" itemscope
        itemtype="http://schema.org/PostalAddress">
      <span itemprop="streetAddress">7 S. Broadway</span><br>
      <span itemprop="addressLocality">Denver</span>,
      <span itemprop="addressRegion">CO</span>
      <span itemprop="postalCode">80209</span>
    </div>
  </div>
  <div class="event-time">9:30 PM</div>
</div>
```

- `itemscope` creates an item and `itemtype` gives its type
- `itemprop` gives values for properties of the item

Format: RDFa

Competing format to Microdata, seems less common[2]

```
<div vocab="http://schema.org/" class="event-wrapper" typeof="Event">
  <div class="event-date" property="startDate"
      content="2013-09-14T21:30">Sat Sep 14</div>
  <div class="event-title" property="name">
      Typhoon with Radiation City</div>
  <div class="event-venue" property="location" typeof="Place">
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</div>
```

[2] https://webdatacommons.org/structureddata/index.html#toc2

Format: JSON-LD

Alternative approach: give the structured data separately in JSON

```
<script type="application/ld+json">
{
  "@context": "http://schema.org",
  "@type": "Event",
  "location": {
    "@type": "Place",
    "address": {
      "@type": "PostalAddress",
      "addressLocality": "Denver",
      "addressRegion": "CO",
      "postalCode": "80209",
      "streetAddress": "7 S. Broadway"
    },
    "name": "The Hi-Dive"
  },
  "name": "Typhoon with Radiation City",
  "startDate": "2013-09-14T21:30"
}
</script>
```

- The `@context` attribute gives the namespace for the `@type`.
- No longer gives any link to the page contents
- Also `@id` to give an URI to a node
- Many other features (W3C recommendation is 215 pages)

Web Data Commons Structured Data

- Extraction of semantic content from the Common Crawl
- Also useful to measure usage of structured data:
  - In October 2022, the Common Crawl contained 83 TB (compressed), 380 TB (uncompressed), 3.2G pages
  - `https://index.commoncrawl.org/CC-MAIN-2022-40/`
  - 50% of pages (and 42% of domains) contain semantic data
  - 19G entities and 88G triples
  - `https://webdatacommons.org/structureddata/`

Knowledge bases

Common Knowledge bases

- Generalistic: DBpedia, YAGO, Freebase (defunct), Wikidata
