THE NON-EXISTING LOD CLOUD
AND HOW IT COULD FINALLY BE (RE-)CREATED

Axel Polleres, Maulik Kamdar, Maulik R. Kamdar, Javier D. Fernández, Tania Tudorache, and Mark A. Musen

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About myself: proud member of the Pedantic Web group (ranting unsuccessfully about Linked Data Quality) since 2009 …

Welcome to the Pedantic Web Group

pe·dan·tic /ˈpeɪ.ðəntɪk/: 
overly concerned with formal rules and trivial points of learning

Your data is broken.
You publish RDF on the web, and thereby contribute to our shared passion: the emerging global information space that we call the web of data. Thank you for that! Thank you for sharing your data!

But your data is broken. Syntax errors, unescaped characters, encoding problems, broken links, ambiguous identifiers, undefined vocabulary terms, mismatched semantics, unintended inferences: If you publish anything on the web of data, chances are that there is some problem.
Linked Data - The four holy commandments:

**Linked Data Principles**

- **LDP1**: use URIs as names for things
- **LDP2**: use HTTP URIs so those names can be dereferenced
- **LDP3**: return useful – RDF? – information upon dereferencing those URIs
- **LDP4**: include links using externally dereferenceable URIs.
What happened since?

lod-cloud.net by McCrae et al.
Use case: Drug repurposing

- Drug discovery costs have increased exponentially
  - $2.85 billion for a bio-pharma company to research and sell a new drug

- Alternative solution: looking for novel uses of existing drugs
  - all information about a drug entity
  - drug–protein target interactions
  - publications mentioning the drug
  - adverse reactions
  - downstream drug targets located in biological pathways,
  - essays that test the binding activity of the “drug active ingredient”

\[ \text{Use case: Drug repurposing} \]

\[ = \text{0 drug repurposing (AFAIK)} \]
Why it is still (too?) hard... what about Web-scale queries

• E.g. retrieve all entities in LOD with the label “WBGene00000001 (aap-1)“

```sql
select distinct ?x {
    ?x rdfs:label "WBGene00000001 (aap-1)"
}
```

• Options:
  • Crawl and index LOD locally (-no for a single query-)
  • Follow-your-nose (where should I start?)
  • Federated querying (as good as the endpoints you query)
  • Use a seed (e.g. datahub.io or LOD Laundromat) as a “good approximation” (still querying potentially many datasets, 650K in LOD Laundromat)
What really happened since?

Among the mentioned 5435 resource URLs in the 1281 "LOD"-tagged datasets on old.datahub.io there are only 1917 resources URLs that could be dereferenced. Among all the datasets only 646 dataset descriptions contain such dereferenceable (not counting links to PDF, CSV, TSV files) resource URLs; i.e., almost half, 635 dataset descriptions contain no dereferenceable resource URLs that would point to data at all 😊
Not only our datasets, but also our services and tools disappear....
Some concrete challenges...
Current LOD Cloud:

- Challenge 1: Size
  - single datasets (e.g. Pubmed dump has 7b triples, Wikidata ttl.gz dump +30GB, 5.7b triples)
  - bigger than a significant rest of the LOD cloud (whole LOD-a-lot experiment 28b triples)
- Current Triple stores scale probably up to ~20-30b?
  - But:
    - Provide significant bottlenecks in access (e.g. limits for timeouts in wikidata query-services)
    - Bio2RDF endpoint has only ~1b triples
    - Where’s the rest??

*Current SPARQL endpoints are at their limits*
Current LOD Cloud:

- Challenge 2: SPARQL endpoints availability, findability and limits:
  - http://pubchem.bio2rdf.org/sparql is down
  - cf. also: http://sparqles.ai.wu.ac.at/

→ Better try dumps?