- Proprietary: Google Knowledge Graph, Bing Knowledge Graph (aka Satori)
- Domain-specific
- We will focus afterwards on Wikidata

DBpedia

- Started in 2007
- License: CC-BY-SA
- Code license: GPLv2
- Actors: consortium of members
- Latest release: 2022-09
- Extracted from Wikimedia projects and other data
- 850M triples in 2022-09[3],

[3] https://www.dbpedia.org/blog/dbpedia-snapshot-2022-09-release/

YAGO

- Started in 2008
- License: CC-BY
- Code license: GPLv3
- Actors: Max Planck Institute for Informatics, Télécom Paris
- Latest release: YAGO 4 (2020)
- Extracted from Wikidata
- 50M entities and 2G triples[4],

[4] `https://yago-knowledge.org/downloads/yago-4`

Freebase

- Started in 2007, discontinued in 2016
- License: CC-BY
- Code license: Apache2 (provided after-the-fact by Google)
- Actors: Metaweb, acquired by Google in 2010
- Initially imported from various sources
- Could be edited by anyone
- Partially imported into Wikidata (but not completely)
- Last release: 2016
- Last dump has 1.9G triples

Wikidata

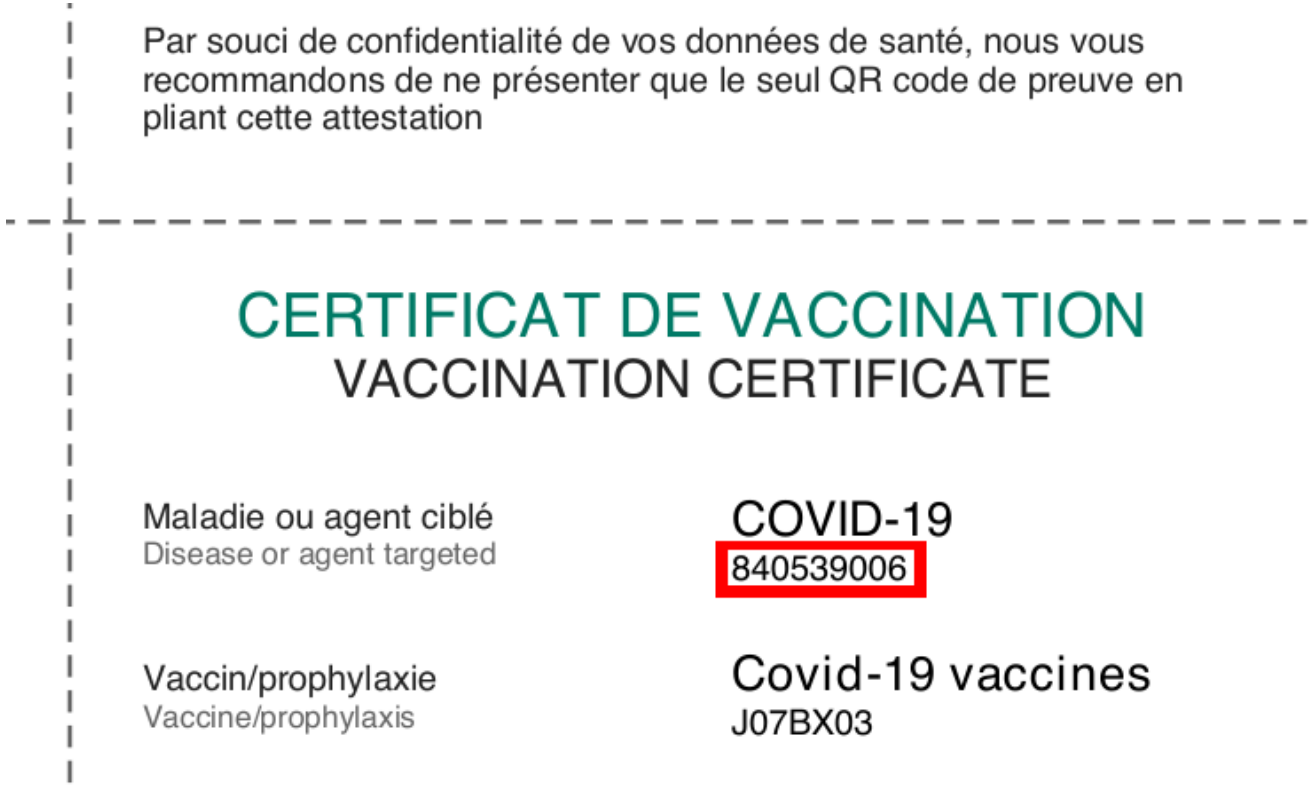
- Started in 2012
- License: public domain
- Code license: GPLv2
- Actors: Wikimedia Deutschland, Wikimedia
- Last release: weekly
- Around 1.4G triples[5] and 102M items[6]
- Can be edited by anyone! Around 25k active users.

[5] https://grafana.wikimedia.org/d/000000175/wikidata-datamodel-statements?orgId=1
[6] https://www.wikidata.org/wiki/Wikidata:Statistics

Domain-specific

- MusicBrainz, for CDs and music in general (20 million recordings)
- British National Bibliography: bibliographic details about books published in the UK since 1950
- data.bnf.fr, data from the French national library
- OpenStreetMaps, and Geonames
- Medicine and chemistry with SNOMED CT, and other databases: DrugBank, KEGG, UniProt, ChEMBL, etc.
- Linguistic resources, e.g., Babelnet
- Bibliography, e.g., DBLP, Crossref

A real-world use of SNOMED CT...



Par souci de confidentialité de vos données de santé, nous vous recommandons de ne présenter que le seul QR code de preuve en pliant cette attestation

CERTIFICAT DE VACCINATION
VACCINATION CERTIFICATE

Maladie ou agent ciblé
Disease or agent targeted

COVID-19
840539006

Vaccin/prophylaxie
Vaccine/prophylaxis

Covid-19 vaccines
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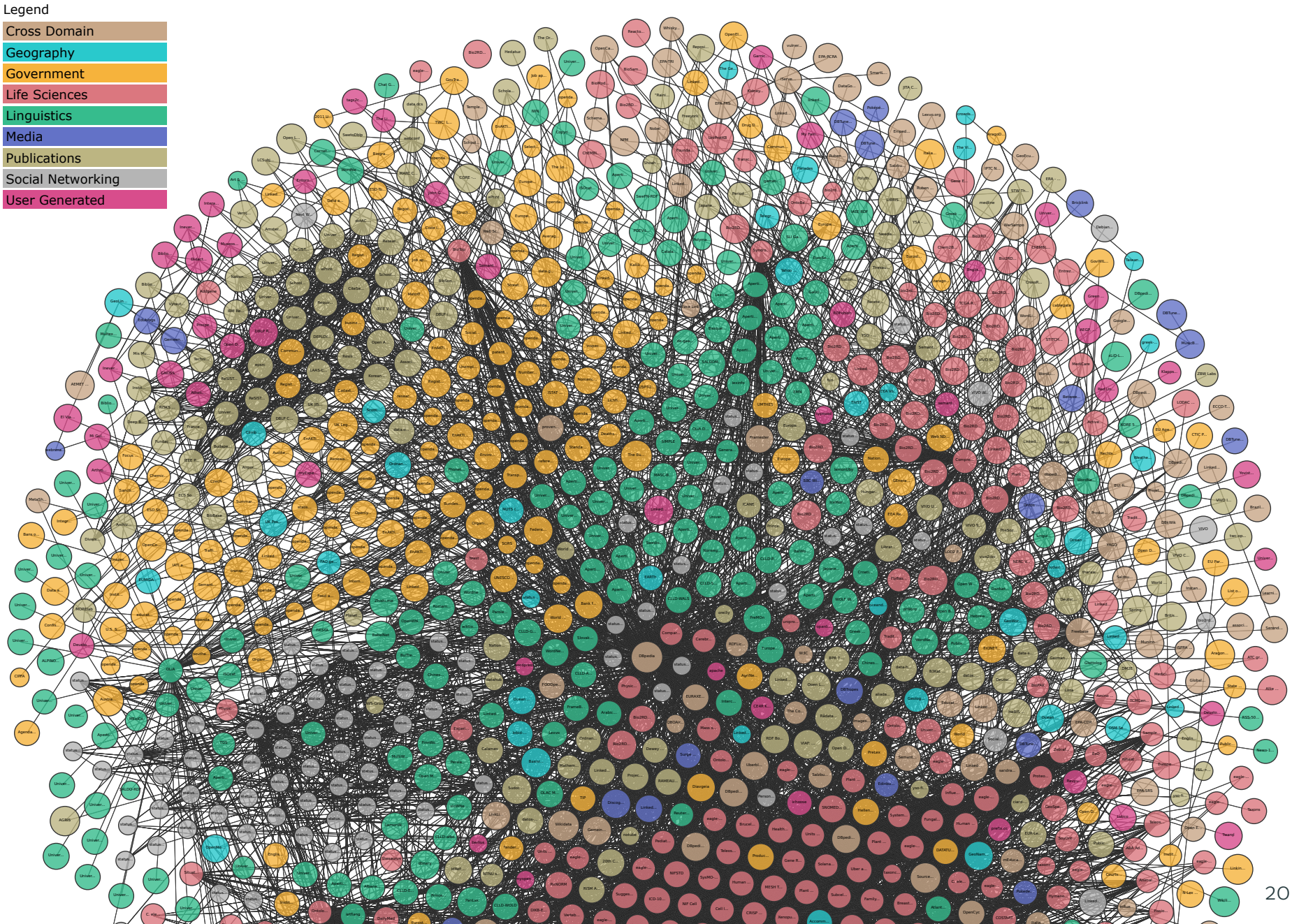
COVID-19

MedGen UID: 1699653 • Concept ID: C5203670 • Disease or Syndrome

Synonym:	Coronavirus disease 2019
SNOMED CT:	Disease caused by 2019 novel coronavirus (840539006); COVID-19 (840539006); Disease caused by Severe acute respiratory syndrome coronavirus 2 (840539006)

Linked Open Data



Gathering Semantic Web Data

- Browsing online versions of KBs
- Using ad-hoc APIs to retrieve relevant triples
- Using a SPARQL endpoint
- Downloading a dump (e.g., Web Data Commons)
- Crawling other knowledge bases, e.g., dereferencing Cool URIs

Systems

- RDF stores (triplestores) with relational or native backend, open-source or commercial, related to graph databases
  - Apache Jena
  - Virtuoso
  - QLever
  - Eclipse RDF4J
  - Blazegraph, essentially acquired by Amazon
  - Amazon Neptune (proprietary)
- SPARQL engines, usually on top of a triplestore.

  `https://en.wikipedia.org/wiki/SPARQL`
- Tool to view semantic data in Web pages:

  `https://developers.google.com/search/docs/advanced/structured-data`

Semantic Web challenges

- Complexity:
  - Writing structured content is harder than writing text!
  - Using structured content (with heterogeneous schema) is complicated!
  - Discoverability problem for knowledge bases, vocabularies
- Performance:
  - Data is large
  - Running queries on graphs is tricky
  - Reasoning makes it even worse
  - Federation makes things worse again

Semantic Web challenges, cont'd

- Data quality:
  - Vagueness and modeling issues
  - Trust (anyone can add a triple)
  - Canonicity and alignment
  - Temporality, sources often complicated to represent
  - Open-world semantics: missing values vs no values
- Incentives: many data providers do not want to be eaten by others

Wikidata

Why Wikidata matters

- Backed by the Wikimedia foundation: credible and noncommercial
- Not run by academics, but some academics are involved
- Genuine uses on Wikipedia (to some extent)
- Centralized model, which is a good idea for now
- Good tradeoffs in terms of expressiveness, scope…
- Uses the successful wiki model

Wikidata basics

- Entities: Q1, Q2, Q3, ...
- Properties: P1, P2, P3, ...