Current SPARQL endpoints are non-available

Availability - 440 SPARQL Endpoints

- Available: 57%
- Unavailable: 43%

Responses: ASK{ ?s ?p ?o }
Current LOD Cloud:

- Challenge 3: APIs not uniformly findable
  - Dumps not easily accessability
    - [http://download.bio2rdf.org/#/current/pubmed/](http://download.bio2rdf.org/#/current/pubmed/)
      - Javascript page which can only be crawled with a headless browser
    - [https://www.ebi.ac.uk/rdf/datasets/#Bulk Downloads](https://www.ebi.ac.uk/rdf/datasets/#Bulk Downloads)
      - Bulk download links as result of SPARQL queries against VoID descriptions, e.g.
          - Various compressions used, etc.
  - SPARQL service description vocabulary does NOT have an attribute for pointing to alternative dumps or proper description of limitations imposed
Current LOD Cloud:

- Challenge 4: **What do Links in LOD cloud actually mean?**
  - What are in-links/out-links?
    - Computed from meta-data on datahub.io
    - But description is ambiguous:
      - **Definition**: “either your dataset must use URIs from the other dataset, or vice versa”
  - What does it actually mean?
    - Ontology reuse?
    - Instance Links?
    - Joint reuse of entities from 3rd dataset?
    - Who does a namespace belong to?
Current LOD Cloud:

• Challenge 5: Completeness/consistency

• Well known RDF datasets missing
  • E.g. EBI RDF not there (plus around 10 other well known Bio data bases), or even wikidata not there (sic!)
  • Datasets no longer available or moved elsewhere... how do I find them?
    • How does the party Linking to a dataset get notified that the dataset has been updated?

→ Needs monitoring & ability to link to versions!

How to deal with updates? New versions of datasets? Archives?
Last, but not least:
Non-Technical Challenges

Other non-technical challenges

• **The steep learning curve**
  • Often frustrating experiences with using LD
  • Data publishers lack tools and guidelines to help them discover and reuse existing content
  • How to perform sophisticated (federated) SPARQL queries, without minimal automated support?

• **Trust & Sustainability**
  • Outdated, once-off RDF exports
  • Doubts of the maintenance: will dataset X be kept up to date?

• **Documentation and Usability**
  • Often inexistent or poor documentation, support or maintenance

• **Funding**
  • No cross-continental projects, no overlapping topics (rather complementary)
  • Duplicated services among communities, e.g. SPARQLES and [http://yummydata.org/endpoints](http://yummydata.org/endpoints) (life sciences)
Still there is hope! Brave PhD candidates defend and “stitch” the Web of Data!
What did Maulik solve in his PhD?

Advances in Drug Repurposing through the integration of different LOD sources!

- **Good news**: Great use cases out there for Linked Data applications!
- **Bad news**: needs a superhero with a PHD to “stitch” & integrate the Web of data
Still there is hope! Brave PhD candidates defend and “stitch” the Web of Data!

Get more than 650K HDT datasets from LOD Laundromat...

Wait a second? 650K? Wasn’t it 1200?
Conclusion:

The LOD cloud is as messy as my slides 😞

... 

It is **NOT** a machine-readable entry-point to the Web of Linked Data
Some good starting point (but not yet a solution)

- LDF+HDT: “a swiss-army-knife for large RDF datasets”
  - Emerged from the PhD thesis of another Linked Data superhero

- Provides a uniform compressed exchange format for dumps
- Enables Linked Data fragments endpoints
  (= of-the-box lightweight (“SPARQL light”) endpoints)
- Keeps data and metadata together and in sync (in header)
  - MetaData such as dataset size, number of links could be computed at publishing time.
  - Implicit notion of “dataset”: 1 dataset = 1 HDT file

- Active developer & user community (some are in the room!)
Active Research and Development in HDT

• HDTQ: Enable quads & and versioning:

Evaluating Query and Storage Strategies for RDF Archives

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Abstract. There is an emerging demand on efficiently archiving and (temporal) querying different versions of evolving semantic Web data. As novel archiving systems are starting to address this challenge, foundations/standards for benchmarking RDF archives are needed to evaluate its storage space efficiency and the performance of different retrieval operations. To this end, we provide theoretical foundations on the design of data and queries to evaluate emerging RDF archiving systems. Then, we instantiate

... allow to deal with versioned dataset dumps and integration of different datasets in one HDT.
Active Research and Development in HDT

• k-shortest path queries:

... could eventually enable use cases like this:
Active Research and Development in HDT

• Work in progress: re-compute a LOD Cloud from a set of HDTs

• Completely auto-created from “HDTized” Bioportal and Bio2RDF

• Idea:
  • Treat each dump-file as a dataset
  • Hueristically assign namespace authority of to datasets heuristically
  • Compute links numbers based on dataset dictionaries using HDT

• (at the moment, uses heuristics to “guess” ownership of namespaces)
Active Research and Development in HDT

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The 5th element and two routes ahead:

- **LDP5**: Publish your dataset as an **HDT dump**, including **VoID metadata** as part of its header and declaring (i) the **owned namespaces**, (ii) **links to previous versions** of the dataset, (iii) whenever you use namespaces owned by other datasets or ontologies – the **link to specific versions** of these other datasets.
How can we jointly move things forward?