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- Entities and properties have a **label** and short **description** in each language, along with **aliases** (search engine)
- Entities can also have **sitelinks** to Wikimedia projects (e.g., the corresponding Wikimedia pages)

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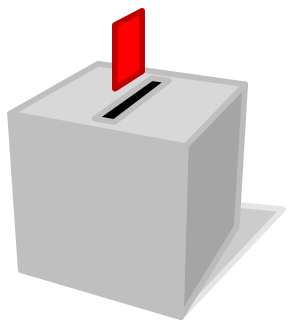
- **Software:** Wikibase, a set of extensions to **Mediawiki**

Wikidata editing

What can you do on Wikidata without prior approval

- **A**: Only edit facts
- **B**: Edit facts and create entities
- **C**: Edit facts and create entities and classes
- **D**: Edit facts and create entities, classes, and properties



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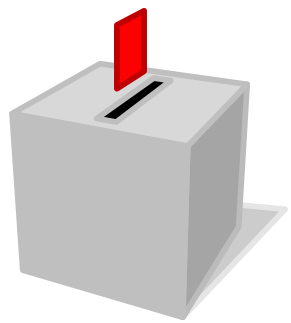

Qualifiers, references, ranks, data types

- Each fact can have qualifiers to indicate things like start/end time, details (e.g., major/degree for P69 “educated at”)
- Each fact can also have sources to indicate where it comes from (a source is a set of key–value pairs)
- Each fact can have a rank among “normal”, “preferred” (e.g., for the current value), or “deprecated”.
- Literal values can have data types

  `https://www.wikidata.org/wiki/Special:ListDatatypes`
- Also two special values
  - “unknown value” (a value exists but is unknown)
  - “no value” (it is known that there is no value)

Constraints

- Wikidata has constraints which are only advisory (= you can create violations) and are quite simple. Main ones:
  - "single (best) value constraint"
  - "inverse constraint" (mother vs child), "symmetric constraint"
  - "type constraint", or requiring/disallowing certain facts
  - "range constraint" "contemporary constraint", "format constraint"
  - "one-of/none-of constraint" (list of allowed/forbidden values)
  - Requiring/allowing qualifiers or units
  - Allowing use as a qualifier/unit
- There is a mechanism for exceptions
- Many constraint violations in practice

Usage on Wikipedia

- Used for interwiki links, i.e., the links between Wikipedia pages across languages
- Used in some infoboxes on Wikipedia, e.g., to automatically populate some fields
- Used to give captions to files on Wikimedia Commons
- Can be used for other things, e.g., filling tables, or external links to other sources
- Policy depends on each Wikipedia: some communities are more welcoming than others...

Ongoing Wikidata discussions

- Project scope: what belongs in Wikidata?
  - The public domain license is a strong requirement
  - Concerns, e.g., about the high number of bibliographic entities (almost half of the entities)
  - Some external datasets are imported, but Wikipedia (historically) gave much importance to human validation of imports
  - Some support for federation in queries; and many external links
- Notability:

  `https://www.wikidata.org/wiki/Wikidata:Notability`
- Managing vandalism?
- Importance of references?

Accessing Wikidata data

- Simply by browsing
- Can retrieve in multiple formats, e.g., `https://www.wikidata.org/wiki/Special:EntityData/Q42.json`
- Wikimedia API, e.g., API for recent changes
- SPARQL queries, `https://query.wikidata.org/` (and API)
- Weekly dumps in JSON, RDF, XML (around 50 GB compressed)

Other cool Wikidata stuff

- Distributed Wikidata Game: crowdsourcing edits on Wikidata `https://tools.wmflabs.org/wikidata-game/distributed/`
- Reasonator: automatically generate a Wikipedia-like page from a Wikidata entity `https://tools.wmflabs.org/reasonator/`
- Lexemes: ongoing effort to add linguistic data to Wikidata
- OWL ontology: `https://wikiba.se/ontology`
- askplatyp.us: natural language question answering tool
- OpenRefine to reconcile datasets with Wikidata and add Wikidata facts `https://www.wikidata.org/wiki/Wikidata:Tools/OpenRefine/Editing/Tutorials/Video`

Slide acknowledgements

- Many thanks to Thomas Pellissier-Tanon for his helpful feedback
- Slide 5: `https://en.wikipedia.org/wiki/FOAF_(ontology)`
- Slide 6: `https://www.w3.org/Submission/ccREL/`
- Slide 9–11: `https://schema.org/Event`
- Slide 14: `https://commons.wikimedia.org/wiki/File:DBpediaLogo.svg`
- Slide 15: `https://en.wikipedia.org/wiki/File:YAGO.svg`
- Slide 16: `https://commons.wikimedia.org/wiki/File:Freebase_Logo_optimised.svg`
- Slide 17, 25: `https://en.wikipedia.org/wiki/File:Wikidata-logo-en.svg`