Leave it to Denny…

… or work together?
Can only PhD superheroes integrate Linked Data?
Let’s collaborate to make it easier for sheer mortals!
More rants, starting points and a call for collaboration:

A More Decentralized Vision for Linked Data

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Abstract. In this deliberately provocative position paper, we claim that ten years into Linked Data there are still (too?) many unresolved challenges towards arriving at a truly machine-readable and decentralized Web of data. We take a deeper look at the biomedical domain—currently, one of the most promising “adopters” of Linked Data—if we believe the ever-present “LOD cloud” diagram.\(^3\) Herein, we try to highlight and exemplify key technical and non-technical challenges to the success of LOD, and we outline potential solution strategies. We hope that this paper will serve as a discussion basis for a fresh start towards more actionable, truly decentralized Linked Data, and as a call to the community to join forces.

Didn’t talk about:
- Linking with ML,
- Provenance,
- Quality monitoring, ...

Thank you!

Under submission for DESEMWEB2018: https://openreview.net/forum?id=H1I5_g81gX
Backup Slides:
Giovanni Tummarello Actually read it, thanks for the citations 😊. I was excited to read about GO as possible example of success but disappointed in visiting the site, its pretty abandonware too.

Axel you guys cite problems, but IMO you dont mention the only one: *why*? Why should people do that.

Without a business reason (broad definition: fsmoting that pays you back directly so that you feel compelled and justified - in your non grant non academic work - to do it today as opposed to do other things) nothing can move past the toying around - by people receiving grants to toy around.

(had posted too early previously 😞) now for the second part

Like · Reply · 2w · Edited

Axel Polleres more input, great... thanks yes, as long as incentives are only academic fame, competition among research groups is one of the show-stoppers... this is there in the paper, in section 4.2 - implicitly, but we could maybe make it more explicit.

Like · Reply · 1m · Edited

Dan Brickley "We promised (as a community) to revolve Social networks in a way that every data subject owns their social network data in decentralized FOAF" Actually the FOAF project never promised that. We promised to make a machine-readable version. See more

Like · Reply · 2w

Axel Polleres I would say many understood it like that, at least as having the potential, which you seem to confirm? Anyway, the paper is meant to raise discussion, and happy to reword this if it gets accepted to the workshop in the final version... comment appreciated!

Like · Reply · 2w

Dan Brickley Axel Polleres I think the early press - https://www.theguardian.com/.../2004/feb/19... was reasonable, that it was more about better search over public data. The thing that killed that was that none of us had the tools to even deal with it... See more

Like · Reply · 2w

Jürgen Umbrich There exists something else than the lod cloud? And it is called Linked Data? 😊

Like · Reply · 1w

Tobias Käfer Impertinent, how dare people not to register their dataset 😧

Of course Linked Data not registered in the cloud is obvious, but at least the LDP deserves a name-drop I think.

Like · Reply · 1w

Jürgen Umbrich I am seriously confused with all the terminology.

Semantic Web was not about the web but about RDF and OWL next Linked Data (principles) which is RDF on the Web, next decentralising the SW (again?) and now Linked Data needs decentralization...... See more

Like · Reply · 1w · Edited

Axel Polleres that would've been even too provocative for me to dare to write, while I like the wording :)!!

Like · Reply · 2w · Edited

Dan Brickley Axel Polleres may I quote you on that?

Like · Reply · 2w

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Like · Reply · 1w · Edited


Like · Reply · 2w

Axel Polleres @Tobias, true, that is an aspect... in the paper, we focused on the LOD cloud, since it seems to be the single most cited entry point these days.... LDP would have been worth a mention, true, do you have any link that says something about adoption? I wonder how many of the LOD datasets (if any) adhere to the LDP interface. Good one!

Like · Reply · 1w

Axel Polleres p.s.: @Tobias Käfer, we emphasize that we do not mean to be exhaustive, but please, by all means, can you add this as a comment to Openreview? Then, I will try to include it later one!

Like · Reply · 1m · Edited